
ENCYCLOPÆDIA BRITANNICA.

EIGHTH EDITION.

THE

ENCYCLOPÆDIA BRITANNICA,

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ENCYCLOPÆDIA BRITANNICA.

SEAMANSHIP.

THE present article will be found to embrace a threefold division of the subject of seamanship. The reader will find, in the first portion, those general principles which are applicable alike to all cases, and suited to all times of the past and present state of naval affairs. The second portion will be closely connected with this, and will, in fact, consist of a description of some manœuvres, of which the object is to illustrate and further explain the theory previously laid down. Whilst the third portion will bring up the knowledge of the subject in its improved condition, and deal with all those questions which the invention of chain cables, steam, as applied to marine engines, the new system of signals, and other discoveries have introduced into nautical affairs during the last fifty years; avoiding minute details, when they are given under the separate heads in other parts of this work. We commence, therefore, with the great facts and principles of seamanship, in its most general bearing and aspect.

Definition.

By this word we express that noble art, or, more properly, the qualifications which enable a man to exercise the noble art of rigging and working a ship. A SEAMAN, in the language of the profession, is not merely a mariner or labourer on board a ship, but a man who understands the structure of this wonderful machine, and every subordinate part of its mechanism, so as to enable him to employ it to the best advantage for pushing her forward in a particular direction, and for avoiding the numberless dangers to which she is exposed by the violence of the winds and waves. He also knows what courses can be held by the ship, according to the wind that blows, and what cannot, and which of these is most conducive to her progress in her intended voyage; and he must be able to perform every part of the necessary operation with his own hands.

Importance and difficulty of the art;

We are justified in calling it a *noble art*, not only by its importance, which it is quite needless to amplify or embellish, but by its immense extent and difficulty, and the prodigious number and variety of principles on which it is founded, all of which must be possessed in such a manner that they shall offer themselves without reflection in an instant, otherwise the so-called seaman, whatever be his pretensions, cannot be trusted in charge of a watch.

Seamanship.

The art is practised, to a certain extent, by persons without what we call *education*, and in the humbler walks of life, and therefore it suffers in the estimation of the careless spectator. It is thought little of because little attention is paid to it. But if multiplicity, variety, and intricacy of principles, and a systematic knowledge of these principles, entitle any art to the appellation of *scientific* and *liberal*, seamanship claims these epithets in an eminent degree. We are amused with the pedantry of the seaman, which appears in his whole language. Indeed, it is the only pedantry that amuses. A scholar, a soldier, a lawyer, nay, even the elegant courtier, would disgust us, were he to make the thousandth part of the allusions to his profession that is well received from the seaman; and we do the seaman no more than justice. His profession *must* engross his whole mind, otherwise he can never learn it. A sailor, although uneducated, may possess a prodigious deal of knowledge; but cannot tell what he knows, or rather what he feels, for his science is really at his finger-ends. We can say with confidence, that if a person of education, versed in mechanics, and acquainted with the structure of a ship, were to observe with attention the movements which are made on board a first or second rate ship of war during a shifting storm, under the direction of an intelligent officer, he would be rapt in admiration.

What a pity it is that an art so important, so difficult, and so intimately connected with the invariable laws of mechanical nature, should be so held by many of its possessors, that it cannot improve, but must die with each individual. Having no advantages of previous education, they cannot scientifically arrange their thoughts. They can far less express or communicate to others the intuitive knowledge which they possess; and their art, acquired by habit alone, is little different from an instinct. We are not entitled to expect much improvement here; yet a ship may be considered as a machine. We know the forces which act on it, and we

know the results of its construction; all these are as fixed as the laws of motion. What hinders this to be reduced to a set of practical maxims, as well founded and as logically deduced as the working of a steam-engine or a cotton-mill? The stoker or the spinner acts only with his hands, and may "whistle as he works, for want of thought;" but the mechanist, the engineer, thinks for him, improves his machine, and directs him to a better practice. May not the seaman look for the same assistance; and may not the ingenious speculist in his closet unravel the intricate thread of mechanism which connects all the manual operations with the unchangeable laws of nature, and both furnish the seaman with a better machine, and direct him to a more dexterous use of it.

which has been zealously cultivated by the French philosophers.

We cannot help thinking that much may be done; nay, we may say that much has been done. We think highly of the progressive labours of Renaud, Pitot, Bouguer, Du Hamel, Groignard, Bernoulli, Euler, Romme, and others; and are both surprised and sorry that Britain has contributed so little in these attempts. Gordon is the only one of our countrymen who has given a professedly scientific treatise on a small branch of the subject. The government of France has always been strongly impressed with the notion of great improvements being attainable by systematic study of this art; and we are indebted to the endeavours of that ingenious nation for any thing of practical importance that has been obtained. M. Bouguer was professor of hydrology at one of the marine academies of France, and was enjoined, as part of his duty, to compose dissertations both on the construction and the working of ships. His *Traité du Navire* and his *Manœuvre des Vaisseaux*, are undoubtedly very valuable performances. So are those of Euler and Bernoulli, considered as mathematical dissertations; and they are wonderful works of genius, considered as the productions of persons who hardly ever saw a ship, and were totally unacquainted with the profession of a seaman. In this respect Bouguer had great superiority, having always lived at a sea-port, and having made many very long voyages. His treatises, therefore, are infinitely better accommodated to the demands of the seaman, and more directly instructive; but still the author is more a mathematician than an artist, and his performance is intelligible only to mathematicians. It is true, the academical education of the young gentleman of the French navy is such, that a great number of them may acquire the preparatory knowledge that is necessary; and we are well informed that, in this respect, the officers of the British navy are greatly inferior to them. At the same time, we may observe, that the French themselves appear so little sensible of the advantage of these publications, that no person among them has attempted to make a familiar abridgment of them, written in a way fitted to attract attention; and they still remain neglected in their original abstruse and uninteresting form; in consequence of which, these very ingenious and learned dissertations are by no means so useful as we should expect. They are large books, and appear to contain much; and as their plan is logical, it seems to occupy the whole subject, and, therefore, to have done almost all that can be done. But, alas! they have only opened the subject, and the study is yet in its infancy. The whole science of the art must proceed on the knowledge of the impulsions of the wind and water. These are the forces which act on the machine; and its motions, which are the ultimatum of our research, whether as an end to be obtained or as a thing to be prevented, must depend on these forces. Now it is with respect to this fundamental point that we are as yet almost totally in the dark. And in the performances of M. Bouguer, as also in those of the other authors we have named, the theory of these forces, by which their quantity and the direction of their action are ascertained, is altogether erroneous; and its results deviate so enormously from what is observed in the motions of a ship, that the persons who should direct the operations on shipboard, in conformity to the maxims deducible from M. Bouguer's propositions, would be baffled in most of his attempts, and be in danger of losing the ship. The whole proceeds on the supposed truth of that theory which states the impulse of a fluid to be in the proportion of the square of the sine of the angle of incidence; and that its action on any small portion, such as a square foot of the sails or hull, is the same as if that portion were detached from the rest, and were exposed, single and alone, to the wind or water in the same angle. But it can be shown, both from theory and experience, that both of these principles are erroneous, and this to a very great degree, in cases which occur most frequently in practice, that is, in the small angles of inclination. When the wind falls nearly perpendicular on the sails, theory is not very erroneous; but in these cases, the circumstances of the ship's situation are generally such that the practice is easy, occurring almost without thought; and in this case too, even considerable deviations from the very best practice are of no great moment. The interesting cases, where the intended movement requires or depends upon very oblique actions of the wind on the sails, and its practicability or impracticability depends on a very small variation of this obliquity; a mistake of the force, either as to intensity or direction, produces a mighty effect on the resulting motion. This is the case in sailing to windward, the most important of all the general problems of seamanship. The trim of the sails, and the course of the ship, so as to gain most on the wind, are very nice things; that is, they are confined within very narrow limits, and a small mistake produces a very considerable effect. The same thing obtains in many of the nice problems of tacking, box-hauling, wearing after lying-to in a gale of wind, &c.

Argument against the utility of their performances;

which are confessedly erroneous in their fundamental principles;

The error in the second assertion of the theory is still greater, and the action on one part of the sail or hull is so greatly modified by its action on another adjoining part, that a stay-sail is often seen hanging like a loose rag, although there is nothing between it and the wind; and this merely because a great sail in its neighbourhood sends off a lateral stream of wind, which completely hinders the wind from getting at it. Till the theory of the action of fluids be established, therefore, we cannot tell what are the forces which are acting on every point of the sail and hull; therefore we cannot tell either the mean intensity or direction of the whole force which acts on any particular sail, nor the intensity and mean direction of the resistance to the hull; circumstances absolutely necessary for enabling us to say what will be their energy in producing a rotation round any particular axis. In like manner, we cannot, by such a computation, find the spontaneous axis of conversion, or the velocity of such conversion. In short, we cannot pronounce with tolerable confidence *à priori* what will be the motions in any case, or what dispositions of the sails will produce the movement we wish to perform. The experienced seaman learns by habit the general effects of every disposition of the sails; and though his knowledge is far from being accurate, it seldom leads him into any very blundering operation. Perhaps he seldom makes the best adjustment possible, but seldomer still does he deviate very far from it; and in the most general and important problems, such as working to windward, the result of much experience and many corrections has settled a trim of the sails, which is certainly not far from the truth, but it must be acknowledged, deviates widely and uniformly from the theories of the mathematician's closet.

After this account of the theoretical performances in the art of seamanship, and entertaining, as we do, small hopes of seeing a perfect theory of the impulse of fluids, it will not be expected that we enter very minutely on the subject in this place; nor is it our intention. But let it be observed that the theory is defect-

Seamanship.

ive in one point only; and although this is a most important point, and the errors in it destroy the conclusions of the chief propositions, the reasonings remain in full force, and the *modus operandi* is precisely such as is stated in the theory. The *principles* of the art are therefore to be found in these treatises; but false inferences have been drawn, by computing from erroneous quantities. The rules and the practice of the computation, however, are still beyond controversy. Nay, since the process of investigation is legitimate, we may make use of it in order to discover the very circumstance in which we are at present mistaken; for by converting the proposition, instead of finding the motions by means of the supposed forces, combined with the known mechanism, we may discover the forces by means of this mechanism and the observed motions.

though use may be made of them.

Design of this article.

We shall, therefore, in this place, give a very general view of the movements of a ship under sail, showing how they are produced and modified by the action of the wind on her sails, the water on her rudder and on her bows. We shall not attempt a precise determination of any of these movements; but we shall say enough to enable the curious landsman to understand how this mighty machine is managed amidst the fury of the winds and waves; and, what is more to our wish, we hope to enable the thinking seaman, to generalise that knowledge which he possesses; to class his ideas, and give them a sort of rational system; and even to improve his practice, by making him sensible of the immediate operation of everything he does, aud in what manner it contributes to produce the movement which he has in view.

A ship considered as in free space, impelled and resisted by opposite forces.

A ship may be considered at present as a mass of inert matter in free space, at liberty to move in every direction, according to the forces which impel or resist her; and when she is in actual motion, in the direction of her course, we may still consider her as at rest in absolute space, but exposed to the impulse of a current of water moving equally fast in the opposite direction; for in both cases the pressure of the water on her bows is the same; and we know that it is possible, and frequently happens in currents, that the impulse of the wind on her sails, and that of the water on her bows, balance each other so precisely, that she not only does not stir from the place, but also remains steadily in the same position, with her head directed to the same point of the compass. This state of things is easily conceived by any person accustomed to consider mechanical subjects, and every seaman of experience has observed it. It is of importance to consider it in this point of view, because it gives us the most familiar notion of the manner in which these forces of the wind and water are set in opposition, and made to balance or not to balance each other by the intervention of the ship, in the same manner as the goods and the weights balance each other in the scales by the intervention of a beam or steelyard.

Impulse of the wind on the sails opposite to that of the water on the bows.

When a ship proceeds steadily in her course, without changing her rate of sailing, or varying the direction of her head, we must in the first place conceive the accumulated impulses of the wind on all her sails as precisely equal and directly opposite to the impulse of the water on her bows. In the next place, because the ship does not change the direction of her keel, she resembles the balanced steelyard, in which the energies of the two weights, which tend to produce rotations in opposite directions, and thus to change the position of the beam, mutually balance each other round the fulcrum; so the energies of the actions of the wind on the different sails balance the energies of the water on the different parts of the hull.

Skill of the seaman displayed in shaping his course.

The seaman has two principal tasks to perform. The first is to keep the ship steadily in that course which will bring her farthest on in the line of her intended voyage. This is frequently very different from that line, and the choice of the best course is sometimes a matter of considerable difficulty. It is sometimes possible to shape the course precisely along the line of the voyage; and yet the intelligent seaman knows that he will arrive sooner, or with greater safety, at his port, by taking a different course; because he will gain more by increasing his speed than he loses by increasing the distance. Some principle must direct him in the selection of this course. This we must attempt to lay before the reader.

Having chosen such a course as he thinks most advantageous, he must set such a quantity of sail as the strength of the wind will allow him to carry with safety and effect, and must trim the sails properly, or so adjust their positions to the direction of the wind, that they may have the greatest possible tendency to impel the ship in the line of her course, and to keep her steadily in that direction.

His other task is to produce any deviations which he sees proper from the present course of the ship; and to produce these in the most certain, the safest, and the most expeditious manner. It is chiefly in this movement that the mechanical nature of a ship comes into view, and it is here that the superior address and resources of an expert seaman is to be perceived.

Under the article SAILING, some notice has been taken of the first task of the seaman, and it was there shown how a ship, after having taken up her anchor and fitted her sails, accelerates her motion, by degrees which continually diminish, till the increasing resistance of the water becomes precisely equal to the diminished impulse of the wind, and then the motion continues uniformly the same, so long as the wind continues to blow with the same force, and in the same direction.

It is perfectly consonant to experience, that the impulse of fluids is in the duplicate ratio of the relative velocity. Let it be supposed that when water moves one foot per second, its perpendicular pressure or impulse on a square foot is m pounds. Then, if it be moving with the velocity V estimated in feet per second, its perpendicular impulse on a surface S, containing any number of square feet, must be $m\,SV^2$.

In like manner, the impulse of air on the same surface may be represented by $n\,SV^2$; and the proportion of the impulse of these two fluids will be that of m to n. We may express this by the ratio of q to 1, making $\frac{m}{n}=q$.

Impulse of the water computed in ounces on the square foot.

M. Bouguer's computations and tables are on the supposition that the impulse of sea-water moving 1 foot per second is twenty-three ounces on a square foot, and that the impulse of the wind is the same when it blows at the rate of 24 feet per second. These measures are all French, and by no means agree with the experiments of Buat and others, whose conclusions confirm the results of investigation, namely, that nothing like precise measures can be expected, and that the impulsions and resistances at the same surface, with the same obliquity of incidence, and the same velocity of motion, are different according to the form and situation of the adjoining parts. Thus the total resistance of a thin board is greater than that of a long prism, having this board for its front or bow, &c.

We are greatly at a loss what to give as absolute measures of these impulsions.

1. With respect to water. The experiments of the French academy on a prism 2 feet broad and deep, and 4 feet long, indicate a resistance of 0.973 pounds avoirdupois to a square foot, moving with the velocity of 1 foot per second at the surface of still water.

Mr Buat's experiments on a square foot wholly immersed in a stream, were as follow:—

A square foot as a thin plate....................1·81 pounds.
„ „ as the front of a box 1 foot long.1·42 „
„ „ as the front of a box 3 feet long.1·29 „
The resistance of sea-water is about $\frac{1}{37}$ greater.

2. With respect to air the varieties are as great. The resistance of a square foot to air moving with the velocity of 1 foot per second, appears from Mr Robin's experiments on 16 square inches to be—

On a square foot	0·001596 pounds.
Chevalier Borda's on 16 inches	0·001757 „
„ „ on 81 inches	0·002042 „
Mr Rouse's on large surfaces	0·002291 „

Precise measures are not to be expected, nor are they necessary in this inquiry. Here we are chiefly interested in their proportions, as they may be varied by their mode of action in the different circumstances of obliquity and velocity.

Direct impulse on the sail perpendicular to the yard.

We begin by recurring to the fundamental proposition concerning the impulse of fluids,—viz., that the absolute pressure is always in a direction perpendicular to the impelled surface, whatever may be the direction of the stream of fluid. We must therefore illustrate the doctrine, by always supposing a flat surface of sail stretched on a yard, which can be braced about in any direction, and giving this sail such a position and such an extent of surface that the impulse on it may be the same, both as to direction and intensity, with that on the real sails. Thus the consideration is greatly simplified. The direction of the impulse is therefore perpendicular to the yard. Its intensity depends on the velocity with which the wind meets the sail, and the obliquity of its stroke. We shall adopt the constructions founded on the common doctrine, that the impulse is as the square of the sine of the inclination, because they are simple; whereas, if we were to introduce the values of the oblique impulses, such as they have been observed in the excellent experiments of the Academy of Paris, the constructions would be complicated in the extreme, and we could hardly draw any consequences which would be intelligible to any but expert mathematicians. The conclusions will be erroneous, not in kind but in quantity only; and we shall point out the necessary corrections, so that the final results will be found not very different from real observation.

A ship compared to an oblong box.

If a ship were a round cylindrical body like a flat tub, floating on its bottom, and fitted with a mast and sail in the centre, she would always sail in a direction perpendicular to the yard. This is evident. But she is an oblong body, and may be compared to a chest, whose length greatly exceeds its breadth. She is so shaped that a moderate force will push her through the water with the head or stern foremost; but it requires a very great force to push her sideways with the same velocity. A fine sailing ship of war will require about twelve times as much force to push her sideways as to push her head foremost. In this respect, therefore, she will very much resemble a chest whose length is twelve times its breadth; and whatever be the proportion of these resistances in different ships, we may always substitute a box, which shall have the same resistances headways and sideways.

Let EFGH (fig. 1) be the horizontal section of such a box, and AB its middle line, and C its centre. In whatever direction this box may chance to move, the direction of the whole resistance on its two sides will pass through C. For as the whole stream has one inclination to the side

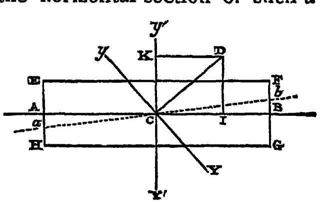

Fig. 1.

EF, the equivalent of the equal impulses on every part will be in a line perpendicular to the middle of EF. For the same reason it will be in a line perpendicular to the middle of FG. These perpendiculars must cross in C. Suppose a mast erected at C, and YC*y* to be a yard hoisted on it carrying a sail. Let the yard be first conceived as braced right athwart at right angles to the keel, as represented by Y'*y*'. Then, whatever be the direction of the wind abaft this sail, it will impel the vessel in the direction CB. But if the sail has the oblique position Y*y*, the impulse will be in the direction CD perpendicular to CY, and will both push the vessel ahead and sideways; for the impulse CD is equivalent to the two impulses CK and CI (the sides of a rectangle of which CD is the diagonal). The force CI pushes the vessel ahead, and CK pushes her sideways. She must therefore take some intermediate direction *ab*, such that the resistance of the water to the plane FG is to its resistance to the plane EF as CI to CK.

Makes lee way when not sailing directly before the wind.

The angle *b*CB between the real course and the direction of the head is called the leeway; and in the course of this dissertation we shall express it by the symbol x. It evidently depends on the shape of the vessel and on the position of the yard. An accurate knowledge of the quantity of leeway, corresponding to different circumstances of obliquity of impulse, extent of surface, &c., is of the utmost importance in the practice of navigation; and even an approximation is valuable. The subject is so very difficult that this must content us for the present.

Let V be the velocity of the ship in the direction C*b*, and let the surfaces FG and FE be called A' and B'. Then the resistance to the lateral motion is $mV^2 \times B' \times \text{sine}^2$, *b*CB, and that to the direct motion is $mV^2 \times A' \times \text{sine}^2$, *b*CK, or $mV^2 \times A' \times \cos^2 b\text{CB}$. Therefore these resistances are in the proportion of $B' \times \text{sine}^2, x$ to $A' \times \cos^2, x$ (representing the angle of leeway *b*CB by the symbol x).

Therefore we have CI : CK, or $\text{CI} : \text{ID} = A' \cdot \cos.^2 x : B' \cdot \text{sine}^2 x, = A' : B' \cdot \frac{\text{sine}^2 x}{\cos.^2 x} = A' : B' \cdot \text{tangent}^2 x.$

How to find the quantity of leeway

Let the angle YCB, to which the yard is braced up, be called the trim of the sails, and expressed by the symbol b. This is the complement of the angle DCI. Now $\text{CI} : \text{ID} = \text{rad.} : \text{tan. DCI}, = 1 : \text{tan. DCI}, = 1 : \text{cotan. } b$. Therefore we have finally $1 : \text{cotan. } b = A' : B' \cdot \tan.^2 x$, and $A' \cdot \text{cotan. } b = B' \cdot \text{tangent}^2 x$, and $\tan.^2 x = \frac{A'}{B'} \text{cot. } b$. This equation evidently ascertains the mutual relation between the trim of the sails and the leeway, in every case where we can tell the proportion between the resistances to the direct and broadside motions of the ship, and where this proportion does not change by the obliquity of the course. Thus, suppose the yard braced up to an angle of 30° with the keel. Then cotan. 30° = 1·732 very nearly. Suppose also that the resistance sideways is twelve times greater than the resistance headways. This gives A = 1 and B' = 12. Therefore $1{\cdot}732 = 12 \times \text{tangent}^2 x$, and $\text{tangent}^2 x = \frac{1{\cdot}732}{12}, = 0{\cdot}14434$, and tan. $x = 0{\cdot}3799$, and $x = 20°, 48'$ very nearly two points of leeway.

This computation, or rather the equation which gives room for it, supposes the resistances proportional to the squares of the sines of incidence. The experiments of the Academy of Paris (see article HYDRODYNAMICS) show that this supposition is not far from the truth when the angle of incidence is great. In the present case the angle of incidence on the front FG is about 70°, and the experiments just now mentioned show that the real resistances exceed the theoretical ones only $\frac{1}{180}$. But the angle of incidence on EF is only 20° 48'. Experiment shows that in this inclination the resistance is almost quadruple of the theoretical resistances. Therefore the lateral resistance is assumed much too small in the present instance. Therefore a much smaller leeway will suffice for producing a lateral resistance which will balance the lateral impulse CK, arising from the obliquity of the sail, viz., 30°. The matter of fact is, that a pretty good sailing ship, with her sails braced to this angle at a medium, will not make above five or six de-

grees leeway in smooth water and fine weather; and yet in this situation the hull and rigging present a very great surface to the wind, in the most improper positions, so as to have a very great effect in increasing her leeway. And if we compute the resistances for this leeway of six degrees by the actual experiments of the French Academy on the angle, we shall find the result not far from the truth,—that is, the direct and lateral resistances will be nearly in the proportion of CI to ID.

It results from this view of the matter, that the leeway is in general much smaller than what the usual theory assigns.

which depends on trim of the sails.

We also see that, according to whatever law the resistances change by a change of inclination, the leeway remains the same while the trim of the sails is the same. The leeway depends only on the direction of the impulse of the wind; and this depends solely on the position of the sails with respect to the keel, whatever may be the direction of the wind. This is a very important observation, and will be frequently referred to in the progress of the present investigation. Note, however, that we are here considering only the action on the sails, and on the same sails. We are not considering the action of the wind on the hull and rigging. This may be very considerable; and it is always in a lee direction, and augments the leeway; and its influence must be so much the more sensible, as it bears a greater proportion to the impulse on the sails. A ship under close-reefed topsails and courses, must make more leeway than when under all her canvas, trimmed to the same angle. But to introduce this additional cause of deviation here would render the investigation too complicated to be of any use.

Illustration of this doctrine by experiments on models and on ships.

This doctrine will be considerably illustrated by attending to the manner in which a lighter is tracked along a canal, or swings to its anchor in a stream. The track-rope is made fast to some staple or bolt E on the deck (fig. 2), and is passed between two of the timber-heads of the bow D, and laid hold of at F on shore.

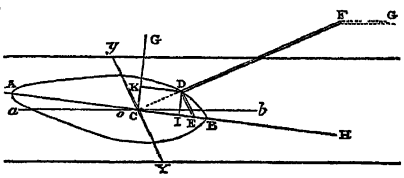

Fig. 2.

The men or cattle walk along the path FG, the rope keeps extended in the direction DF, and the lighter arranges itself in an oblique position AB, and is thus dragged along in the direction *ab*, parallel to the side of the canal; or, if the canal has a current in the opposite direction *ba*, the lighter may be kept steady in its place by the rope DF made fast to a post at F. In this case, it is always observed, that the lighter swings in a position AB, which is oblique to the stream *ab*. Now, the force which retains it in this position, and which precisely balances the action of the stream, is certainly exerted in the direction DF; and the lighter would be held in the same manner if the rope were made fast at C amidship, without any dependence on the timberheads at D; and it would be held in the same position, if, instead of the single rope CF, it were riding by two ropes CG and CH, of which CH is in a direction right ahead, but oblique to the stream, and the other CG is perpendicular to CH or AB. And, drawing DI and DK perpendicular to AB and CG, the strain on the rope CH is to that on the rope CG as CI to CK. The action of the rope in these cases is precisely analogous to that of the sail yY; and the obliquity of the keel to the direction of the motion, or to the direction of the stream, is analogous to the leeway. All this must be evident to any person accustomed to mechanical disquisitions.

A most important use may be made of this illustration. If an accurate model be made of a ship, and if it be placed in a stream of water, and ridden in this manner by a rope made fast at any point D of the bow, it will arrange itself in some determined position AB. There will be a certain obliquity to the stream, measured by the angle B*ob*; and there will be a corresponding obliquity of the rope, measured by the angle FCB. Let yCY be perpendicular to CF. Then CY will be the position of the yard, or trim of the sails corresponding to the leeway bCB. Then, if we shift the rope to a point of the bow distant from D by a small quantity, we shall obtain a new position of the ship, both with respect to the stream and rope; and in this way may be obtained the relation between the position of the sails and the leeway, independent of all theory, and susceptible of great accuracy; and this may be done with a variety of models suited to the most usual forms of ships.

In further thinking on this subject, we are persuaded that these experiments, instead of being made on models, may with equal ease be made on a ship of any size. Let the ship ride in a stream at a mooring D (fig. 3), by means of a short hawser BCD from her bow, having a spring AC on it carried out from her quarter. She will swing to her moorings, till she ranges herself in a certain position AB with respect to the direction *ba* of the stream; and the direction of the hawser DC will point to some point E of the line of the keel.

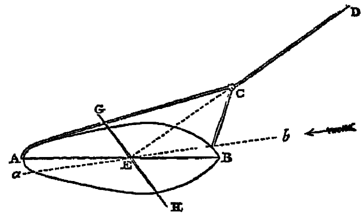

Fig. 3.

Now, it is plain to any person acquainted with mechanical disquisitions, that the deviation BEb is precisely the leeway that the ship will make when the average position of the sails is that of the line GEH perpendicular to ED; at least this will give the leeway which is produced by the sails alone. By heaving on the spring, the knot C may be brought into any other position we please; and for every new position of the knot the ship will take a new position with respect to the stream and to the hawser. And we persist in saying, that more information will be got by this train of experiments than from any mathematical theory: for all the theories of the impulses of fluids must proceed on physical postulates with respect to the motions of the filaments, which are exceedingly conjectural.

The comparison of a ship to an oblong body is only useful to give clear notions on the subject.

And it must now be farther observed, that the substitution which we have made of an oblong parallelopiped for a ship, although well suited to give us clear notions of the subject, is of small use in practice; for it is next to impossible (even granting the theory of oblique impulsions) to make this substitution. A ship is of a form which is not reducible to equations; and therefore the action of the water on her bow or broadside can only be had by a most laborious and intricate calculation for almost every square foot of its surface.[1] And this must be different for every ship. But, which is more unlucky, when we have got a parallelopiped which will have the same proportion of direct and lateral resistance for a particular angle of leeway, it will not answer for another leeway of the same ship; for when the leeway changes, the figure actually exposed to the action of the water changes also. When the leeway is increased, more of the lee-quarter is acted on by the water, and a part of the weather-bow is now removed from its action. Another parallelopiped must therefore be discovered, whose resistances shall suit this new position of the keel with respect to the real course of the ship.

[1] Bezout's *Cours de Mathem.*, vol. v., p. 72, &c.

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We proceed, in the next place, to ascertain the relation between the velocity of the ship and that of the wind, modified as they may be by the trim of the sails and the obliquity of the impulse.

The relation between the velocity of the ship and wind ascertained.

Let AB (figs. 4, 5, and 6) represent the horizontal section of a ship. In place of all the drawing sails—that is, the sails which are really filled—we can always substitute one sail of equal extent, trimmed to the same angle with the keel. This being supposed attached to the yard DCD, let this yard be first of all at right angles to the keel, as represented in fig. 4. Let the wind blow in the direction WC, and let CE (in the direction WC continued) represent the velocity V of the wind. Let CF be the velocity v of the ship. It must also be in the direction of the ship's motion, because when the sail is at right angles to the keel, the absolute impulse on the sail is in the direction of the keel, and there is no lateral impulse, and consequently no leeway. Draw EF, and complete the parallelogram CFEe, producing eC through the centre of the yard to w. Then wC will be the relative or apparent direction of the wind, and Ce or FE will be its apparent or relative velocity. For if the line Ce be carried along CF, keeping always parallel to its first position, and if a particle of air move uniformly along CE (a fixed line in absolute space) in the same time, this particle will always be found in that point of CE, where it is intersected at that instant by the moving line Ce; so that if Ce were a tube, the particle of air, which really moves in the line CE, would always be found in the tube Ce. While CE is the real direction of the wind, Ce will be the position of the vane at the mast-head, which will therefore mark the apparent direction of the wind, or its motion relative to the moving ship.

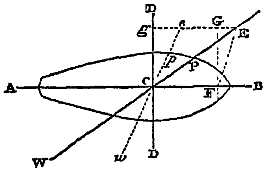

Fig. 4.

We may conceive this in another way. Suppose a cannon-shot fired in the direction CE at the passing ship, and that it passes through the mast at C with the velocity of the wind. It will not pass through the off-side of the ship at P, in the line CE; for while the shot moves from C to P, the point P has gone forward, and the point p is now in the place where P was when the shot passed through the mast. The shot will therefore pass through the ship's side in the point p, and a person on board seeing it pass through C and p, will say that its motion was in the line Cp.

When a ship is in motion, the apparent direction of the wind is always different from the real direction.

Thus it happens, that when a ship is in motion the apparent direction of the wind is always ahead of its real direction. The line wC is always found within the angle WCB. It is easy to see from the construction, that the difference between the real and apparent directions of the wind is so much the more remarkable as the velocity of the ship is greater. For the angle WCw or ECe depends on the magnitude of Ee or CF, in proportion to CE. Persons not much accustomed to attend to these matters are apt to think all attention to this difference to be nothing but affectation of nicety. All seamen are aware that the velocity of a ship has a sensible proportion to that of the wind. "Swift as the wind," is a proverbial expression: but it is one which sometimes indeed falls short of the truth, as it is known, that at times the ship's velocity may exceed that of the wind. The difference between the real direction of the wind and that which in fact impels the ship, namely, its apparent direction, is of great importance when steam propulsion is combined with sails; and will be again noticed when we come to that part of our subject. We may form a pretty exact notion of the velocity of the wind by observing the shadows of the summer clouds flying along the face of a country, and it may be very well measured by this method. The motion of such clouds cannot be very different from that of the air below; and when the pressure of the wind on a flat surface, while blowing with a velocity measured in this way, is compared with its pressure when its velocity is measured by more unexceptionable methods, they are found to agree with all desirable accuracy. Now, observations of this kind frequently repeated, show that what we call a pleasant brisk gale blows at the rate of about ten miles an hour, or about fifteen feet in a second, and exerts a pressure of half a pound on a square foot. Mr Smeaton has frequently observed the sails of a windmill, driven by such a wind, moving faster nay, much faster, towards their extremities, so that the sail, instead of being pressed to the frames on the arms, was taken aback, and fluttering on them. Nay, we know that a good ship, with all her sails set, and the wind on the beam, will, in such a situation, sail above ten knots an hour in smooth water. There is an observation made by every experienced seaman, which shows this difference between the real and apparent directions of the wind very distinctly. When a ship that is sailing briskly with the wind on the beam tacks about, and then sails equally well on the other tack, the wind always appears to have shifted and come more ahead. This is familiar to all seamen. The seaman judges of the direction of the wind by the position of the ship's vanes. Suppose the ship sailing due west on the starboard tack, with the wind apparently N.N.W., the vane pointing S.S.E. If the ship put about, and stands due east on the port tack, the vane will be found no longer to point S.S.E., but perhaps S.S.W., the wind appearing N.N.E., and the ship must be nearly close-hauled in order to make an east course. The wind appears to have shifted four points. If the ship tacks again, the wind returns to its old quarter. We have often observed a greater difference than this. The celebrated astronomer Dr Bradley, taking the amusement of sailing in a pinnace on the river Thames, observed this, and was surprised at it, imagining that the change of the wind was owing to the approaching to or retiring from the shore. The boatmen told him that it always happened at sea, and explained it to him in the best manner they were able. The explanation struck him, and set him a-musing on an astronomical phenomenon which he had been puzzled by for some years, and which he called the aberration of the fixed stars. Every star changes its place a small matter for half a year, and returns to it at the completion of the year. He compared the stream of light from the star to the wind, and the telescope of the astronomer to the ship's vane, while the earth was like the ship, moving in opposite directions when in the opposite point of its orbit. The telescope must always be pointed ahead of the real direction of the star, in the same manner as the vane is always in a direction ahead of the wind; and thus he ascertained the progressive motion of light, and discovered the proportion of its velocity to the velocity of the earth in its orbit, by observing the deviation which was necessarily given to the telescope. Observing that the light shifted its direction about 40″, he concluded its velocity to be about 11,000 times greater than that of the earth; just as the intelligent seaman would conclude from this apparent shifting of the wind, that the velocity of the wind is about triple that of the ship. This is indeed the best method for discovering the velocity of the wind. Let the direction of the vane at the mast-head be very accurately noticed on both tacks, and let the velocity of the ship be also accurately measured. The angle between the directions of the ship's head on these different tacks being halved, will give the real direction of the wind, which must be compared with the position of the vane in order to determine the angle contained between the real and apparent directions of the wind or the angle ECe; or half of the observed shifting of the wind

Observation of Dr Bradley on this subject.

will show the inclination of its true and apparent directions. This being found, the proportion of EC to FC (fig. 6) is easily measured.

We have been very particular on this point, because since the mutual actions of bodies depend on their relative motions only, we should make prodigious mistakes if we estimated the action of the wind by its real direction and velocity, when they differ so much from the relative or apparent.

Velocity of a ship when its sails are at right angles to the keel.

We now resume the investigation of the velocity of the ship (fig. 4), having its sails at right angles to the keel, and the wind blowing in the direction and with the velocity CE, while the ship proceeds in the direction of the keel with the velocity CF. Produce E*e*, which is parallel to BC, till it meet the yard in *g*, and draw FG perpendicular to E*g*. Let *a* represent the angle WCD, contained between the sail and the real direction of the wind, and let *b* be the angle of trim DCB. CE, the velocity of the wind, was expressed by V, and CF, the velocity of the ship, by *v*.

The absolute impulse on the sail is (by the usual theory) proportional to the square of the relative velocity, and to the square of the sine of the angle of incidence; that is, to $FE^2 \times \sin^2 w\mathrm{CD}$. Now the angle $\mathrm{GFE} = w\mathrm{CD}$, and EG is equal to $\mathrm{FE} \times \sin \mathrm{GFE}$; and EG is equal to $\mathrm{E}g - \mathrm{G}g$. But $\mathrm{E}g = \mathrm{EC} \times \sin \mathrm{EC}g, = \mathrm{V} \times \sin a$; and $g\mathrm{G} = \mathrm{CF}, = v$. Therefore $\mathrm{EG} = \mathrm{V} \times \sin a - v$, and the impulse is proportional to $(\mathrm{V} \times \sin a - v)^2$. If S represent the surface of the sail, the impulse, in pounds, will be $n\mathrm{S}\,(\mathrm{V} \times \sin a - v)^2$.

Let A be the surface which, when it meets the water perpendicularly with the velocity *v*, will sustain the same pressure or resistance which the bows of the ship actually meet with. This impulse, in pounds, will be $m\mathrm{A}v^2$. Therefore, because we are considering the ship's motion as in a state of uniformity, the two pressures balance each other; and therefore $m\mathrm{A}v^2 = n\mathrm{S}(\mathrm{V} \times \sin a - v)^2$ and $\frac{m}{n}\mathrm{A}v^2 = \mathrm{S}(\mathrm{V} \times \sin a - v)^2$; therefore $\sqrt{\frac{m}{n}}\sqrt{\mathrm{A}} \times v = \sqrt{\mathrm{S}} \times \mathrm{V} \times \sin a - v\sqrt{\mathrm{S}}$, and $v =$

$$\frac{\sqrt{\mathrm{S}} \times \mathrm{V} \times \sin a}{\sqrt{\frac{m}{n}\mathrm{A}} + \sqrt{\mathrm{S}}} = \frac{\mathrm{V} \times \sin a}{\sqrt{\frac{m\mathrm{A}}{n\mathrm{S}}} + 1} = \frac{\mathrm{V} \times \sin a}{\sqrt{q\frac{\mathrm{A}}{\mathrm{S}}} + 1}.$$

We see, in the first place, that the velocity of the ship is, *cæteris paribus*, proportional to the velocity of the wind, and to the sine of its incidents on the sail jointly; for while the surface of the sail S and the equivalent surface for the bow remains the same, *v* increases or diminishes at the same rate with $\mathrm{V} \cdot \sin.\ a$. When the wind is right astern, the sine of *a* is unity, and then the ship's velocity is $\frac{\mathrm{V}}{\sqrt{\frac{m\mathrm{A}}{n\mathrm{S}}} + 1}$.

Note, that the denominator of this fraction is a common number; for *m* and *n* are numbers and A and S being quantities of one kind, $\frac{\mathrm{A}}{\mathrm{S}}$ is also a number.

It must also be carefully attended to, that S expresses a quantity of sail actually receiving wind with the inclination *a*. It will not always be true, therefore, that the velocity will increase as the wind is more abaft, because some sails will then becalm others. This observation is not, however, of great importance; for it is very unusual to put a ship in the situation considered hitherto; that is, with the yards square, unless she be right before the wind.

If we should discover the relation between the velocity and the quantity of sail in this simple case of the wind right aft, observe that the equation $v = \frac{\mathrm{V}}{\sqrt{\frac{m\mathrm{A}}{n\mathrm{S}}} + 1}$ gives us $\sqrt{\frac{m\mathrm{A}}{n\mathrm{S}}}\,v + v = \mathrm{V}$, and $\sqrt{\frac{m\mathrm{A}}{n\mathrm{S}}}\,v = \mathrm{V} - v$, and $\frac{m\mathrm{A}}{n\mathrm{S}}v^2 = \overline{\mathrm{V} - v}^2$, and $\frac{n\mathrm{S}}{m\mathrm{A}} = \frac{v^2}{(\mathrm{V} - v)^2}$; and because *n* and *m* and A are constant quantities, S is proportional to $\frac{v^2}{(\mathrm{V} - v)^2}$, or the surface of sail is proportional to the square of the ship's velocity directly, and to the square of the relative velocity inversely. Thus, if a ship be sailing with one-eighth of the velocity of the wind, and we would have her sail with one-fourth of it, we must quadruple the sail. This is more easily seen in another way. The velocity of the ship is proportional to the velocity of the wind; and therefore the relative velocity is also proportional to that of the wind, and the impulse of the wind is as the square of the relative velocity. Therefore, in order to increase the relative velocity by an increase of sail only, we must make this increase of sail in the duplicate proportion of the increase of velocity.

Let us, in the next place, consider the motion of a ship whose sails stand oblique to the keel.

Its velocity when the sails stand oblique to the keel.

The construction for this purpose differs a little from the former, because, when the sails are trimmed to any oblique position DCB (figs. 5 and 6), there must be a deviation from the direction of the keel, or a leeway BC*b*. Call this *x*. Let CF be the velocity of the ship. Draw, as before, E*g* perpendicular to the yard, and FG perpendicular to E*g*; also, draw FH perpendicular to the yard; then, as before, EG, which is in the subduplicate ratio of the impulse on the sail, is equal to E*g*—G*g*. Now E*g* is, as before, $= \mathrm{V} \times \sin a$, and G*g* is equal to FH, which is $= \mathrm{CF} \times \sin\ \mathrm{FCH}$, or $= v \times \sin\ (b + x)$. Therefore we have the impulse $= n\mathrm{S}(\mathrm{V} \cdot \sin a - v \cdot \sin\ (b + x))^2$.

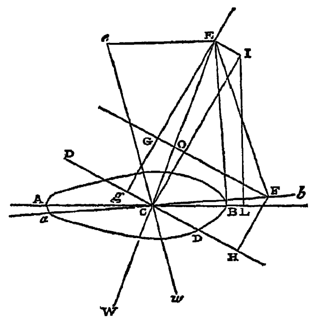

Fig. 5.

This expression of the impulse is perfectly similar to that in the former case, its only difference consisting in the subductive part, which is here $v \times \sin \overline{b + x}$ instead of *v*. But it expresses the same thing as before, viz., the diminution of the impulse. The impulse being reckoned solely in the direction perpendicular to the sail, it is diminished solely by the sail withdrawing itself *in that direction* from the wind; and as *g*E may be considered as the real impulsive motion of the wind, GE must be considered as the relative and effective impulsive motion. The impulse would have been the same had the ship been at rest, and had the wind met it perpendicularly with the velocity GE.

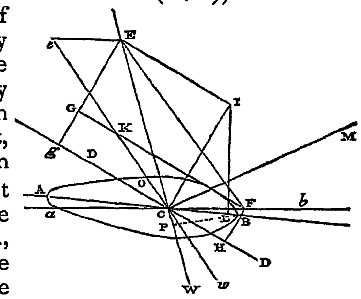

Fig. 6.

Connection between the impulse and motion of the ship.

We must now show the connection between this impulse and the motion of the ship. The sail, and consequently the ship, is pressed by the wind in the direction CI perpendicular to the sail or yard with the force which we have just now determined. This (in the state of uniform motion) must be equal and opposite to the action of the water. Draw IL at right angles to the keel. The impulse in the direction CI (which we may measure by CI) is equivalent to the impulses CL and LI. By the first the ship is impelled right forward, and by the second she is driven side-

ways. Therefore we must have a leeway, and a lateral as well as a direct resistance. We suppose the form of the ship to be known, and therefore the proportion is known, or discoverable, between the direct and lateral resistances corresponding to every angle x of leeway. Let A be the surface whose perpendicular resistance is equal to the direct resistance of the ship corresponding to the leeway x, that is, whose resistance is equal to the resistance really felt by the ship's bows in the direction of the keel when she is sailing with this leeway; and let B in like manner be the surface whose perpendicular resistance is equal to the actual resistance to the ship's motion in the direction LI, perpendicular to the keel. (This is not equivalent to A′ and B′ adapted to the rectangular box, but to $A' \cdot \cos.^2 x$ and $B' \cdot \sin.^2 x$). We have therefore A : B = CL : LI, and $LI = \frac{CL \cdot B}{A}$. Also, because $CI = \sqrt{CL^2 + LI^2}$, we have $A : \sqrt{A^2+B^2} = CL : CI$, and $CI = \frac{CL \cdot \sqrt{A^2+B^2}}{A}$. The resistance in the direction LC is properly measured by $m A v^2$, as has been already observed. Therefore the resistance in the direction IC must be expressed by $m\sqrt{A^2+B^2}|v^2$; or (making C the surface which is equal to $\sqrt{A^2+B^2}$, and which will therefore have the same perpendicular resistance to the water having the velocity v) it may be expressed by mCv^2.

Therefore, because there is an equilibrium between the impulse and resistance, we have $mCv^2 = nS(V \cdot \sin a - v \cdot \sin \overline{b+x})^2$, and $\frac{m}{n} Cv^2$, or $qCv^2 = S(V \cdot \sin a - v \cdot \sin \overline{b+x})^2$ and $\sqrt{q}\sqrt{C}v = \sqrt{S}(V \cdot \sin a - v \cdot \sin \overline{b+x})$.

Therefore $v = \frac{\sqrt{S} \cdot V \cdot \sin a}{\sqrt{q}\sqrt{C} + \sqrt{S} \cdot \sin \overline{b+x}}, = \frac{V \cdot \sin a}{\sqrt{q}\frac{\sqrt{C}}{\sqrt{S}} + \sin \overline{b+x}} = V \frac{\text{Sin } a}{\sqrt{q}\frac{\sqrt{C}}{\sqrt{S}} + \sin \overline{b+x}}$.

Observe that the quantity which is the co-efficient of V in this equation is a common number; for sin. a is a number, being a decimal fraction of the radius 1, $\sin \overline{b+x}$ is also a number, for the same reason. And since m and n were numbers of pounds, $\frac{m}{n}$ or q is a common number. And because C and S are surfaces, or quantities of one kind, $\frac{C}{S}$ is also a common number.

This is the simplest expression that we can think of for the velocity acquired by the ship, though it must be acknowledged to be too complex to be of very prompt use. Its complication arises from the necessity of introducing the leeway x. This affects the whole of the denominator; for the surface C depends on it, because C is $= \sqrt{A^2+B^2}$, and A and B are analogous to $A' \cos {}^2x$ and $B' \sin {}^2x$.

Important consequences deduced from the foregoing theorem.

But we can deduce some important consequences from this theorem.

While the surface S of the sail actually filled by the wind remains the same, and the angle DCB, which in future we shall call the trim of the sails, also remains the same, both the leeway x and the substituted surface C remains the same. The denominator is therefore constant; and the velocity of the ship is proportional to $\sqrt{S} \cdot V \cdot \sin a$; that is, directly as the velocity of the wind, directly as the absolute inclination of the wind to the yard, and directly as the square root of the surface of the sails.

We also learn from the construction of the figure, that FG parallel to the yard cuts CE in a given ratio. For CF is in a constant ratio to Eg, as has been just now demonstrated. And the angle DCF is constant. Therefore CF · sin b, or FH or Gg, is proportional to Eg, and OC to EC, or EC is cut in one proportion, whatever may be the angle ECD, so long as the angle DCF is constant.

We also see that it is very possible for the velocity of the ship on an oblique course to exceed that of the wind. This will be the case when the number $\frac{\sin a}{\sqrt{q\frac{C}{S}} + \sin \overline{b+x}}$ exceeds unity, or when sin a is greater than $\sqrt{q\frac{C}{S}} + \sin \overline{b+x}$. Now this may easily be by sufficiently enlarging S and diminishing $b+x$. It is indeed frequently seen in fine sailers with all their sails set and not hauled too near the wind.

We remarked above that the angle of leeway x affects the whole denominator of the fraction which expresses the velocity. Let it be observed that the angle ICL is the complement of LCD, or of b. Therefore, CL : LI, or A : B = 1 : tan ICL = 1 : cot b, and B = A · cotan b. Now A is equivalent to $A' \cdot \cos^2 x$, and thus b becomes a function of x. C is evidently so, being $\sqrt{A^2+B^2}$. Therefore before the value of this fraction can be obtained, we must be able to compute, by our knowledge of the form of the ship, the value of A for every angle x of leeway. This can be done only by resolving her bows into a great number of elementary planes, and computing the impulses on each and adding them into one sum. The computation is of immense labour, as may be seen by one example given by Bouguer. When the leeway is but small, not exceeding ten degrees, the substitution of the rectangular prism of one determined form is abundantly exact for all leeways contained within this limit; and we shall soon see reason for being contented with this approximation. We may now make use of the formula expressing the velocity for solving the chief problems in this part of the seaman's task.

Problem I. To determine the best position of the sails for standing on a given course, when the direction and velocity of the wind and its angle with the course are given.

And first let it be required to determine the best position of the sail for standing on a given course ab, when CE the direction and velocity of the wind, and its angle with the course WCF, are given. This problem has exercised the talents of the mathematicians ever since the days of Newton. The best plan of solving this problem will be to place the yard CD in such a position that the tangent of the angle FCD may be one half of the tangent of the angle DCW. This will indeed be the best position of the sail for beginning the motion; but as soon as the ship begins to move in the direction CF, the effective impulse of the wind is diminished, and also its inclination to the sail. The angle DCw diminishes continually as the ship accelerates; for CF is now accompanied by its equal eE, and by an angle ECe, or WCw. CF increases, and the impulse on the sail diminishes, till an equilibrium obtains between the resistance of the water and the impulse of the wind. The impulse is now measured by $CE^2 \times \sin^2 eCD$ instead of $CE^2 \times \sin^2 ECD$, that is, by EG^2 instead of Eg^2.

This introduction of the relative motion of the wind renders the actual solution of the problem extremely difficult. It is very easily expressed geometrically: Divide the angle wCF in such a manner that the tangent of DCF may be half of the tangent of DCw, and the problem may be constructed geometrically as follows:—

Let WCF (fig. 7) be the angle between the sail and course. Round the centre C describe the circle WDFY; produce WC to Q, so that $CQ = \frac{1}{3}WC$, and draw QY parallel to CF cutting the circle in Y; bisect the arch WY in D, and draw DC. DC is the proper position of the yard.

Draw the cord WY, cutting CD in V and CF in T; draw the tangent PD, cutting CF in S and CY in R.

It is evident that WY, PR, are both perpendicular to CD, and are bisected in V and D; therefore (by reason of

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the parallels QY, CF) 4 : 3 = QW : CW, = YW : TW, = RP : SP. Therefore PD : PS = 2 : 3, and PD : DS = 2 : 1. Q.E.D. But this division cannot be made to the best advantage till the ship has attained its greatest velocity, and the angle w CF has been produced.

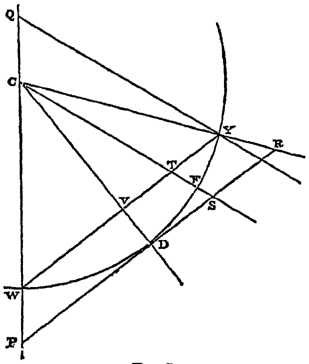

Fig. 7.

We must consider all the three angles, a, b, and x, as variable in the equation which expresses the value of v, and we must make the fluxion of this equation $=0$; then, by means of the equation $B = A \cdot$ cotan b, we must obtain the value of b and of $\dot{b}$ in terms of x and $\dot{x}$. With respect to a, observe, that if we make the angle WCF$=p$, we have $p = a + b + x$; and p being a constant quantity, we have $\dot{a} + \dot{b} + \dot{x} = 0$. Substituting for a, b, $\dot{a}$, and $\dot{b}$, their values in terms of x and $\dot{x}$, in the fluxionary equation $= 0$, we readily obtain x, and then a and b, which solves the problem.

Let it be required, in the next place, to determine the course and the trim of the sails most proper for plying to windward.

Prob. II. To determine the course and trim of the sails most proper for plying to windward.

In fig. 6, draw FP perpendicular to WC. CF is the motion of the ship; but it is only by the motion PC that she gains to windward. Now CP is = CF + cosin WCF, or $v \cdot$ cosin $(a + b + x)$. This must be rendered a maximum, as follows.

By means of the equation which expresses the value of v and the equation $B = A \cdot$ cotan b, we exterminate the quantities v and b; we then take the fluxion of the quantity into which the expression $v \cdot \cos(a + b + x)$ is changed by this operation. Making this fluxion $= 0$, we get the equation which must solve the problem. This equation will contain the two variable quantities a and x with their fluxions; then make the co-efficient of $\dot{x}$ equal to 0, also the co-efficient of $\dot{a}$ equal to 0. This will give two equations, which will determine a and x, and from this we get $b = p - a - x$.

Prob. III. To determine the best course and trim of the sails for getting away from a given line of coast.

Should it be required, in the third place, to find the best course and trim of the sails for getting away from a given line of coast CM (fig. 6), the process perfectly resembles this last, which is in fact getting away from a line of coast which makes a right angle with the wind. Therefore, in place of the angle WCF, we must substitute the angle WCM$\pm$WCF. Call this angle e. We must make $v \cos (e \pm a \pm b \pm x)$ a maximum. The analytical process is the same as the former, only e is here a constant quantity.

Observations on the preceding problems.

These are the three principal problems which can be solved by means of the knowledge that we have obtained of the motion of the ship when impelled by an oblique sail, and therefore making leeway; and they may be considered as an abstract of this part of M. Bouguer's work. We have only pointed out the process for this solution, and have even omitted some things taken notice of by M. Bezout in his very elegant compendium. Our reasons will appear as we go on. The learned reader will readily see the extreme difficulty of the subject, and the immense calculations which are necessary even in the simplest cases, and will grant that it is out of the power of any but an expert analyst to derive any use from them; but the mathematician can calculate tables for the use of the practical seaman. Thus he can calculate the best position of the sails for advancing in a course of 90° from the wind, and the velocity in that course; then for 85°, 80°, 75°, &c. M. Bouguer has given a table of this kind; but to avoid the immense difficulty of the process, he has adapted it to the apparent direction of the wind. We have inserted a few of his numbers, suited to such cases as can be of service, namely, when all the sails draw, or none stand in the way of others. Column 1st is the apparent angle of the wind and course; column 2d is the corresponding angle of the sails and keel; and column 3d is the apparent angle of the sails and wind.

M. Bouguer's table for finding the best position of the sails for advancing in any course.

1 w CF	2 DCB	3 wCD
103°53′	42°30′	61°23′
99 13	40 —	59 13
94 25	37 30	56 55
89 28	35 —	54 28
84 23	32 30	51 53
79 06	30 —	49 06
73 39	27 30	46 09
68 —	25 —	43 —

Inutility of these calculations.

In all these numbers we have the tangent of w CD double of the tangent of DCF. The above table will, we think, be found useful. Column 2 carries the calculation up to 25°, the angle of the yards with the keel; and although some modern ships may go beyond this, and brace their yards up to 23°, we consider 25° a fair average of what can be effected. Certainly the apparent direction of the wind is unknown to the seaman till the ship is sailing with uniform velocity. It is, however, of service to him to know, for instance, that when the angle of the vanes and yards is 56°, the yards should be braced up to 37° 30′. In that case the course would be 94° 25′, from the apparent direction of the wind, that is, with the wind apparently 4° 25′ abaft the beam; a good sailing ship in this position, with the water very smooth and the wind light, may acquire a velocity even exceeding that of the true wind. But the mathematician may require that the yards should be braced up to a smaller angle than is possible.

Let us see whether this restriction in power of bracing up, arising from necessity, leaves anything in our choice, and makes one course preferable to another. We see that there are a prodigious number of courses, and these the most usual and the most important, which we must hold with one trim of the sails; no doubt, sometimes sailing with the wind, even no further forward than the beam, must be performed with this unfavourable trim of the sails, as it must be in all cases if plying to windward. We are certain that the smaller we make the angle of incidence, real or apparent, the smaller will be the velocity of the ship; but it may happen that we shall gain more to windward, or get sooner away from a lee-coast, or any object of danger, by sailing slowly on one course than by sailing quickly on another.

We have seen that while the trim of the sails remains the same, the leeway and the angle of the yard and course remains the same, and that the velocity of the ship is as the sine of the angle of real incidence, that is, as the sine of the angle of the sail and the real direction of the wind.

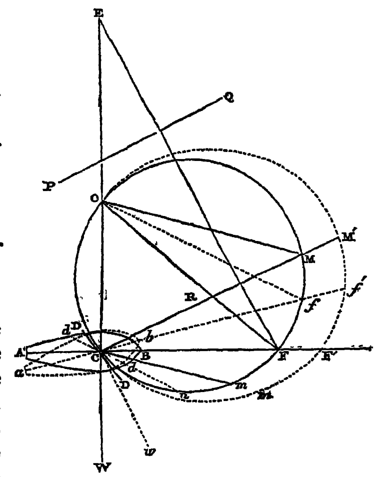

Fig. 8.

Let the ship AB (fig. 8) hold the course CF, with the wind blowing in the direction WC, and having her yards DCD braced up to the smallest angle BCD which the rigging can admit. Let CF be to CE as the velocity of the

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ship to the velocity of the wind; join FE and draw Cw parallel to EF; it is evident that FE is the relative motion of the wind, and wCD is the relative incidence on the sail.

Draw FO parallel to the yard DC, and describe a circle through the points COF; then we say that if the ship, with the same wind and the same trim of the same drawing sails, be made to sail on any other course Cf, her velocity along CF is to the velocity along Cf as CF is to Cf; or, in other words, the ship will employ the same time in going from C to any point of the circumference CFO.

Join fO. Then, because the angles CFO, CfO are on the same cord CO, they are equal, and fO is parallel to dCd, the new position of the yard corresponding to the new position of the keel ab, making the angle dCb=DCB. Also, by the nature of the circle, the line CF is to Cf as the sine of the angle CFO to the sine of the angle COf, that is (on account of the parallels CD, OF and Cd, Of), as the sine of WCD to the sine of WCd. But when the trim of the sails remains the same, the velocity of the ship is as the sine of the angle of the sail with the direction of the wind; therefore CF is to Cf as the velocity on CF to that on Cf, and the proposition is demonstrated.

To determine the best course for avoiding a rock.

Let it now be required to determine the best course for avoiding a rock R lying in the direction CR, or for withdrawing as fast as possible from a line of coast PQ. Draw CM through R, or parallel to PQ, and let m be the middle of the arch CmM. It is plain that m is the most remote from CM of any point of the arch CmM, and therefore the ship will recede farther from the coast PQ in any given time, by holding the course Cm than by any other course.

This course is easily determined; for the arch CmM $=360°$—(arch CO + arch OM), and the arch CO is the measure of twice the angle CFO, or twice the angle DCB, or twice $\overline{b+x}$, and the arch OM measures twice the angle ECM.

Thus, suppose the sharpest possible trim of the sails to be 35°, and the observed angle ECM to be 70°; then CO + OM is 70° + 140° or 210°. This being taken from 360°, leaves 150°, of which the half Mm is 75°, and the angle MCm is 37° 30′. This added to ECM makes ECm 170° 30′, leaving WCm=72° 30′, and the ship must hold a course making an angle of 72° 30′ with the real direction of the wind, and WCD will be 37° 30′.

This supposes no leeway. But if we know that under all the sail which the ship can carry with safety and advantage she makes 5 degrees of leeway, the angle DCm of the sail and course, or $b+x$, is 40°. Then CO + OM = 220°, which being taken from 360°, leaves 140°, of which the half is 70°, = Mm, and the angle MCm = 35°, and ECm = 105, and WCm = 75°, and the ship must lie with her head 70° from the wind, making 5 degrees of leeway, and the angle WCD is 35°.

The general rule for the position of the ship is, *that the line on shipboard which bisects the angle* b + x *may also bisect the angle* WCM, or make the angle between the course and the line, from which we wish to withdraw, equal to the angle between the sail and the real direction of the wind.

Corollaries.

It is plain that this problem includes that of plying to windward. We have only to suppose ECM to be 90°; then, taking our example in the same ship, with the same trim and the same leeway, we have $b+x=40°$. This taken from 90° leaves 50°, and WCn = 90—25 = 65, and the ship's head must lie 60° from the wind, and the yard must be 25° from it.

It must be observed here, that it is not always eligible to select the course which will remove the ship fastest from the given line CM; it may be more prudent to remove from it more securely though more slowly. In such cases the procedure is very simple, viz., to shape the course as near the wind as is possible.

The reader will also easily see that the propriety of these practices is confined to those courses only where the practicable trim of the sails is not sufficiently sharp. Whenever the course lies so far from the wind that it is possible to make the tangent of the apparent angle of the wind and sail double the tangent of the sail and course, it should be done.

The adjustment of the sails supposed in the theory impracticable.

These are the chief practical consequences which can be deduced from the theory. But we should consider how far this adjustment of the sails and course can be performed. And here occur difficulties so great as to make it almost impracticable. We have always supposed the position of the surface of the sail to be distinctly observable and measurable; but this can be hardly affirmed even with respect to a sail stretched on a yard. Here we supposed the surface of the sail to have the same inclination to the keel that the yard has. This is by no means the case; the sail assumes a concave form, of which it is almost impossible to assign the direction of the mean impulse. We believe that this is always considerably to leeward of a perpendicular to the yard, lying between CI and CE (fig. 6). This is of some advantage, being equivalent to a sharper trim. We cannot affirm this, however, with any confidence, because it renders the impulse on the weather-leech of the sail so exceedingly feeble as hardly to have any effect. In sailing close to the wind, the ship is kept so near that the weather-leech of the sail is almost ready to receive the wind edgewise, and to flutter or shiver. The most effective or drawing sails with a side-wind, especially when plying to windward, are the trysails. We believe that it is impossible to say, with anything approaching to precision, what is the position of the general surface of a staysail, or to calculate the intensity and direction of the general impulse; and we affirm with confidence that no man can pronounce on these points with any exactness. If we can guess within a third or a fourth part of the truth, it is all we can pretend to; and after all, it is but a guess. Add to this, the sails coming in the way of each other, and either becalming them or sending the wind upon them in a direction widely different from that of its free motion. All these points we think beyond our power of calculation, and therefore that it is in vain to give the seaman mathematical rules, or even tables of adjustment ready calculated; since he can neither produce that medium position of his sails that is required, nor tell what is the position which he employs.

This is one of the principal reasons why so little advantage has been derived from the very ingenious and promising disquisitions of Bouguer and other mathematicians.

We subjoin an abstract of the experiments made by the Royal Academy of Sciences at Paris. Column 1st gives the angle of incidence; column 2d gives the impulsions really observed; column 3d the impulses, had they followed the duplicate ratio of the sines; and column 4th the impulses, if they were in the simple ratio of the sines.

Angle of incid.	Impulsion observed.	Impulse as sine.^{2}	Impulse as sine.
90°	1000	1000	1000
84	989	989	995
78	958	957	978
72	908	905	951
66	845	835	914
60	771	750	866
54	693	655	809
48	615	552	743
42	543	448	669
36	480	346	587
30	440	250	500
24	424	165	407
18	414	96	309
12	406	43	208
6	400	11	105

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The theory erroneous, and the deductions useless.

Here we see an enormous difference in the great obliquities. When the angle of incidence is only six degrees, the observed impulse is forty times greater than the theoretical impulse; at 12° it is ten times greater; at 18° it is more than four times greater; and at 24° it is almost three times greater.

No wonder then that the deductions from this theory are so useless and so unlike what we familiarly observe. We took notice of this when we were considering the leeway of a rectangular box, and thus saw a reason for admitting an incomparably smaller leeway than what would result from the laborious computations necessary by the theory. This error in theory has as great an influence on the impulsions of air when acting obliquely on a sail; and the experiments of Mr Robins and of the Chevalier Borda, on the oblique impulsions of air, are perfectly conformable (as far as they go) to those of the academicians on water. The oblique impulsions of the wind are therefore much more efficacious for pressing the ship in the direction of her course than the theory allows us to suppose; and the progress of a ship plying to windward is much greater, both because the oblique impulses of the wind are more effective, and because the leeway is much smaller, than we suppose. Were not this the case, it would be impossible for a square-rigged ship to get to windward. The impulse on her sails, when close hauled, would be so trifling, that she would not have a third part of the velocity which we see her acquire: and this trifling velocity would be wasted in leeway; for we have seen that the diminution of the oblique impulses of the water is accompanied by an increase of leeway. But we see that in the great obliquities the impulsions continue to be very considerable, and that even an incidence of 6° gives an impulse as great as the theory allows to an incidence of 40°. We may, therefore, on all occasions keep the yards more square; and the loss which we sustain by the diminution of the very oblique impulse will be more than compensated by its more favourable direction with respect to the ship's keel. Let us take an example of this. Suppose the wind about two points before the beam, making an angle of 68° with the keel. The theory assigns 43° for the inclination of the wind to the sail, and 15° for the trim of the sail. The perpendicular impulse being supposed 1000, the theoretical impulse for 45° is 465. This reduced in the proportion of radius to the sine of 25°, gives the impulse in the direction of the course only 197.

But if we ease off the lee-braces till the yard makes an angle of 50° with the keel, and allows the wind an incidence of no more than 18°, we have the experimented impulse 414, which, when reduced in the proportion of radius to the sine of 50°, gives an effective impulse 317. In like manner, the trim 56°, with the incidence 12°, gives an effective impulse 337; and the trim of 62°, with the incidence only 6°, gives 353.

Hence it would at first sight appear that the angle DCB of 62° and WCD of 6° would be better for holding a course within six points of the wind than any more oblique position of the sails; but it will only give a greater initial impulse. As the ship accelerates, the wind apparently comes ahead, and we must continue to brace up as a ship freshens her way. It is not unusual for her to acquire half or two-thirds of the velocity of the wind; in which case the wind comes apparently ahead more than two points, when the yards must be braced up to 35°, and thus allows an impulse no greater than about 7°. Now, this is very frequently observed in good ships, which, in a brisk gale and smooth water, will go five or six knots close-hauled, the ship's head six points from the wind, and the sails no more than just full, but ready to shiver by the smallest luff. All this would be impossible by the usual theory; and in this respect these experiments of the French Academy give a fine illustration of the seaman's practice. They account for what we should otherwise be much puzzled to explain; and the great progress which is made by a ship close-hauled being perfectly agreeable to what we should expect from the law of oblique impulsions, deducible from these so often-mentioned experiments, while it is totally incompatible with the common theory, should make us abandon the theory without hesitation, and strenuously set about the establishment of another, founded entirely on experiments.

Experiments proper for establishing another.

For this purpose the experiments should be made on the oblique impulsions of air, on as great a scale as possible, and in as great a variety of circumstances, so as to furnish a series of impulsions for all angles of obliquity. We have but four or five experiments on this subject, viz., two by Mr Robins, and two or three by the Chevalier Borda. Having thus gotten a series of impulsions, it is very practicable to raise on this foundation a practical institute, and to give a table of the velocities of a ship suited to every angle of inclination and of trim; for nothing is more certain than the resolution of the impulse perpendicular to the sail into a force in the direction of the keel, and a lateral force.

We are also disposed to think that experiments might be made on a model very nicely rigged with sails, and trimmed in every different degree, which would point out the mean direction of the impulse on the sails, and the comparative force of these impulses on different directions of the wind. The method would be very similar to that for examining the impulse of the water on the hull. If this can also be ascertained experimentally, the intelligent reader will easily see that the whole motion of a ship under sail may be determined for every case. Tables may then be constructed by calculation, or by graphical operations, which will give the velocities of a ship in every different course, and corresponding to every trim of sail. And let it be here observed, that the trim of the sail is not to be estimated in degrees of inclination of the yards; because, as we have already remarked, we cannot observe nor adjust the fore and aft sails in this way. But, in making the experiments for ascertaining the impulse, the exact position of the tacks and sheets of the sails are to be noted; and this combination of adjustments is to pass by the name of a certain trim. Thus that trim of all the sails may be called 40, whose direction is experimentally found equivalent to a flat surface trimmed to the obliquity 40°.

Having done this, we may construct a figure for each trim similar to fig. 8, where, instead of a circle, we shall have a curve COM'F', whose cords CF', cf', &c., are proportional to the velocities in these courses; and by means of this curve we can find the point m', which is most remote from any line CM from which we wish to withdraw; and thus we may solve all the principal problems of the art.

We hope that it will not be accounted presumption in us to expect more improvement from a theory founded on judicious experiments only, than from a theory of the impulse of fluids, which is found so inconsistent with observation, and of whose fallacy all its authors, from Newton to D'Alembert, entertained strong suspicions.

With those observations we conclude our discussion of the first part of the seaman's task, and now proceed to consider the means that are employed to prevent or to produce any deviations from the uniform rectilineal course which has been selected.

Means employed to prevent or produce deviations from a course.

Here the ship is to be considered as a body in free space, convertible round her centre of inertia. For whatever may be the point round which she turns, this motion may always be considered as compounded of a rotation round an axis passing through her centre of gravity or inertia. She is impelled by the wind and by the water acting on many surfaces differently inclined to each other, and the impulse on each is perpendicular to the surface. In order, therefore, that she may continue steadily in one course, it is not only necessary that the impelling forces, estimated in their

mean direction, be equal and opposite to the resisting forces estimated in their mean direction; but also that these two directions may pass through one point, otherwise she will be affected as a log of wood is when pushed in opposite directions by two forces, which are equal indeed, but are applied to different parts of the log. A ship must be considered as a lever, acted on in different parts by forces in different directions, and the whole balancing each other round that point or axis where the equivalent of all the resisting forces passes. This may be considered as a point supported by this resisting force and as a sort of fulcrum; therefore, in order that the ship may maintain her position, the energies or *momenta* of all the impelling forces round this point must balance each other.

Impulses on a ship sailing right before the wind different from those on her when sailing obliquely.

When a ship sails right afore the wind, with her yards square, it is evident that the impulses on each side of the keel are equal, as also their mechanical *momenta* round any axis passing perpendicularly through the keel. So are the actions of the water on her bows. But when she sails on an oblique course, with her yards braced on either side, she sustains a pressure in the direction CI (fig. 5) perpendicular to the sail. This, by giving her a lateral pressure LI, as well as a pressure CL ahead, causes her to make leeway, and to move in a line C*b* inclined to CB. By this means the balance of action on the two bows is destroyed, the general impulse on the lee-bow is increased, and that on the weather-bow is diminished. The combined impulse is therefore no longer in the direction BC, but (in the state of uniform motion) in the direction IC.

Suppose that in an instant the whole sails are annihilated and the impelling pressure CI, which precisely balanced the resisting pressure on her bows, removed. The ship tends, by her inertia, to proceed in the direction C*b*. This tendency produces a continuation of the resistance in the opposite direction IC, which is not directly opposed to the tendency of the ship in the direction C*b*; therefore the ship's head would immediately come up to the wind. The experienced seaman will recollect something like this when the sails are suddenly lowered when coming to anchor. It does not happen solely from the obliquity of the action on the bows. It would happen to the parallelopiped of fig. 2, which was sustaining a lateral impulsion $B\cdot\sin^2 x$, and a direct impulsion $A\cdot\cos^2 x$. These are continued for a moment after the annihilation of the sail; but being no longer opposed by a force in the direction CD, but by a force in the direction C*b*, the force $B\cdot\sin^2 x$ must prevail, and the body is not only retarded in its motion, but its head turns towards the wind. But this effect of the leeway is greatly increased by the curved form of the ship's bows. This occasions the centre of effort of all the impulsions of the water on the leeside of the ship to be very far forward, and this so much the more remarkably as she is sharper afore. It is in general not much abaft the foremast. Now the centre of the ship's tendency to continue her motion is the same with her centre of gravity, and this is generally but a little before the mainmast. She is therefore in the same condition nearly as if she were pushed at the mainmast in a direction parallel to C*b*, and at the foremast by a force parallel to IC. The evident consequence of this is a tendency to come up to the wind. This is independent of all situation of the sails, provided only that they have been trimmed obliquely.

In the generality of ships sailing in smooth water, there is a tendency in their heads to approach the wind, which must be counteracted by keeping the helm a little a-weather. This tendency is greatest in ships that are sharp forward. This circumstance is easily understood. Whatever is the direction of the ship's motion, the absolute impulse on that part of the bow immediately contiguous to B is perpendicular to that very part of the surface. The more acute, therefore, that the angle of the bow is, the more will the impulse on that part be perpendicular to the keel, and the greater will be its energy to turn the head to windward.

Propriety of the disposition of the sails of a ship.

Thus we are enabled to understand or to see the propriety of the disposition of the sails of a ship. We see her crowded with sails forward, and even many sails extended far before her bow, such as the fore-topmast staysail, the jib, and flying jib. The sails abaft are comparatively smaller. The sails on the mizenmast are much smaller than those on the foremast. All the staysails hoisted on the mainmast may be considered as headsails, because their centres of effort are considerably before the centre of gravity of the ship; and notwithstanding this disposition, it generally requires a small action of the rudder to counteract the windward tendency of the lee-bow. This is considered as a good quality when moderate, because it enables the seaman to throw the sails aback, and stop the ship's way in a moment, if she be in danger from anything ahead; and the ship which does not carry a little of a weather helm is always a dull sailer.

Action of the water and the sails.

In order to judge somewhat more accurately of the action of the water and sails, suppose the ship AB (fig. 9) to have its sails on the mizenmast D, the mainmast E, and the foremast F, braced up or trimmed alike, and the three lines D *i*, E *e*, F *f*, perpendicular to the sails, are in the proportion of the impulses on the sails. The ship is driven ahead and to leeward, and moves in the path *a*C*b*. This path is so inclined to the line of the keel, that the medium direction of the resistance of the water is parallel to the direction of the impulse. A line CI may be drawn parallel to the lines D *i*, E *e*, F *f*, and equal to their sum; and it may be drawn from such a point C, that the actions on all the parts of the hull between C and B may balance the *momenta* of all the actions on the hull between C and A. This point may justly be called the *centre of effort*, or the *centre of resistance*. We cannot determine this point for want of a proper theory of the resistance of fluids. Nay, although experiments like those of the Parisian Academy should give us the most perfect knowledge of the intensity of the oblique impulses on a square foot, we should hardly be benefited by them; for the action of the water on a square foot of the hull at *p*, for instance, is so modified by the intervention of the stream of water which has struck the hull about B, and glided along the bow B *o p*, that the pressure on *p* is totally different from what it would have been were it a square foot or surface detached from the rest, and presented in the same position to the water moving in the direction *b*C. For it is found, that the resistances given to planes joined so as to form a wedge, or to curved surfaces, are widely different from the accumulated resistances calculated for their separate parts, agreeably to the experiments of the academy on single surfaces. We therefore do not attempt to ascertain the point C by theory; but it may be accurately determined by the experiments which we have so strongly recommended, and we offer this as an additional inducement for prosecuting them.

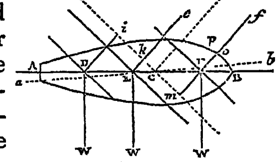

Fig. 9.

Centre of effort.

To be determined by experiments.

Draw through C a line perpendicular to CI, that is, parallel to the sails; and let the lines of impulse of the three sails cut in the points *i*, *k*, and *m*. This line *i m* may be considered as a lever, moveable round C, and acted on at the points *i*, *k*, and *m*, by three forces. The rotatory momentum of the sails on the mizenmast is $D\,i \times i\,C$; that of the sails on the mainmast is $E\,e \times k\,C$; and the momentum of the sails on the foremast is $F\,f \times m\,C$. The two first tend to press forward the arm C *i*, and then to turn the ship's head towards the wind. The action of the sails on the foremast tends to pull the arm C *m* forward, and produce a

contrary rotation. If the ship under these three sails keeps steadily in her course, without the aid of the rudder, we must have $Di \times iC + Ee \times kC = Ff \times mC$. This is very possible, and is often seen in a ship under her mizen-topsail, main-topsail, and fore-topsail, all parallel to one another, and their surfaces duly proportioned by reefing. If more sails are set, we must always have a similar equilibrium. A certain number of them will have their efforts directed from the larboard arm of the lever *i m* lying to leeward of CI, and a certain number will have their efforts directed from the starboard arm lying to windward of CI. The sum of the products of each of the first set, by their distances from C, must be equal to the sum of the similar products of the other set. As this equilibrium is all that is necessary for preserving the ship's position, and the cessation of it is immediately followed by a conversion; and as these states of the ship may be had by means of the three square sails only, when their surfaces are properly proportioned, it is plain that every movement may be executed and explained by their means. This will greatly simplify our future discussions. We shall therefore suppose in future that there are only the three topsails set, and that their surfaces are so adjusted by reefing, that their actions exactly balance each other round that point C of the middle line AB, where the actions of the water on the different parts of the ship's bottom in like manner balance each other. This point C may be differently situated in the ship according to the leeway she makes, depending on the trim of the sails; and, therefore, although a certain proportion of the three surfaces may balance each other in one state of leeway, they may happen not to do so in another state. But the equilibrium is evidently attainable in every case, and we therefore shall always suppose it.

Equilibrium preserved by the position of the sails.

Consequence of destroying it.

It must now be observed, that when this equilibrium is destroyed, as, for example, by turning the edge of the mizen-topsail to the wind, which the seamen call *shivering* the mizen-topsail, and which may be considered as equivalent to the removing the mizen-topsail entirely, it does not follow that the ship will turn round the point C, this point remaining fixed. The ship must be considered as a free body, still acted on by a number of forces, which no longer balance each other; and she must therefore *begin* to turn round a spontaneous axis of conversion, which must be determined in the way set forth in the article ROTATION. It is of importance to point out in general where this axis is situated. Therefore let G (fig. 10) be the centre of gravity of the ship. Draw the line q G v parallel to the yards, cutting D d in q, Ee in r, CI in t, and Ff in v. While the three sails are set, the line $q\,v$ may be considered as a lever acted on by four forces, viz., Dd, impelling the lever forward perpendicularly in the point q; Ee, impelling it forward in the point r; Ff, impelling it forward in the point v; and CI, impelling it backward in the point t. These forces balance each other both in respect of progressive motion and of rotatory energy; for CI was taken equal to the sum of Dd, Ee, and Ff; so that no acceleration or retardation of the ship's progress in her course is supposed.

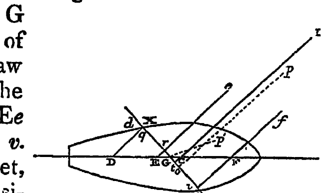

Fig. 10.

But by taking away the mizen-topsail, both the equilibriums are destroyed. A part Dd of the accelerating force is taken away; and yet the ship, by her inertia or inherent force, tends, for a moment, to proceed in the direction Cp with her former velocity: and by this tendency exerts for a moment the same pressure CI on the water, and sustains the same resistance IC. She must therefore be retarded in her motion by the excess of the resistance IC over the remaining impelling forces Ee and Ff; that is, by a force equal and opposite to Dd. She will therefore be retarded in the same manner as if the mizen-topsail were still set, and a force equal and opposite to its action were applied to G, the centre of gravity, and she would soon acquire a smaller velocity, which would again bring all things into equilibrium; and she would stand on in the same course, without changing either her leeway or the position of her head.

But the equilibrium of the lever is also destroyed. It is now acted on by three forces only, viz., Ee and Ff, impelling it forward in the points r and v, and IC impelling it backward in the point t. Make $rv : ro = \text{E}e + \text{F}f : \text{F}f$, and make $o\,p$ parallel to CI and equal to Ee + Ff. Then we know, from the common principles of mechanics, that the force $o\,p$ acting at o will have the same momentum or energy to turn the lever round *any* point whatever as the two forces Ee and Ff applied at r and v; and now the lever is acted on by two forces, viz., IC, urging it backwards in the point t, and $o\,p$ urging it forwards in the point o. It must therefore turn round like a floating log, which gets two blows in opposite directions. If we now make $\text{IC}-op : op = to : tx$, or $\text{IC}-op : \text{IC} = to : ox$, and apply to the point x a force equal to IC—$o\,p$ in the direction IC; we know by the common principles of mechanics, that this force IC—$o\,p$ will produce the same rotation round any point as the two forces IC and $o\,p$ applied in their proper directions at t and o. Let us examine the situation of the point x.

The force IC—$o\,p$ is evidently = D d, and $o\,p$ is = Ee + Ff. Therefore $ot : tx = \text{D}d : op$. But because, when all the sails were filled, there was an equilibrium round C, and therefore round t, and because the force $o\,p$ acting at o is equivalent to E e and F f acting at r and v, we must still have the equilibrium; and therefore we have the momentum $\text{D}d \times qt = op \times ot$. Therefore $ot : tq = \text{D}d : op$, and $tq = tx$. Therefore the point x is the same with the point q.

By shivering the mizen-topsail.

Therefore, when we shiver the mizen-topsail, the rotation of the ship is the same as if the ship were at rest, and if a force equal and opposite to the action of the mizen-topsail were applied at q or at D, or any point on the line D q.

This might have been shown in another and shorter way. Suppose all sails filled, the ship is in equilibrio. This will be disturbed by applying to D a force opposite to D d; and if the force be also equal to D d, it is evident that these two forces destroy each other, and that this application of the force d D is equivalent to the taking away of the mizen-topsail. But we chose to give the whole mechanical investigation; because it gave us an opportunity of pointing out to the reader, in a case of very easy comprehension, the precise manner in which the ship is acted on by the different sails and by the water, and what share each of them has in the motion ultimately produced. We shall not repeat this manner of procedure in other cases, because a little reflection on the part of the reader will now enable him to trace the *modus operandi* through all its steps.

We now see that, in respect both of progressive motion and of conversion, the ship is affected by shivering the sail D, in the same manner as if a force equal and opposite to D d were applied at D, or at any point in the line D d.

Let p represent a particle of matter, r its radius vector, or its distance p G from an axis passing through the centre of gravity G, and let M represent the whole quantity of matter of the ship. Then its momentum of inertia is $= \int p\,r^2$. The ship, impelled in the point D by a force in the direction dD, will begin to turn round a spontaneous vertical axis, passing through a point S of the line q G, which is drawn through the centre of gravity G, perpendicular to the direction dD of the external force, and the distance GS of this axis from the centre of gravity is $= \dfrac{\int p\,r^2}{\text{M}\cdot\text{G}q}$, and it is taken on the opposite side of G from q, that is, S and q are on opposite sides of G.

Let us express the external force by the symbol F. It is equivalent to a certain number of pounds, being the pressure of the wind moving with the velocity V and inclination a on the surface of the sail D; and may therefore be computed either by the theoretical or experimental law of oblique impulses. Having obtained this, we can ascertain the angular velocity of the rotation and the absolute velocity of any given point of the ship by means of the theorems established in the article ROTATION.

Action of the rudder.

But before we proceed to this investigation, we shall consider the action of the rudder, which operates precisely in the same manner. Let the ship AB (fig. 11) have her rudder in the position AD, the helm being hard a-starboard, while the ship sailing on the starboard tack, and making leeway, keeps on the course ab. The lee surface of the rudder meets the water obliquely. The very foot of the rudder meets it in the direction DE parallel to $a\,b$. The parts farther up meet it with various obliquities, and with various velocities, as it glides round the bottom of the ship and falls into the wake. It is absolutely impossible to calculate the accumulated impulse. We shall not be far mistaken in the deflection of each contiguous filament, as it quits the bottom and glides along the rudder; but we neither know the velocity of these filaments, nor the deflection and velocity of the filaments gliding without them. We therefore imagine that all computations on the subject are in vain. But it is enough for our purpose that we know the direction of the absolute pressure which they exert on its surface. It is in the direction D d, perpendicular to that surface. We also may be confident that this pressure is very considerable, in proportion to the action of the water on the ship's bows, or of the wind on the sails; and we may suppose it to be nearly in the proportion of the square of the velocity of the ship in her course; but we cannot affirm it to be accurately in that proportion, for reasons that will readily occur to one who considers the way in which the water falls in behind the ship.

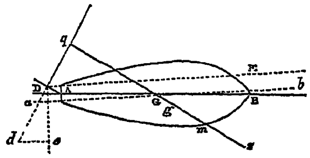

Fig. 11.

Greatest in a fine sailer.

It is observed, however, that a fine sailer always steers well, and that all movements by means of the rudder are performed with great rapidity when the velocity of the ship is great. We shall see by and by, that the speed with which the ship performs the angular movements is in the proportion of her progressive velocity: for we shall see that the squares of the times of performing the revolution are as the impulses inversely, which are as the squares of the velocities. There is perhaps no force which acts on a ship that can be more accurately determined by experiment than this. Let the ship ride in a stream or tideway whose velocity is accurately measured; and let her ride from two moorings, so that her bow may be a fixed point. Let a small tow line be laid out from her stern or quarter at right angles to the keel, and connected with some apparatus fitted up on shore or on board another ship, by which the strain on it may be accurately measured; a person conversant with mechanics will see many ways in which this can be done. Perhaps the following may be as good as any: let the end of the tow-line be fixed to some point as high out of the water as the point of the ship from which it is given out, and let this be very high. Let a block with a hook be on the rope, and a considerable weight hung on this hook. Things being thus prepared, put down the helm to a certain angle, so as to cause the ship to sheer off from the point to which the far end of the tow-line is attached. This will stretch the rope, and raise the weight out of the water. Now heave upon the rope, to bring the ship back again to her former position, with her keel in the direction of the stream. When this position is attained, note carefully the form of the rope, that is, the angle which its two parts make with the horizon. Call this angle a. Every person acquainted with these subjects knows that the horizontal strain is equal to half the weight multiplied by the cotangent of a, or that 2 is to the cotangent of a as the weight to the horizontal strain. Now it is this strain which balances, and therefore measures the action of the rudder, or D e in fig. 11. Therefore, to have the absolute impulse D d, we must increase D e in the proportion of radius to the secant of the angle b, which the rudder makes with the keel. In a great ship sailing six miles in an hour, the impulse on the rudder inclined 30° to the keel is not less than 3000 pounds. The surface of the rudder of such a ship contains nearly 80 square feet. It is not, however, very necessary to know this absolute impulse Dd, because it is its parts D e alone which measure the energy of the rudder in producing a conversion. Such experiments, made with various positions of the rudder, will give its energies corresponding to these positions, and will settle that long disputed point, which is the best position for turning a ship. On the hypothesis that the impulsions of fluids are in the duplicate ratio of the sines of incidence, there can be no doubt that it should make an angle of 54° 44′ with the keel, being about the angle with the keel that the rudder can be put over in modern ships; the angle of maximum effect assigned by theory.

How to determine it.

Why a ship misses stays, &c.

A ship misses stays in rough weather for want of a sufficient progressive velocity, and because her bows are beat off by the waves; and there is seldom any difficulty in wearing the ship, if she has any progressive motion. It is, however, always desirable to give the rudder as much influence as possible. Its surface should be enlarged (especially below) as much as can be done consistently with its strength, and with the power of the steersman to manage it; and it should be put in the most favourable situation for the water to get at it with great velocity; and it should be placed as far from the axis of the ship's motion as possible. In order to ascertain the motion produced by the action of the rudder, draw from the centre of gravity a line G q perpendicular to Dd (Dd being drawn through the centre of effort of the rudder). Then, as in the consideration of the action of the sails, we may conceive the line qG as a lever connected with the ship, and impelled by a force Dd acting perpendicularly at q. The consequence of this will be, an incipient conversion of the ship about a vertical axis passing through some point S in the line qG, lying on the other side of G from q; and we have, as in the former case,

$$GS = \frac{\int p \cdot r^2}{M \cdot Gq}.$$

The action of the rudder similar to that of the sails, and very great.

Thus the action and effects of the sails and of the rudder are perfectly similar, and are to be considered in the same manner. We see that the action of the rudder, though of a small surface in comparison of the sails, must be very great: for the impulse of water is many hundred times greater than that of the wind; and the arm qG of the lever, by which it acts, is incomparably greater than that by which any of the impulsions on the sails produces its effect; accordingly, the ship yields much more rapidly to its action than she does to the lateral impulse of a sail.

Observe here, that if G were a fixed or supported axis, it would be the same thing whether the absolute force Dd of the rudder acts in the direction Dd, or its transverse parts De act in the direction De, both would produce the same rotation; but it is not so in a free body. The force Dd both tends to retard the ship's motion and to produce a rotation: it retards it as much as if the same force Dd had been immediately applied to the centre. And thus the real motion of the ship is compounded of a motion of the centre in a direction parallel to Dd, and of a motion round the centre. These two constitute the motion round S.

As the effects of the action of the rudder are both more

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Employed as an example of the motions of conversion.

remarkable and somewhat more simple than those of the sails, we shall employ them as an example of the mechanism of the motions of conversion in general; and as we must content ourselves, in a work like this, with what is very general, we shall simplify the investigation by attending only to the motion of conversion. We can get an accurate notion of the whole motion, if wanted for any purpose, by combining the progressive or retrograde motion parallel to Dd with the motion of rotation which we are about to determine.

In this case, then, we observe, in the first place, that the angular velocity is $\frac{Dh \cdot qG}{\int pr^2}$; and, as was shown in ROTATION, this velocity of rotation increases in the proportion of the time of the forces' uniform action, and the rotation would be uniformly accelerated if the forces did really act uniformly. This, however, cannot be the case, because, by the ship's change of position and change of progressive velocity, the direction and intensity of the impelling force is continually changing. But if two ships are performing similar evolutions, it is obvious that the changes of force are similar in similar parts of the evolution. Therefore the consideration of the momentary evolution is sufficient for enabling us to compare the motions of ships actuated by similar forces, which is all we have in view at present. The velocity v, generated in any time t by the continuance of an invariable momentary acceleration (which is all that we mean by saying that it is produced by the action of a constant accelerating force), is as the acceleration and the time jointly. Now, what we call the *angular velocity* is nothing but this momentary acceleration. Therefore the velocity v, generated in the time t, is $=\frac{F \cdot qG}{\int pr^2}t$.

Angular velocity.

The expression of the angular velocity is also the expression of the velocity v of a point situated at the distance 1 from the axis G.

Let z be the space or arch of revolution described in the time t by this point, whose distance from G is $=1$. Then $\dot{z} = v\dot{t} = \frac{F \cdot qG}{\int pr^2}t\,\dot{t}$, and taking the fluent $z=\frac{F \cdot qG}{\int pr^2}t^2$. This arch measures the whole angle of rotation accomplished in the time t. These are, therefore, as the squares of the times from the beginning of the rotation.

Those evolutions are equal which are measured by equal arches. Thus two motions of 45 degrees each are equal. Therefore because z is the same in both, the quantity $\frac{F \cdot qG}{\int pr^2}t^2$ is a constant quantity, and t^2 is reciprocally proportional to $\frac{F \cdot qG}{\int pr^2}$, or is proportional to $\frac{\int pr^2}{F \cdot qG}$, and t is proportional to $\frac{\sqrt{\int pr^2}}{\sqrt{F \cdot qG}}$. That is to say, the times of the similar evolutions of two ships are as the square root of the momentum of inertia directly, and as the square root of the momentum of the rudder or sail inversely. This will enable us to make the comparison easily. Let us suppose the ships perfectly similar in form and rigging, and to differ only in length L and l; $\int P \cdot R^2$ is to $\int pr^2$ as L^5 to l^5. For the similar particles P and p contain quantities of matter which are as the cubes of their lineal dimensions; that is, as L^3 to l^3. And because the particles are similarly situated, R^2 is to r^2 as L^2 to l^2. Therefore $P \cdot R^2 : p \cdot r^2 = L^5 : l^5$. Now F is to f as L^2 to l^2. For the surfaces of the similar rudders or sails are as the squares of their lineal dimensions; that is, as L^2 to l^2. And lastly, Gq is to gq as L to l, and therefore $F \cdot Gq : f \cdot gq = L^3 : l^3$. Therefore we have $T^2 : t^2 = \frac{\int P \cdot R^2}{F \cdot Gq} : \frac{\int p \cdot r^2}{f \cdot gq} = \frac{L^5}{L^3} : \frac{l^5}{l^3} = L^2 : l^2$, and $T : t = L : l$.

Times of similar evolutions with similar ships.

Therefore the times of performing similar evolutions with similar ships are proportional to the lengths of the ships when both are sailing equally fast; and since the evolutions are similar, and the forces vary similarly in their different parts, what is here demonstrated of the smallest incipient evolutions is true of the whole. They therefore not only describe equal angles of revolution, but also similar curves.

A small ship, therefore, works in less time and in less room than a great ship, and this in the proportion of its length. This is a great advantage in all cases, particularly in wearing, in order to sail on the other tack close-hauled. In this case she will always be to windward and ahead of the large ship, when both are got on the other tack. It would appear at first sight that the large ship will have the advantage in tacking. Indeed the large ship is farther to windward when again trimmed on the other tack than the small ship when she is just trimmed on the other tack. But this happened before the large ship had completed her evolution, and the small ship, in the meantime, has been going forward on the other tack, and going to windward. She will therefore be before the large ship's beam, and perhaps as far to windward.

We have seen that the velocity of rotation is proportional, *cæteris paribus*, to F × Gq. F means the absolute impulse on the rudder or sail, and is always perpendicular to its surface. This absolute impulse on a sail depends on the obliquity of the wind to its surface. The usual theory says, that it is as the square of the sine of incidence; but we find this not true. We must content ourselves with expressing it by some as yet unknown function φ of the angle of incidence a, and call it φa; and if S be the surface of the sail, and V the velocity of the wind, the absolute impulse is $nV^2S \times \varphi a$. This acts (in the case of the mizen-topsail, fig. 10) by the lever qG, which is equal to DG × cos DGq, and DGq is equal to the angle of the yard and keel; which angle we formerly called b. Therefore its energy in producing a rotation is $nV^2S \times \varphi a \times DG \times \cos b$. Leaving out the constant quantities n, V^2, S, and DG, its energy is proportional to $\varphi a \times \cos b$. In order, therefore, that any sail may have the greatest power to produce a rotation round G, it must be so trimmed that $\varphi a \times \cos b$ may be a maximum. Thus, if we would trim the sails on the foremast, so as to pay the ship off from the wind right ahead with the greatest effect, and if we take the experiments of the French academicians as proper measures of the oblique impulses of the wind on the sail, we will brace up the yard to angle of 48° with the keel. The impulse corresponding to 48° is 615, and the cosine of 48° is 669. These give a product of 411·435. If we brace the sail to 54·44, the angle assigned by the theory, the effective impulse is 405·274. If we make the angle 45°, the impulse is 408·774. It appears then that 48° is preferable to either of the others. But the difference is inconsiderable, as in all cases of maximum a small deviation from the best position is not very detrimental. But the difference between the theory and this experimental measure will be very great when the impulses of the wind are of necessity very oblique. Thus, in tacking ship, as soon as the headsails are taken aback, they serve to aid the evolution, as is evident. But if we were now to adopt the maxim inculcated by the theory, we should immediately round in the foreweather braces, so as to increase the impulse on the sail, because it is then very small; and although we by this means make the yard more square, and therefore diminish the rotatory momentum of this impulse, yet the impulse is more increased (by the theory) than its vertical lever is diminished. Let us examine this a little

A nice point of seamanship.

more particularly, because it is reckoned one of the nicest points of seamanship to aid the ship's coming round by means of the headsails; and experienced seamen differ in their practice in this manœuvre. Suppose the fore-yard braced up to 40°, the sail shivers, and from letting go the head bow-lines the sail immediately takes aback, and in a moment we may suppose an incidence of 6 degrees. The impulse corresponding to this is 400 (by experiment), and the cosine of 40° is 766. This gives 306·400 for the effective impulse. To proceed according to the theory, we should brace the yard to 70°, which would give the wind (now 34° on the weather-bow) an incidence of nearly 36°, and the sail an inclination of 20° to the intended motion, which is perpendicular to the keel. For the tangent of 20° is about $\frac{1}{2}$ of the tangent of 36°. Let us now see what effective impulse the experimental law of oblique impulsions will give for this adjustment of the sails. The experimental impulse for 36° is 480; the cosine of 70° is 342; the product is 164·160, not much exceeding the half of the former. Nay, the impulse for 36°, calculated by the theory, would have been only 346, and the effective impulse only 118·332. And it must be farther observed, that this theoretical adjustment would tend greatly to check the evolution, and in most cases would entirely mar it, by checking the ship's motion ahead, and consequently the action of the rudder, which is the most powerful agent in the evolution; for here would be a great impulse directed almost astern.

We were justifiable, therefore, in saying, in the beginning of this article, that a seaman would frequently find himself baffled if he were to work a ship according to the rules deduced from M. Bouguer's work; and we see by this instance of what importance it is to have the oblique impulsions of fluids ascertained experimentally. The practice of the most experienced seamen is directly the opposite to this theoretical maxim, and its success greatly confirms the usefulness of these experiments of the academicians so often praised by us.

We return again to the general consideration of the rotatory motion. We found the velocity $v=\frac{F\cdot qG}{\int pr^2}$. It is therefore proportional, *cæteris paribus*, to qG. We have seen in what manner qG depends on the position and situation of the sail or rudder when the point G is fixed. But it also depends on the position of G. With respect to the action of the rudder, it is evident that it is so much the more powerful, as it is more remote from G. The distance from G may be increased either by moving the rudder farther aft or G farther forward. And as it is of the utmost importance that a ship answer her helm with the greatest promptitude, those circumstances have been attended to which distinguished fine steering ships from such as had not this quality; and it is in a great measure to be ascribed to this, that, in the gradual improvement of naval architecture, the centre of gravity has been placed far forward. Perhaps the notion of a centre of gravity did not come into the thoughts of the rude builders in early times; but they observed that those boats and ships steered best which had their extreme breadth before the middle point, and consequently the bows not so acute as the stern. This is so contrary to what one would expect, that it attracted attention more forcibly; and, being somewhat mysterious, it might prompt to attempts of improvement, by exceeding in this singular maxim. We believe that it has been carried as far as is compatible with other essential requisites in a ship.

Of importance to determine the best place for a ship's centre of gravity.

We believe that this is the chief circumstance in what is called the trim of a ship; and it were greatly to be wished that the best place for the centre of gravity could be accurately ascertained. A practice prevails, which is the opposite of what we are now advancing. It is usual to load a ship so that her keel is not horizontal, but lower abaft. This is found to improve her steerage. The reason of this is obvious. It increases the acting surface of the rudder, and allows the water to come at it with much greater freedom and regularity; and it generally diminishes the griping of the ship forward, by removing a part of the bows out of the water. It has not always this effect; for the form of the ship's bow is sometimes such, that the tendency to gripe is diminished by immersing more of the bow in the water.

But waiving these circumstances, and attending only to the rotatory energy of the rudder, we see that it is of advantage to carry the centre of gravity forward. The same advantage is gained to the action of the after-sails. But, on the other hand, the action of the headsails is diminished by it; and we may call every sail a headsail whose centre of gravity is before the centre of gravity of the ship; that is, all the sails hoisted on the bowsprit and foremast, and the staysails hoisted on the mainmast; for the centre of gravity is seldom far before the mainmast.

Suppose that when the rudder is put into the position AD (fig. 11), the centre of gravity could be shifted to g, so as to increase qG, and that this is done without increasing the sum of the products pr^2. It is obvious that the velocity of conversion will be increased in the proportion of qG to qg. This is very possible, by bringing to that side of the ship parts of her loading which were situated at a distance from G on the other side. Nay, we can make this change in such a manner that $\int pr^2$ shall even be less than it was before, by taking care that everything which we shift shall be nearer to g than it was formerly to G. Suppose it all placed in one spot m, and that m is the quantity of matter so shifted, while M is the quantity of matter in the whole ship. It is only necessary that $m\cdot g\mathrm{G}^2$ shall be less than the sum of the products pr^2, corresponding to the matter which has been shifted. Now, although the matter which is easily moveable is generally very small in comparison to the whole matter of the ship, and therefore can make but a small change in the place of the centre of gravity, it may frequently be brought from places so remote that it may occasion a very sensible diminution of the quantity $\int pr^2$, which expresses the whole momentum of inertia.

A practice of seamen in putting about explained.

This explains a practice of the seamen in small wherries or skiffs, who, in putting about, are accustomed to place themselves to leeward of the mast. They even find that they can aid the quick motions of these light boats by the way in which they rest on their two feet, sometimes leaning on one foot, and sometimes on the other. And we have often seen this evolution very sensibly accelerated in a ship of war, by the crew running suddenly, as the helm is put down, to the lee-bow. And we have heard it asserted by very expert seamen, that after all attempts to wear ship (after lying-to in a storm) have failed, they have succeeded by the crew collecting themselves near the weather fore-shrouds the moment the helm was put down. It must be agreeable to the reflecting seaman to see this practice supported by undoubted mechanical principles.

The evolution accelerated by additional matter.

It will appear paradoxical to say that the evolution may be accelerated even by an addition of matter to the ship; and though it is only a piece of curiosity, our readers may wish to be made sensible of it. Let m be the addition, placed in some point m lying beyond G from q. Let S be the spontaneous centre of conversion before the addition. Let v be the velocity of rotation round g, that is, the velocity of a point whose distance from g is 1, and let ρ be the radius vector, or distance of a particle from g. We have $\frac{F\cdot qg}{\int p\rho^2+m\cdot mg^2}$. But we know that $\int p\rho^2=\int pr^2+\mathrm{M}\cdot\mathrm{G}g^2$.

Therefore $v=\frac{F\cdot qg}{\int pr^2+\mathrm{M}\cdot\mathrm{G}g^2+m\cdot mg^2}$. Let us determine G$g$ and mg and qg.

Let mG be called z. Then, by the nature of the centre

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of gravity, $\mathrm{M}+m:\mathrm{M}=\mathrm{G}m:gm=z:gm$, and $gm=\frac{\mathrm{M}}{\mathrm{M}+m}z$, and $m\cdot gm^2=\frac{m\mathrm{M}^2}{\mathrm{M}+m)^2}z^2$. In like manner, $\mathrm{M}\cdot\mathrm{G}g^2=\frac{\mathrm{M}m^2}{\mathrm{M}+m)^2}z^2$. Now $m\mathrm{M}^2+m^2\mathrm{M}=\mathrm{M}m\times\mathrm{M}+m$. Therefore $\mathrm{M}\cdot\mathrm{G}g^2+m\cdot gm^2=\frac{\mathrm{M}m\times(\mathrm{M}+m)}{\mathrm{M}+m)^2}z^2, =\frac{\mathrm{M}m}{\mathrm{M}+m}z^2$. Let u be $=\frac{m}{\mathrm{M}+m}$, then $\mathrm{M}\cdot\mathrm{G}g^2+m\cdot gm^2=\mathrm{M}nz^2$. Also $\mathrm{G}g=nz$, being $=\frac{m}{\mathrm{M}+n}z$. Let $q\mathrm{G}$ be called c: then $qg=c+nz$. Also let SG be called e.

We have now for the expression of the velocity $v=\frac{\mathrm{F}(c+nz)}{\int pr^2+\mathrm{M}nz^2}$, or $v=\frac{\mathrm{F}}{\mathrm{M}}\times\frac{c+nz}{\frac{\int pr^2}{\mathrm{M}}+nz^2}$. But $\frac{\int pr^2}{\mathrm{M}}=ce$.

Therefore, finally, $v=\frac{\mathrm{F}}{\mathrm{M}}+\frac{c+nz}{ce+nz^2}$. Had there been no addition of matter made, we should have had $v=\frac{\mathrm{F}}{\mathrm{M}}\times\frac{c}{ce}$.

It remains to show, that z may be so taken that $\frac{c}{ce}$ may be less than $\frac{c+nz}{ce+nz^2}$. Now, if c be to z as ce to z^2, that is, if z be taken equal to e, the two fractions will be equal. But if z be less than e, that is, if the additional matter is placed anywhere between S and G, the complex fraction will be greater than the fraction $\frac{c}{ce}$, and the velocity of rotation will be increased. There is a particular distance which will make it the greatest possible, namely, when z is made $=\frac{1}{n}(\sqrt{c^2+nce}-c)$, as will easily be found by treating the fraction $\frac{c+nz}{ce+nz^2}$, with z, considered as the variable quantity, for a maximum. In what we have been saying on this subject, we have considered the rotation only inasmuch as it is performed round the centre of gravity, although in every moment it is really performed round a spontaneous axis lying beyond that centre. This was done because it afforded an easy investigation, and any angular motion round the centre of gravity is equal to the angular motion round any other point. Therefore the extent and the time of the evolution are accurately defined. From observing that the energy of the force F is proportional to qG, an inattentive reader will be apt to conceive the centre of gravity as the centre of motion, and the rotation as taking place, because the momenta of the sails and rudder, on the opposite sides of the centre of gravity, do not balance each other. But we must always keep in mind that this is not the cause of the rotation. The cause is the want of equilibrium round the point C (fig. 10), where the actions of the water balance each other. During the evolution, which consists of a rotation combined with a progressive motion, this point C is continually shifting, and the unbalanced momenta which continue the rotation always respect the momentary situation of the point C. It is, nevertheless, always true, that the energy of a force F is proportional, *cæteris paribus*, to qG, and the rotation is always made in the same direction as if the point G were really the centre of conversion. Therefore the mainsail acts always (when oblique) by pushing the stern away from the wind, although it should sometimes act on a point of the vertical lever through C, which is ahead of C.

The rotation performed round a spontaneous axis.

These observations on the effects of the sails and rudder in producing a conversion, are sufficient for enabling us to explain any case of their action which may occur. We have not considered the effects which they tend to produce by inclining the ship round a horizontal axis, viz., the motions of rolling and pitching. To treat this subject properly would lead us into the whole doctrine of the equilibrium of floating bodies, and it would rather lead to maxims of construction than to maxims of manœuvre. M. Bouguer's *Traité du Navire* and Euler's *Scientia Navalis* are excellent performances on this subject, and we are not here obliged to have recourse to any erroneous theory.

Different operations of the water on the ship and wind on the sails balance each other.

It is easy to see that the lateral pressure both of the wind on the sails and of the water on the rudder tends to incline the ship to one side. The sails also tend to press the ship's bows into the water, and if she were kept from advancing, would press them down considerably. But by the ship's motion, and the prominent form of her bows, the resistance of the water to the fore part of the ship produces a force which is directed upwards. The sails also have a small tendency to raise the ship, for they constitute a surface which in general separates from the plumb-line below. This is remarkably the case in the staysails, particularly the jib and fore-topmast staysail. And this helps greatly to soften the ship's bows into the head seas. The upward pressure also of the water on her bows, which we just now mentioned, has a great effect in opposing the immersion of the bows which the sails produce, by acting on the long levers furnished by the masts. M. Bouguer gives the name of *point velique* to the point V (fig. 12) of the mast, where it is cut by the line CV, which marks the mean place and direction of the whole impulse of the water on the bows. And he observes, that if the mean direction of all the actions of the wind on the sails be made to pass also through this point, there will be a perfect equilibrium, and the ship will have no tendency to plunge into the water or to rise out of it; for the whole of the water on the bows, in the direction CV, is equivalent to, and may be resolved into the action CE, by which the progressive motion is resisted, and the vertical action CD, by which the ship is raised above the water. The force CE must be opposed by an equal force VD, exerted by the wind on the sails, and the force CD is opposed by the weight of the ship. If the mean effort of the sails passes above the point V, the ship's bow will be pressed into the water; and if it pass below V, her stern will be pressed down. But, by the union of these forces, she will rise and fall with the sea, keeping always in a parallel position. We apprehend that it is of very little moment to attend to the situation of this point. Except when the ship is right before the wind, it is a thousand chances to one that the line CV of mean resistance does not pass through any mast; and the fact is, that the ship cannot be in a state of uniform motion on any other condition but the perfect union of the line of mean action of the sails, and the line of mean action of the resistance. But its place shifts by every change of leeway or of trim; and it is impossible to keep these lines in one constant point of intersection for a moment, on account of the incessant changes of the surface of the water on which she floats. M. Bouguer's observations on this point are, however, very ingenious and original.

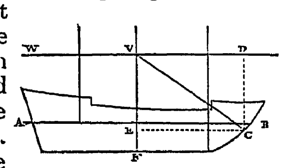

Fig. 12.

Action of the rudder upon the ship described.

To prevent unnecessary complication in this treatise, it has been supposed, what is no doubt correct in theory, that the helm acts upon the ship in the same proportion, only producing exactly contrary effects, whether the vessel is going ahead or astern. But in practice this is not the case, and the reason is as follows:—In general a ship is so constructed, unless brought down extremely by the stern, that with headway, sailing with a side-wind, the natural tendency of the bow of the vessel is to approach the wind. That is prevented, partly by the sails before the centre of

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gravity being larger than those abaft, and partly by keeping the helm a little a-weather. As soon, however, as the ship get stern-way, she acquires a tendency to fall off from the wind, in the same proportion as her tendency was to approach the wind, as long as the vessel went ahead. But on account of the larger size of the sails forward to those abaft, this tendency to put before the wind is so increased, that with a very moderate breeze, a ship, when making a stern-board, soon pays off against her helm, until the wind is on the quarter. No doubt the helm will counteract this motion to some extent, but in practice the effect is hardly perceptible.

The substance of this article, up to this point, has been taken from one written by the celebrated Professor John Robison, for a former edition of this work. The course of adopting Professor Robison's treatise as a groundwork has been taken, not only out of deference to the high authority of that author, but it is also believed that the interests of the readers of the *Encyclopædia* have been considered in this matter. We have indeed the means of knowing that the original article has been of extensive utility.

Chief evolutions described.

We shall now, instead of repeating the evolutions, which are described by the Professor, give a few examples of the manner in which a ship is manœuvred, in order to elucidate the theory which has been already explained.

To tack ship, in smooth water, with a fine breeze, and under all sail.—Everything being ready, the ship is gradually luffed up, putting the helm down slowly, at the same time hauling over, until nearly amidships, the spanker-boom. As soon as the helm is down, the word is given, the "helm is a-lee," immediately the fore and head sheets are let go. As soon as the wind is fairly out of the after-sails, or when the ship is about three points from the wind, the order is given to raise tacks and sheets. As the ship approaches to about half-a-point of being head to wind, the after-yards are braced round, and their sails trimmed. As soon as she commences fairly to fall off on the new tack, the order is given of "all haul;" then the head-yards are braced round, and all the sails are trimmed. During this evolution the way of the ship must be watched, and if lost, the helm must be righted; if the ship gets stern-way, the helm must be shifted.

The above is the ordinary process of tacking ship under favourable circumstances; a process in which all the different modes of action of the rudder and sails may be employed. To execute this evolution in the most expeditious manner, and so get the ship as much as possible to windward, is considered as the test of an expert seaman.

A fast-sailing ship, just able to carry three reefs out of the topsails and top-gallant sails, working to windward under the above-mentioned circumstances, ought to make about 9 knots per hour, and sail within five and a-half points of the wind. Such being the case, and supposing half-a-point leeway to be made, if nothing was lost in stays, the ship would go to windward at the rate of 3·4 miles per hour. Perhaps 0·3 of the whole distance run may be considered good for a square-rigged vessel.

We have here supposed that, during this operation, the ship has preserved, or nearly so, her progressive motion. She must therefore have described a curved line, advancing all the time to windward; and the ship has been tacked without much assistance from the sails, but principally by the action of the rudder. But this evolution has often to be performed when, either from a swell, want of wind, or, on the other hand, too much wind, sluggishness of the vessel, or from too little sail being set and the ship having little velocity, there arises a considerable probability that, unless great care is used, the ship may not stay, or as it is technically called, may miss stays. Under these circumstances the skilful sailor will adopt many devices, which are neither necessary nor useful, when he is placed in a more favourable situation. For instance, before putting the helm down, the jib-sheet ought to be eased off, or perhaps the jib hauled down. As soon as the word "helm-is-a-lee" is given, besides the fore-sheet, the foretop-bowline is also let go, and the weather-foretopsail-brace is hauled in, the yard to be braced up again as soon as the ship approaches within two points of being head to wind. When the word "raise tacks and sheets" is given, the fore-tack is to be kept fast until the ship is head to wind. The after yards ought not to be hauled until the ship is quite head to wind. The shaking of the spanker under these circumstances affords a good guide to show when the after-yards ought to be braced round. During the time occupied by this evolution, the way of the ship ought to be watched; and as soon as the ship begins to go astern, the helm ought to be shifted. Sometimes it is necessary that the ship should have well paid off on her new tack, before the head-yards are braced round, otherwise the vessel may be placed in what is called irons; that is to say, for some considerable time her head will not pay off either way, and the ship during this time is going astern.

If the ship loses all her headway after the headsails have taken aback, but before the wind has been brought right ahead, the evolution becomes uncertain, but by no means hopeless. Under these circumstances, the ship will soon have stern-way, and the helm must then be shifted hard over. It is evident that the resistance of the water to the stern-way of the rudder will act in a favourable direction, pushing the stern outwards. In the meantime, the action of the wind on the headsails pushes the head in the opposite direction. These actions conspire, therefore, in promoting the evolution; and if the wind can be brought right ahead, it cannot fail, but may even be completed speedily. As soon as the wind comes on the former lee-bow, the action of the water on the now lee-quarter will greatly accelerate the conversion. Therefore, when the wind has once been brought right ahead, there is no risk of failure.

To get under Weigh.—When a ship's anchor is to be weighed, the head-yards are braced round to the opposite tack to which it is intended to cast the ship, the after-yards being braced upon the other tack. Supposing it is intended to cast upon the port tack, the helm will be ported, but shifted when the anchor is out of the ground, and the ship commences to get stern-way. As soon as the head sails will take on the port tack, they are hoisted, and after that, the head-yards braced round, and the sails properly trimmed.

To wear Ship.—Put the helm up, and brail up the after-sails, round in the weather after-braces, keeping the mizen-topsail shivering, and the main-topsail just touching. When the wind is about one point abaft the beam, let go the head bowlines, and get a pull of the weather head-braces. This is preferable to the usual plan of not touching the head-yards, until the wind is well on the quarter. When the wind is nearly aft, square the head-yards; and when it comes on the other quarter, haul out the spanker, shift over the head-sheets, righting the helm in time, and brace sharp up. We cannot help losing much ground in this movement. Therefore, though it be simple, it requires attention and rapid execution to do it with as little loss as possible. At first one is apt to think, that it would be better to keep the head-sails braced up on the former tack, until the ship is nearly before the wind; as we might expect assistance from the obliquity of the head-sails. But the rudder being the principal agent in the evolution, it is found that more time is gained by increasing the ship's velocity than by an impulse upon the head-sails more favourably directed. It has been considered by many seamen, that a ship, when she cannot be stayed, loses the least ground by what is termed box-hauling. This is effected by bracing the head-yards flat aback as soon as the

helm is put up, and keeping the after-sails shivering; when the ship gets stern-way, the helm is shifted, to be righted when she gathers headway; when before the wind, square the yards, and proceed as in wearing. This evolution, if well done, may be useful if some danger be suddenly seen right ahead.

In a strong gale with a contrary wind, or even with a fair wind with too heavy a sea to run with safety, the ship is obliged to lie to. Some sail is absolutely necessary to keep the ship steady, otherwise she might strain and work herself to pieces. Different ships behave best under different sails. In a very violent gale, the main-topsail close reefed, storm-trysails and fore-staysail are in general well adapted for keeping a ship steady, and distributing the strain. Under this sail, unless a very heavy sea is running, the ship will have sufficient way to be steered. This is far preferable to the plan adopted before storm-trysails had superseded storm-staysails; the helm used then to be kept a-lee, and the ship's head came up and fell off, the same as a ship hove to in fine weather, with a main-topsail aback.

To take in a topsail during a gale of wind.—Let go the top-bowline, lower the yard, and slack about 4 feet of the lee-sheet. Clew the yard down by the weather clewline, and haul in the weather topsail brace. As soon as the yard is down, ease away the weather-sheet, and haul up the clewline and buntline; when up, ease off the lee-sheet, and haul up the lee clewline and buntline.

To set a topsail blowing hard, the lee-sheet must first be hauled home.

Omitting the details, which we do not pretend to give, the above shows the principle upon which square sails are set and taken in during gales of wind.

Dangerous position of the Magnificent, and her preservation from it described.

In closing this head, we would refer to one of the finest manœuvres of seamanship, and one which has been fully recorded, we mean the saving from a most perilous position Her Majesty's ship Magnificent, of 74 guns, commanded by Captain John Hayes. The following are some of the particulars:—

On the evening of December 16, 1812, the Magnificent anchored with the best bower in 16 fathoms, between Chasseron and Isle of Rhe, in the neighbourhood of the Basque Roads, at 9 h. 40 m. P.M. The ship drove, when the small bower anchor was let go, and brought the ship up in 10 fathoms, the Isle of Rhe reef being distant about the length of two cables. The lower yards and topmasts were immediately struck. By the lead it was soon discovered that they were anchored amongst rocks; and as they were without chain-cables, it was quite obvious the hempen cables would soon be chafed through. The gale continued, with squalls from the S.W., with rain, and a heavy cross sea running. At daylight the ship again drove, and the spare anchor was let go, which brought her up. At noon the gale had increased, without any indication of a favourable change in the weather, joined to which one of the cables having parted, Captain Hayes resolved to make an attempt to save the ship. The courses having been previously reefed, and the topsails close-reefed, the lower yards were swayed up to three-fourths of their usual height; the topmasts were secured close down, leaving the topsail-yards to work on the caps; the largest hawser was passed through the starboard quarter-port, and bent to the cable of the small bower, for the purpose of acting as a spring in casting the ship to port previously to cutting the cable.

The courses and topsails were secured on their respective yards with stops of spun yarn, the gaskets having been removed. The head and main yards were braced up on the starboard tack, the yards on the mizen-mast being kept square. It is quite evident that, in the event of the spring canting the ship, the head-yards would require no alteration. On the other hand, if the spring broke, the yards could not be better placed for producing the stern-board, which would in that case be necessary to clear the reef. The spring was now hove in to a tolerable strain, and all being ready, the cables were cut. The heavy sea on the port-bow acting against the spring, caused it to snap; it was immediately cut adrift to prevent retarding the ship's way, the helm was put hard to starboard, the fore-staysail hoisted, the fore-topsail let fall and sheeted home, the foresail let fall, the tack hauled on board, and the sheet roused aft. All this sail was flat aback, and set in less than half-a-minute. The ship's head paid round quickly towards the reef. When the wind was abaft the beam, the mizen-topsail was set, and the helm shifted. When the wind came right aft, the main-topsail was set, and immediately afterwards the mainsail. As soon as the wind came on the starboard quarter, the sails were trimmed, and the yards braced up on the starboard tack. Thus the ship was saved.

This manœuvre, from the cutting of the spring until the sails were set, did not exceed two minutes. At the moment when the ship's head was in the direction of the rocks, and then only in five fathoms water, the vessel made a desperate plunge; and in hauling to the wind, the send of the sea did not leave, by the soundings, more than a single foot of water under the keel.

Late improvements in art of seamanship.

We now propose to direct attention to the most important improvements in the art of seamanship which have taken place within the last fifty years. This science, as it may now fairly be called, has greatly advanced within that period. With the improvements which have been made in most other departments of industry and knowledge, the public are more or less familiar, and great pains have been taken throughout this work to extend that familiarity by such popular explanations as shall not only be intelligible to general readers, but be useful to those whom pleasure or business inclines to go deeper. But before explaining the more recent changes that have taken place in this art or science, we would direct some attention to its general progress.

Most other sciences may be studied with effect in the closet. An amateur astronomer, for example, or a chemist, furnished with good instruments, and having confidence in the skill and good faith of the leaders in the particular walk of knowledge to which his taste inclines him, may, by adopting their results, pursue the same paths with almost equal profit, and perhaps with more pleasure than those who take all the labour and incur all the responsibility. But there is no royal road of this sort by which an amateur sailor can investigate the results of seamanship, the mysteries of which, to be fully understood, must be studied afloat, at sea, in all weathers, and in every climate.

All the world, however, knows that the results of nautical skill and exertion are not the same as they used to be. A voyage to India and back, in former times, occupied a couple of years, or more; it is now currently done in eight months, even by ordinary merchant-vessels, including the time taken to unload and reload their cargoes. In consequence of the increase of passengers between England and Australia, great emulation has been excited amongst the merchant-ships running between the two countries, and many improvements have taken place. That voyage is now often performed (without the aid of steam) in eighty days, and has been done in seventy. It is recorded that one of these clipper ships, as they are designated, has run the enormous distance of nearly 3000 miles in ten days. In former days, the scurvy struck down half the crew of every ship which made a long voyage, and was even fearfully prevalent in the navy; now the disease is almost unknown. The numbers of all kinds of ships afloat have enormously increased, and the war of the elements by which they were formerly assailed is no less violent than it was; but assuredly a far smaller proportion of vessels are now driven on shore than

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were formerly wrecked. The comforts, too, of travelling by sea, in the articles of provisions and water, are all essentially improved; and, finally, the security, as well as the happiness of all persons on board, whether passengers or crew, has been marvellously augmented by the general establishment of a better system of discipline than was known in bygone days; whilst many old manipulations of seamanship are so modified by new contrivances, that if old Benbow, or even Kempenfelt, were to arise from the dead, he would scarcely know how to handle his ship.

Best courses in passing through the tropics.

It may not be without use, and it certainly must be interesting to those who have not studied such things personally, to see by an example how scientific seamanship is made to triumph over that groping and blundering method of navigating ships which is technically known by the name of the "rule of thumb." If we take a globe, and trace on it the shortest route, by sea, to India, and then fancy that such must be the best course to follow, we shall be very much mistaken. And yet this is very much what our ancestors actually did, till time, and repeated trials, and multitudinous failures, gradually taught them where to seek for winds, and how to profit by them when found. According to the "rule of thumb" sailing, a ship had only to steer from England to Madeira, pass the Canaries and Cape de Verds, and then to make a direct course to the Cape, and thence to India. On trial, however, this experiment always failed; for on getting near the equator, a series of calms and squalls put a stop to this straight-line scheme, and the mariners of old were then forced to toil along the coast of Africa, or were driven towards that of the Brazils, and very often they came back in utter hopelessness. Now-a-days, the exact spot where the north-east trade wind, which prevails in the northern Atlantic, ought to be parted with; in what district the calms and variables are most easily managed; over what degree of longitude on the equator the ship should pass; and, finally, in what place the south-east trade wind of the southern Atlantic is to be found, and how it is to be made most use of when found,—are all matters of such familiarity to the really qualified navigator, that they scarcely occupy his thoughts, but are acted upon as matters of course, and, unless some unforeseen accident occurs, absolutely ensure the success of his voyage. The line he follows, however, is by no means the straight one which an ill-informed person would naturally have chalked out for him to follow, ignorant of the impossibility of pursuing it.

The modern navigator, by not seeking to husband the south-east trade wind too much, but by freely "flanking" through it, sweeps past the coast of Brazil, and by boldly dashing down into pretty high south latitudes, is certain, or almost certain, of finding there such a vein of westerly wind, as amply compensates for the apparent roundabout he has made in his course. In like manner, after passing the Cape, which to the old navigators was truly a "Cabo de tormentos," instead of vainly trying to reach India by steering straight through the Mozambique Channel, the scientific navigator, disregarding the increase of distance, maintains his position in a high latitude, and sails resolutely along a parallel of latitude, with the wind in his poop, till he has obtained such a degree of easting, that, on hauling up to the northward, and making for the south-east trade wind, he enters that mysterious aërial current on such terms as ensure his making it serve his purpose. If, however, he be timid or impatient by nature, and not duly instructed by experience, he will be very apt to haul up too soon to the northward, from not liking to run, as it appears, so far past his port. The consequence will be, that when he encounters the south-east trade wind, he will find, that instead of its being fair, it is blowing in his teeth, and he will have to run back again to the southward to borrow a little more easting from the westerly breezes which prevail there.

Be it observed, however, that the above instructions would lead a seaman into great error, were he to make the rule absolute; for, at certain seasons of the year, that is, when the sun is far to the north of the line, and the south-west monsoon blowing in the Indian Ocean, his course from the Cape to India would lead him between Madagascar and the main land of Africa; and so he would sail across the equator, and enter the Bay of Bengal with a flowing sheet. At other seasons, so far from having a flowing sheet on reaching India, he may have to beat up the bay, "hank for hank," unless he has knowledge enough to know at which side to enter it, and skill enough—for it requires a good deal—to know how to profit by the land and sea breezes of the coasts respectively of Coromandel and of Pegu.

In short, not to swell this example too far, the truly scientific navigator, possessed of the requisite nautical instruments (the most important of which we propose to speak of by and by), by which means he may at all times be certain of his place, may almost command a fair wind at every stage of his voyage, and thus secure his passage within a certain number of days; though, in his way, he will have had to vary his course a hundred times from that which, at first sight, might have been thought the best, merely because, on the map, it seemed the shortest. The old proverb, indeed, which warns us that the longest way about is often the shortest way home, has perhaps its amplest illustration in the practice of modern seamanship; but, let it be always borne in mind, that this is true only when all the varying circumstances of time and place are duly taken into account, and so appropriated as to give to the ship those advantages of fair wind and moderate weather without which no voyage can be securely or speedily made. This branch of seamanship, therefore, more than any other, requires for its successful exercise a singular combination of the widest generalizations in theory, with the most minute and specific disintegrations of scientific research in practice. In the Indian seas especially, the whole history of the winds, examined without some theoretical clue, is a mass of confusion; and yet the profoundest meteorological science would inevitably prove not only useless, but absolutely dangerous to the navigator who should trust to it alone, without the aid of local information, and of the improvements of modern art.

Effects of the introduction of steam in nautical affairs.

The first great improvement of recent times to which we shall allude, is the mighty revolution in nautical affairs brought about by the introduction of steam. We may notice in passing, that the first instance we have of the application of steam-power to propel vessels in this country took place in 1815, and Glasgow led the way. No doubt, steam-engines had been tried on board ships before that time, but in 1815 commenced the first commercial employment of steam-vessels. In the beginning of 1816, a small steam-vessel, of about ten horse-power, began running as a passage-vessel between Sheerness and Chatham. Immediately after that steam-vessels were used upon the Thames. The first time that they made coasting sea-voyages was in 1821, when they commenced running between London and Edinburgh. The first of what may be called an ocean-voyage took place in 1826, when two steam-vessels commenced running between London and Lisbon. Our present object, however, is not to give a history of steam as applied to navigation, but to notice that change, so far as seamanship proper is concerned. For fuller explanations of the subject, and its progress, we would refer to the article STEAM-ENGINE.

Now, to a considerable extent, steam does not essentially interfere with seamanship proper, the manipulations of which remain nearly as before; whilst steam navigation, in spite of its boasted contempt of wind and tide, is still obliged to borrow so much from seamanship to complete its success, that without its aid it would often be useless, and even dangerous in the highest degree. It is quite evident,

that nearly all that branch of our subject which relates to navigation; that is, to the method by which a ship's place is determined at sea, the proper course shaped, and the different ports of the world recognised and made use of, remains the same. Latitudes and longitudes, and the variation of the compass, are evidently just as important to a steam-vessel as to a sailing one; and though winds and currents are not quite so essential, every one who has made a steam voyage of any length is aware how materially its celerity depends upon a knowledge of and due attention to these particulars. It is one of the chief points of a seaman's duty to know where to find a fair wind, and where to fall in with a favourable current; but the obligation, if not equally binding on a steam navigator, is so, to a certain extent, when his voyage is a long one. The most remarkable occasions on which steam has the advantage over sails are in a calm, and when the wind is directly ahead. In a calm, a sailing ship is utterly helpless, and must stand stock-still; with a wind in her teeth, if it blow hard, she can do nothing, or does worse than nothing, drifts away from her point. Although the above statements, as far as they go, are true to the letter, still there are other points of seamanship connected with steam that now can only be acquired on board steam-vessels; one of such points, of most importance, is the best and most efficient mode of combining steam with the use of sails, and to which we would first draw attention.

Remarks upon best mode of combining steam with use of sails.

When first the steam-engine was applied to the propulsion of vessels, the propeller universally adopted was the paddle-wheel; and a general idea existed, that sails under these circumstances were of very little use; acting upon this notion, these vessels were fitted with very small masts and yards. But as soon as we commenced to have steam men-of-war, it was apparent, that if they were not provided with the power of moving under sail alone, so as to save burning their coals, their utility for distant stations, and cruising with a fleet, would be much curtailed. For the above reasons, steam men-of-war, even before the introduction of the screw, were being gradually fitted with loftier masts and squarer yards; so that, by the year 1846, our steam frigates had in general about three-fourths the same extent of canvas that they would have had as sailing ships of the same dimensions. To render these vessels at all effective under sail alone, the wheels had either to be disconnected, or the floats taken off. But even after either of these plans had been adopted, the vessel, owing to its cumbrous paddle-boxes, remained an indifferent sailing vessel. Under these disadvantages, the introduction of the screw as a propeller made here a most important change. A screw-vessel, with its screw hoisted up, becomes as well fitted for sailing as any other vessel; and as the engines can be placed under the water-line, therefore protected from shot. This mode of propulsion was quickly adopted for the navy, and the ships so fitted are now rigged the same as if they had no steam, but were simply sailing-vessels. We need hardly add, that in future no men-of-war will proceed to sea without steam-engines being placed on board. The mercantile world were not slow in adopting screw-vessels; and at present they are not only employed in the coasting trade, but largely in the foreign commerce of the country. Although many of these vessels have great steam-power placed on board, still in a considerable number the power is small in proportion to their tonnage. In all cases large fore and aft sails are fitted for shorter voyages, and they are fully rigged for the longer ones. Although the screw has to a great extent taken the place of the paddle-wheel, and entirely so in the navy, yet, for the mercantile marine and post-office packets, under certain circumstances, the paddle-wheel is still used; for instance, in rivers, and for distant voyages, where strong head winds may be expected, and where a few hours even of delay may be of consequence. Thus we see, that a further advance in the science of steam navigation has had the effect of restoring the use of sails where engine-power is used. It would, indeed, be a disgrace to modern science if such a cheap and powerful agent as the wind could not be applied for our benefit, and that our discoveries only forced us to have recourse to expensive methods to gain our object. The action of the winds as a moving power is now brought under subjection, to be used when it is favourable; but at times when such is not the case, we then, and not till then, ought to have recourse to that power which we have in reserve. It is certainly comparatively easy to have a mere sailing-vessel, or a mere steamer. It is the combination of the two qualities which forms the desideratum, and to which we would now draw attention.

Often with men-of-war the length of a passage is of little moment, in these cases the sails alone ought to be used. But, on the other hand, in post-office packets and mercantile vessels with passengers, time is of so much importance, that if the supply of fuel be sufficient, it is their policy to push on; but there are a great variety of cases, where, although no extreme haste is necessary, yet it is of importance that the voyage should not be protracted beyond a certain time; in those cases a judicious employment of steam and sail is of consequence.

To aid a further elucidation of this subject, we propose now to give a table of the velocity and pressure of the wind:—

	Velocity in miles per hour.	Pressure on a square foot. lbs.	oz.
Light breezes	3·25	0	0·83
Moderate breezes	6·5	0	3·33
Fresh breezes.	16 25	1	5·0
Fresh gale	32·5	5	3 0
Strong gale	56·29	15	9·0
Hurricane	79·61	31	3 9
Violent hurricane	97·5	46	12·0

From this table it appears that the pressure of the wind increases as the square of its velocity; and as the power necessary to overcome the resistance to the speed of the ship is in all cases as the cube of her velocity, the following circumstance is therefore deducible. With a ship propelled by steam, if twice the velocity is to be attained, eight times the power must be used; but under sail (all things remaining the same, and a similar number of square yards of canvas spread), then wind, with three times its former velocity, would give rather more than twice the speed. But take the action of the wind in another point of view, and suppose a ship, with her steam up, going before the wind; if the velocity of the ship be greater than the wind, it is quite evident that the sails would only be a hindrance; but supposing that there is some difference, and that the ship is going slower than the wind, then all the assistance that the ship can receive is the difference between her velocity and the velocity of the wind. From this it is evident, that in a steam-vessel, when the wind is aft, or nearly so, the economical policy is to put the ship under sail alone, and not to use the steam at all, for by so doing, the whole power of the wind is made available. On the other hand, a light breeze on or abaft the beam, otherwise of little importance, may be taken advantage of in the propelling of the ship, by combining with it the power of steam. The reason is this. The ship passing rapidly along creates a considerable breeze; this unites with the wind, no doubt causing it to act more forward upon the ship in the same proportion as it increases its strength. From this we learn, that with light breezes on or about the beam, policy directs to make sail, but also to retain the steam, as it is by the velocity imparted by the engines to the vessel that these light winds become available.

It is not necessary to enlarge farther upon this subject,

as in a former part of this treatise (and the principle is the same) we demonstrated, that a fast ship, under sail alone, with the wind abaft the beam, might go faster than the ordinary current of the wind; although, no doubt, such cases seldom occur. With regard, however, to a vessel propelled by steam it is very different. In this case it will often happen, under the circumstances stated above, that the way of the ship will be increased by the power of the apparent wind, whilst the real wind has not the velocity of the vessel.

Mistake frequently committed in steam sailing.

In connection with this subject, we would now draw attention to a mistake which sailors in charge of steam-vessels sometimes have committed. The mistake made is this. In order, as they consider, to save coals, they keep the steam so low, with sail set, as not to turn the screw or paddle-wheel so fast as the vessel would go under sail alone. We have read an account of a voyage intended to show the advantage of using the sails and steam combined; and although attention is drawn to the small quantity of coal thereby consumed, yet, upon examination, there can be no doubt that the vessel would often have gone faster if the steam had not been used at all, and in such cases there would have been a saving of the whole of the coal.

The principles involved are as follows. With a fair wind, the number of miles obtained from a ton of coals is the number of miles that the engines increased the speed of the vessel above that which she would have gone with sails alone; that is to say, suppose a steam-ship goes nine knots with a fair wind, under sail alone, steam is applied, and the ship goes ten knots; the consumption of coal is, say two tons per hour, then 0·5 knot is obtained from each ton of coal. But now, under the same circumstances, suppose that a comparatively small amount of steam is applied, then it will follow that, unless a sufficiency of coal is used to keep up the revolutions of the screw or paddle-wheel equal to what would be the rate of the ship under sail alone, the way of the ship is less under sail, and this small supply of coal, than it would have been under sail alone; in short, the coal used in such a case would only retard the ship; and from this it may be deduced, that although fore and aft sails, and square sails also, when the wind is not too far forward, with the steam, may, under certain circumstances, often be useful, and save coal; so that, when the object is to make quick and economical passages, steam and sail ought certainly to be combined. Still it is advisable that steam and sail be generally used separately.

With strong head winds, the seaman often finds in his steam-vessel he is burning a large quantity of coal, more particularly if propelled by a screw, and making little way. In such cases the best plan is to keep the ship away and make sail, and if time is an important object, still keeping the screw in motion. So situated, even a dull sailing-vessel with small steam-power, if judiciously handled, will work to windward with considerable celerity.

We have already given an outline of the courses usually followed by a sailing-ship in passing through the tropics. In similar voyages, however, a vessel with steam-power has great advantages; and the skilful seaman would take a much shorter route, regulated of course, first, by his supply of coals and the time of their probable duration, and, secondly, by calculating the importance of time in opposition to expenditure of fuel.

Two voyages made by the Terrible described.

We now propose to give a short account of two voyages made by Her Majesty's steam-frigate Terrible, where sail and steam were combined, and which will therefore show the results of this combination; and as they were made through the tropics, these voyages will also prove that a much more direct and shorter route in such cases can be advantageously taken by steam-vessels than by mere sailing ships. It is necessary, first, to premise, that the Terrible was a steam-frigate carrying heavy armaments of guns, both on the main and upper decks. The Terrible's size was 1847 tons, with 800 horse-power of engines, stowing about 500 tons of coal, barque-rigged, and spreading about the same quantity of canvas as the old 44-gun frigates. It is also proper to state, that during both these voyages, when the steam was employed, it was used as expansively as possible, and with only two boilers, there being four on board for full power. The length of the stroke was 8 feet; the steam was cut off at 22 inches.

The first voyage was performed in August 1847, and was from Madeira, in Lat. 32. 58. N., Long. 16. 55. W., to St Paul de Loando, Lat. 8. 48. S., Long. 13. 13. E. The following is a short summary of the particulars of this voyage, and which requires no explanation :—

Shortest distance between Madeira and St Paul de Loando	3547	miles
Actual distance run by ship	3714	„
Total time occupied	27	days
Under sail alone	20	„
Under steam	156	hours
At anchor	18	„
Distance gone under sail alone	2374	miles
Under steam	1340	„
Whole hourly average rate of going	5·9	„
Total consumption of coal	252	tons

The equator was crossed in Long. 6. 0. E. It is quite obvious from the above table, that the Terrible, in this voyage, took almost the nearest possible route; now, every one at all acquainted with the winds and currents on the African coast to the southward of the line, is well aware that such a plan in a sailing-vessel is totally out of the question, and if attempted might even have prolonged the vogage for months.

The second voyage, concluding October 7, 1847, was from St Paul de Loando to Lisbon; and the following is a table similar to the one given for the previous voyage :—

Shortest distance between St Paul de Loando and Lisbon	4233	miles
Actual distance run by ship	4490	„
Total time occupied	30	days
Under sail alone	21	„
Under steam	224	hours
Distance gone under sail alone	2500	miles
Under steam	1990	„
Whole hourly average rate of going	6·23	„
Total consumption of coal	354	tons

The equator was crossed in Long. 13. 0. W. It will be observed that the same principle was adopted in the second voyage, namely, to make as nearly as possible a direct course. After the Terrible crossed the line, a nearly straight course was made up to 30. N. Lat., steaming through the N.E. trades, passing between Africa and the Canary Islands.

We have now shown that even in long voyages the steam-ship has an immense superiority over the sailing-vessel. We may, however, observe further, that she still retains that superiority under circumstances where both description of vessels are forced to anchor upon a dangerous lee-shore. From the anchors not holding, or the insufficient strength of the cables, there is then risk of their being forced on shore. But in this predicament, a steam-vessel, by the mere agency of her steam, although not exerted to any great extent, will either keep the cable slack, or at all events very materially relieve it from the strain produced by the wind.

There are many other details constantly arising on board steam-vessels, such as taking ships in tow, &c. These are operations which, to do well, require good seamanship; but, as we believe, that they can only be fully and practically learned on board a steam-vessel, it is hardly necessary to enter further upon these arrangements than we have done already.

There is, however, a very natural consideration that arises from the fact, that the royal navy is now entirely steam, and

Skill in some points of seamanship deteriorated.

that the mercantile marine is gradually becoming so. The consideration we allude to is this, Has this change deteriorated our skill and knowledge of seamanship? In our own opinion, to a certain extent, it has, not that our ships are worse rigged or worse handled in any way, in the open sea, but officers and pilots are gradually shrinking from performing those manœuvres that were formerly often executed by mere sailing-vessels, close to the shore or in narrow passages. Suppose, for example, a ship placed, in the present day, in the same position as the Magnificent, which we have already described, most probably she would have steam-power, by which aid the ship could be easily extricated; but if not, it appears to us very doubtful whether the daring manœuvre which saved that ship would now be attempted under sail alone. Formerly it was quite common for ships of the line, with their lower deck guns out, to beat up (not back and fill) from Sheerness to Chatham, and *vice versa;* and we much fear that no pilot would undertake now the responsibility of such a proceeding.

Introduction of chain-cables;

The next improvement to which we shall refer, are the remarkable advantages which have been gained by the extensive use of iron on board ship.

As far back as 1808, Captain Brown, of the navy, proposed the use of iron cables and rigging. There was, however, some difficulty in applying the peculiar welding that was found necessary for the links, so that it was not until 1811 that the cables were fairly tried. Since that time they have gradually been more and more adopted, so much so, that their use may now be considered universal, and certainly no greater boon was ever conferred upon the sea service. The original cost of a chain-cable is about the same as a hempen one, whilst its duration is so much greater that there can be no comparison. The security afforded by it is vastly superior, for it is exposed to none of the deteriorating causes which soon render a hempen cable comparatively so little trustworthy. The alternate wetting and drying which saps the strength of a hempen cable, has little effect on one of iron. The friction against rocks, especially against coral, may fatally damage a cable of hemp in a few minutes; but the same friction, after days of hard use, only polishes a few links of the chain. The introduction of chain-cables has, therefore, whenever the bottom anchored upon is rocky, increased the safety of ships tenfold. Nor does this advantage consist solely in their strength and durability, for they are managed with more facility, occupy much less space, and are coiled away with little trouble; for as they are hove in, they fall in and adjust themselves into a case near the hatchway, from which they are drawn up when wanted. Those who remember the toil and trouble of stowing away a hempen cable into its tier, the wet and dirt, and the number of men required, will not consider these advantages as small ones.

their advantages.

Several adaptations have been found necessary in consequence of the use of chain-cables. The hawse-holes require to be lined with iron, and the bitts cased with the same metal; a new kind of stopper was also required, by which the cable could at any time be prevented from running out, whatever might be the strain upon it. The stopper first adopted, and which answers extremely well, was invented by Captain Brown himself, and is of the nature of a compresser. This stopper is delineated in a figure, and explained in the article CAPSTAN, to which the reader is referred. But the stopper generally used on board men-of-war was invented by Sir Thomas Hardy, and consists of a large swan-necked bar of wrought iron, which embraces the cable as it comes up the hatchway, having one of the ends of the curve fixed to the beams of the lower deck by a powerful bolt, whilst to the other end is attached a tackle, worked on the lower deck, by which the curved stopper can be drawn tight, and the chain pressed so firmly in its embrace against the angle of the hatchway that, however quickly it may be running out, or whatever strain may be brought on it, the cable is at once arrested. For some years after the introduction of chain-cables, hempen messengers were used to heave them in; now chains are adopted, with a considerable saving of expense. The messenger is the endless rope which is taken round the capstan, and being attached to the cable, by what are called nippers, draws in the cable along with it as the capstan is hove round. Nippers are made of rope; iron has been tried, but not, as yet, with much success. But the best arrangement, and that which, we think, will soon be universally adopted, is to dispense with the messenger altogether, and to bring the chain-cable direct to the capstan. (See article CAPSTAN.) No doubt, on board those ships which were first fitted in this way, the chain slipped occasionally, indeed often, when a shackle or swivel came to the capstan; but that defect has now been obviated. When this plan is used, it is necessary to have an addition, called a controller, and which is placed before the bitts, and secures each link of the chain as it is hove in.

One advantage of chain-cables is, that a ship may often lie at single anchor without risk of fouling the anchor. In this case, a good scope of cable ought to be veered out, and the ship backed from her anchor, either by the sails or the power of steam, and if the tides are not very rapid, and if the ground consist of mud, there is no probability of this accident occurring. But if the scope of chain be too short, the tides very strong, and the ground hard, there will be almost the same risk of fouling the anchor as with a hempen cable.

With all these numerous advantages that chain-cables have over hempen ones, there are situations where they cannot be used without modification. For example, anchoring near the land in upwards of forty fathoms water. From such a depth, the great weight of the chain-cable renders the labour of heaving up the anchor very severe; added to which, from the vicinity to the shore, it may be indispensable to get the anchor speedily up, and stowed, so that the ship may be under command. To remedy this evil, which arises from the greater weight of an iron-cable in comparison of one made with hemp, and yet to profit by the security which belongs to rendering invulnerable that part of the cable most exposed to friction by rocks, it has been proposed to bend a length of chain (by seamen called a ganger) to the anchor, and upon the chain to splice a hempen-cable. The outer end of a length of chain being thus shackled to the anchor, the cable may be used in any depth of water, with nearly as much security as if it were made of iron from end to end, with only the inconvenience arising from the additional weight of one length of chain.

Chain rigging.

Chain-slings for the lower yards have been long in use; and, about thirty years ago, chain-topsail-sheets, and chain-ties were introduced, as well as chain-gammoning for the bowsprit, and chain-bobstays, and all have been found, more or less, improvements upon the old plans.

Wire-rope rigging, advantages of.

The great objection to chain-rigging for the lower masts has been its great weight; and, for that reason, it has only been used for those masts of steam-vessels where the hempen rigging would have received injury from the heat coming from the funnel. There is, however, no such objection to rigging made from wire-rope, which, along with all the advantages possessed by chain, is about the same weight and has much of the elasticity of hempen rigging. This wire-rigging is now widely used, and with the most perfect success, for the standing rigging of lower masts. It also, in some respects, answers extremely well for topmast and topgallant-rigging, the only objection being a difficulty of handling it, in the event of its being necessary to shift a mast, or in the event of one being carried away. Her Majesty's ship Terrible, in 1845, was rigged throughout with wire-rope, the lower topmast, topgallant, and royal rigging being all made of it, and there was no complaint of its being

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found inefficient. Besides the great advantage that wire-rigging possesses, of not being affected by the heat and sparks from the funnel, its durability is, at least, three or four times that of common rope, and, when once completely stretched, does not require any further setting up. We may add, that wire-rope can also be used for strapping blocks, and will be found both neat and serviceable.

In men-of-war, the use of iron-ballast, instead of dirty shingle, is also comparatively a recent, but valuable, improvement.

Improvements in the form and manufacturing of anchors.

Soon after the introduction of chain-cables, attention was directed to the defects of the anchor then in common use; but, for a full description of anchors, we must refer our readers to the article under that head; here we shall only briefly allude to the improvement that has taken place. One great defect in the old anchor was the extreme length of the shank, which no doubt was the cause that it so often broke in that part. This accident, after chain-cables were introduced, became more frequent, and was caused by the weight of the chain, which often fell upon the shank and snapped it. Many proposals for a new formation of anchors were made and tried; but, where the old form of anchor was retained, the great principle appears to have been to shorten the shank, but keeping the same weight of iron, thereby increasing the strength of that part. Rodgers, in his anchor, which is now so generally used, adopted that principle, and at the same time made the palm as small as possible. Another species, known by the name of Porter's anchor, improved by Trotman, is now much used in merchant-ships, but has not found much favour with naval officers. This anchor differs from all others, by the flukes being moveable upon a strong pin in the crown of the anchor. Its defect is said to be this: if once it starts from the ground, the facility of bitting again is less than it is with those constructed upon the old plan. In 1852, a committee of naval officers and ship-owners was appointed by the Admiralty to investigate and report upon the properties of different anchors. This committee reported that Trotman's anchor bore the greatest strain without coming home or breaking; but they recommended Lieutenant Rodger's small palmed anchor as the best for all practical purposes.

But anchors are not only now better planned, but by the aid of the powerful steam-hammer, invented by Nasmyth, better made. Formerly, when manual labour only was employed, it often happened, with large anchors, that the iron was not completely welded; that defect is at present unknown. Thus has been added a further security to our ships. The last most important use of iron, to which we shall draw attention, is in a department of seamanship that is of great importance. We allude to the watering of ships. About 1812, iron-tanks were introduced into the navy and mercantile marine, and has very greatly increased the quantity of water which can be carried to sea; whilst the quality has been improved in a manner, of the extent of which no one can form an idea unless he has actually drunk some of the filthy stuff which had been taken out of the wooden casks of bygone days.

Iron-tanks.

An iron-tank of the largest kind at present made for ships of war is called a four-foot cube, though it measures about an inch more in its external dimensions, and occupies sixty-eight cubic feet of space. This area, if entirely filled with water, would contain 424 gallons; but it actually holds 400, which is only twenty-four gallons less than the space would possibly contain.

An increase in the stowage of water is also gained by having tanks made in a form to suit the curve of the ship's hold, or to enter spaces too low to receive cubical tanks.

Introduction of distilled water a great boon.

But the supply of fine wholesome water for steam-ships has been still further increased, by the plan of distilling water on board, as arranged by Sir Thomas Grant, late comptroller of victualling to the navy. By this arrangement, a large ship of the line can distil about two tons an hour by the use of the full power of the apparatus; and, at any time when under steam, can always obtain a sufficient quantity of water from the waste steam without burning extra coals to supply the ship's company's daily use, without trenching upon the stock on board. The plan by which the distilled water is obtained is very simple. The steam is conveyed from a boiler in the engine-room to a condenser placed in the fore-hold. This condenser is placed in water, which is supplied from outside the ship, and conveyed off as it becomes hot. As the steam is condensed into water, it is carried by means of a gutta percha hose into the tanks, where, after it has remained two or three days to be impregnated with atmospheric air, it is ready for use. And we can bear our testimony to all who have not experience of this process, that the water which it produces is of the finest quality, and is fully appreciated by seamen, who justly consider Grant as one of their greatest benefactors—as one of those useful inventors who have added to the comfort, and promoted the health, of their fellow-creatures.

Preserved meats, &c.

Connected with the food of seamen is the discovery of preserving meats, soups, and vegetables, without salt, in cylindrical tin-cases, first devised by M. Appert, a Frenchman, and now in general use at sea. In all her Majesty's ships, these preserved meats have long been supplied to the sick with great advantage. To which has been added for all, rations of chocolate, tea, and sugar, with an increased allowance of the other kinds of provisions, and a decrease of the spirits. This new plan of victualling our seamen has added to their health and sobriety, and leaves little to be desired.

Snow Harris' improvements in lightning-conductors.

In stating these different naval improvements which have characterized the present day, the lightning-conductors of Snow Harris must not be omitted. All who are acquainted with the frequency of disasters at sea are perfectly aware how many are produced by ships being struck by lightning. Impressed with that idea, Snow Harris, as far back as 1822, devised his present plan of conductors, which was fairly tested on board our men-of-war in 1830. They were found to answer their purpose so completely, that all the ships of the navy have long been fitted with these conductors, and gradually they are being adopted in large merchant-ships. And we can state, that there is no instance of a ship being damaged where these conductors were used. Snow Harris's plan differs from all others formerly used in placing his conductor along the different masts, of which it forms, in fact, a component part, and is, therefore, always in its place. In the event of the lightning being about to strike the ship, it comes upon the conductor, and by that means is conveyed through the bottom of the ship without causing the slightest injury. For full details see article ELECTRICITY.

There can be no doubt that, at quite an early period, ships of war had some means of communicating by signals with each other; but it is only within the last few years that this great benefit has been extended to merchant-ships; and at the present time the vessels belonging to the mercantile marine of every nation can, by means of signals, make known their wants, or give intelligence to each other —a boon to the seaman and to the ship-owner that may be easily appreciated.

Various codes of signals.

The codes of signals that are best known in this country, and are of the greatest importance, are comprised in the following list:—

		Year.
1. Admiralty	code	1808
2. Admiralty	„	1816
3. Lynn's	„	1818
4. Squire's	„	1820
5. Admiralty	„	1826
6. Raper's	„	1828
7. Phillipps's	„	1836

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	Year.
8. Rohde's code	1836
9. Admiralty (present code)	——
10. Walker's „	1841
11. Eardley-Wilmot's „	1851
12. Roger's (American) „	1854
13. Reynolds's (French) „	1855
14. Marryatt's (last edition) code	1856
15. Board of Trade (2d edition) code.	1859

Plan of signalizing explained.

There is, however, one general principle adopted in all these codes, whatever be the details, and that is as follows:—A certain number of flags and pendants of different patterns are chosen, and to each is assigned its own name. Some of these flags are called by the different numerals: for instance, one flag is called 1; another 2; and so on. In other systems, the letters of the alphabet are used to denominate the flags. Besides which, other flags or pendants are used for specific purposes: for instance, one pendant is called the interrogative, that is to say, when it is hoisted, it shows that a question is asked, another flag signifies affirmation, another negation, and so on for a variety of other expressions. In the Admiralty signals, this system is carried to a considerable extent; but, in the mercantile codes, the same comprehensiveness is neither attempted nor required, and the number of flags and pendants used is much less. To correspond with the flags, signal-books are formed with sentences or words, which these flags represent. For instance, in using Wilmot's signals, if it were wished to make known the following:—"Boats are in want of ammunition." That sentence would be found in this signal-book opposite to 32; and, therefore, the two flags which express those two numbers must be hoisted. If it were wished to ask the question—"Are the boats in want of ammunition?" then the interrogative pendant would be hoisted over 32.

The Admiralty signals, for the use of men-of-war, are very comprehensive, and require about fifty flags or pendants, and include the following codes:—

First, There is the general signal-book, by which orders for all evolutions are given to the fleet. This also comprises a great deal of routine communication; for instance, one signifies, "Send for fresh beef;" another, "Send for bread;" and so on. The flags that belong to this book are called after the numerals.

Second. The telegraph book includes nearly all the most common words in the English language, and a variety of sentences likely to be useful, a geographical table, and a list of all the ships belonging to her Majesty's navy, with the names of the flags by which each ship is distinguished. The flags and pendants used in this book are called after the letters of the alphabet.

Third. Night-signals: The principle of conveying messages here is the same as in the general signal-book, only the position of lanterns, with or without blue-lights or guns, makes known to the fleet the evolution which the admiral wishes to be performed.

Fourth. Fog-signals: These are, of course, very limited, and can be made only by firing guns; the variation in the signals must be marked by the time elapsed between each report. These signals are confined to a few evolutions, such as giving orders to alter the course, to heave to, anchor, &c. As none of the Admiralty codes are published, we refrain from giving examples.

Each commander of a man-of-war is also furnished with private and secret signals. These are only used to determine whether a ship of war that may be in sight, is a foreigner or not, according as they answer the secret signal; because these signals can only be known to the service.

To the late Captain Marryatt is due the credit of having introduced a code of signals that was practically useful to merchant-vessels, and down to the beginning of 1857 it was the one generally adopted. At that time the Board of Trade gave to the world their work, entitled, *The Commercial Code of Signals for all Nations.* This leaves little to be desired, and is now to be found on board almost all merchant-ships of any size.

This code requires eighteen flags or pendants, which are named from the consonants of the alphabet; and it is so planned that it can show the distinguishing flags of every British merchant-ship. These at present amount to 35,000 registered vessels, and are increasing at about the rate of 1500 per annum; yet, as this system is so arranged as to be able to express the names of 70,000, it will be some years before any enlargement will be required.

The other advantages of this code are as follows:—

1. It is capable of providing for not less than 20,000 distinct signals.

2. Each signal requires at most four flags to be hoisted at the same time.

3. It is so arranged in classes as to admit of the subject being referred to with great facility.

For the further elucidation of these signals, it is necessary to explain, that the Board of Trade publishes annually a list of all British ships registered, with an official number assigned to each. The name and the number never altering, although the port to which the vessel belongs may be changed.

Examples in signalizing.

We shall give, as an example, how three vessels of the same name would make themselves known by this code:—

Flags to be hoisted.	Name.	Official Number.
J Q S B	Mary of Aberdeen	6,901
Q R N L	Mary of Adelaide, South Australia	31,570
S H B P	Mary of Yarmouth, Nova Scotia	37,931

As it may have some interest with our readers, we give, as a specimen of telegraphing, how Nelson's last signal would have been made by Wilmot's code, and also by the code of the board of Trade.

By Wilmot's Code.

Flags to be hoisted.	Signification in the Telegraph book.
Geographical pendant over 793	England
3672	expects-s-ex-ing
5661	every man
8631	to
3208	do-does-done
6435	his
3271	duty-ies-ful-ly-ness.

By the Code of the Board of Trade.

Flags to be hoisted.	Signification in the Telegraph book.
B D P S	England
R F V	expect-s-ing
Q G L	every one
C T G J	will do his duty very well.

Improvements in navigating ships from port to port.

The next most material change for the better, to which we have already shortly alluded, and to which it is our duty now to advert, in speaking of seamanship in the most extensive sense of that word, relates to the manner in which ships are now navigated from port to port, and to and from the most distant parts of the globe, not only with greater celerity, but with greater safety than formerly. No doubt the greater celerity with which voyages are performed is partly due to the better formation of ships (see article SHIP-BUILDING), but the improvements whose tendency have been to add to the security of voyages are mainly due—first, to the superior knowledge of those persons who have charge of ships; secondly, to the improved quality, lower cost, and greatly increased number of scientific instruments and astronomical tables now in the hands of every seamanlike officer; thirdly, to the numbers, accuracy, and cheapness of all the charts of almost all the navigable regions of the world; and lastly, to the more extensive and correct knowledge of the phenomena of the winds, weather, and currents of the ocean. And here we would direct the attention of seamen to the wind and current

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charts of Lieutenant Maury, United States navy, and also to his work, entitled *Explanations and Directions to accompany the above Charts* (eighth edition). Such a magazine of information has never before been opened out to the mariner. In place of giving our own description of the above work, we shall borrow largely from the pages of a popular periodical.

Lieutenant Maury's charts.

"We may expect, as one of the consequences of this publication, that navigation will be divested of some of its delays and dangers. For instance, a sailor, looking at the fog-charts, observes that in one hundred crossings between New York and Liverpool, he may expect to encounter a fog twenty-eight times; that fogs are most frequent in the months of most daylight, and fewest in the darkest months; that certain latitudes are more subject to fogs than others, and hence he can shape his course accordingly. He finds a similar explanation with respect to gales of wind, the seasons when the gales will be favourable, and the reverse; the latitudes where the changes may be looked for, and the course to be taken to make the quickest passages during each month of the year. The scope of the work may be inferred from the fact, that it describes the courses from New York to California, India, Australia, to England and the North of Europe as far as the White Sea, to Africa and the Mediterranean. Mariners know, to their loss and vexation, that crossing the line involves delay. Lieutenant Maury shows how the delay may be avoided, and indicates the best place of crossing the equatorial region for each month of the year.

"Considering the increase of commerce between this country and the United States, and the multiplication of screw-steamers, which make less noise than paddles, we cannot forbear to notice Lieutenant Maury's recommendation for the establishment of what he calls 'steam-lanes' across the Atlantic. Let this recommendation be faithfully followed, and we shall hear but little of collision and loss of life on the sea. Broad as the ocean is, the route taken by steam-ships between this country and the States comprehends a belt of but 300 miles wide. In 1857 there were always fourteen steamers, seven each way, plying within that belt, exclusive of man-of-war steamers; the number is doubtless greater now, whereby the chances of collision are multiplied; and seeing that the number of passengers conveyed in 1857 was 54,700, any practicable measure for diminution of the risk would be worthy of attention. Lieutenant Maury proposes a practicable measure; namely, to set off a lane 20 or 25 miles wide on the northern edge of the belt for steam-ships going west, and a similar lane on the southern edge for those going east, leaving all the middle space, 150 miles in width, for sailing-ships. Were this proposal followed, it is clear that steamers could never meet, though they might overtake each other; and this latter contingency would be an advantage, because, in case of accident, a disabled vessel might be assisted. When once such lanes are properly laid down on the charts, a sailing-ship, if compelled to cross them, would do so as quickly as possible, and would know on what side to look for danger."

Sounding the ocean. Difficulties with the depth of water above 400 fathoms.

Along with this question of currents we must not lose sight of the question of the depths of the ocean. Beyond the depths of three or four hundred fathoms, the usual methods of sounding are very uncertain, and cannot be depended on. When the common lead is used, no shock is communicated at these great depths to those above, and therefore they are not aware when the lead reaches the bottom. Nor when Massey's sounding machine is used does it avail, as that instrument cannot be so constructed as to bear the enormous pressure of so many hundred atmospheres exerted by the vast column of water, which it is necessary to penetrate.

Now, until the Alantic Ocean between England and America was sounded, and the great problem of the depths of water ascertained, it was quite obvious that no attempt could reasonably be made to sink a telegraph cable to the bottom of the ocean, and so join the two countries. To gain the proper soundings, many contrivances were proposed and tried without much success; at length a very simple and ingenious plan was suggested by Lieutenant Brooke, of the United States navy. By his contrivance the sounding line, with an apparatus attached to it, was taken down by a heavy weight, which acted as a sinker; when the bottom was reached, the weight immediately detached itself by a mechanical contrivance, and the apparatus being relieved of its load, was lifted again through the water, bringing up with it, if sufficiently soft, a specimen of the bottom as a proof of its having actually reached solid matter. The contrivance in question consists of a rod, at whose lower end is an inverted cup, provided with a valve, and from the upper end of which is slung a cannon-ball, hollowed to receive the rod. The mode of slinging the ball and suspending the rod is such, that as soon as the bottom of the rod rests upon the bottom of the sea, and the weight is thus removed from the line, the ball is released from its sling, and drops off. The rod, which is of no great weight, can be lifted with the line, and the cup carries up indications of the bottom, and when soft, a portion of the bottom itself.

Plan by which the difficulties were overcome.

This apparatus, with some modifications by Massey, has been adopted by British navigators. The weights to be detached vary from 32 lb. to 96 lb. In the year 1857 her Majesty's steam-vessel Cyclops, Lieutenant Dayman, furnished with these machines, sounded the Atlantic Ocean between Ireland and Newfoundland, and verified the soundings previously ascertained by Lieutenant Berrysman, of the United States steam-vessel Arctic.

It may not be uninteresting to the reader to state, that the greatest depth of water obtained by the Cyclops was nearly 2500 fathoms; at that depth the pressure would be nearly three tons to the square inch. In hauling in the line the friction in lifting it through the water was so great, that before overcoming the inertia and moving the line, it required the whole power of a 12-horse steam-engine, with which the Cyclops had been fitted expressly for the purpose.

We are indebted to the Americans for the first successful attempt to bring to the light of day the secrets of the deep, dark dwelling places, till now, without any relation to human interests, but through which hereafter many of the important events of the world will be communicated. And we have no doubt, that our naval officers will follow up these investigations. and if so, we may hope that in a few years we shall have obtained such accurate knowledge of the bottom of the whole ocean, that the placing of telegraph cables will become a comparatively easy task. For further information upon this subject, the reader is referred to a work entitled, *Deep-Sea Soundings in the North Atlantic Ocean*, by Lieutenant-Commander Joseph Dayman, 1858; also to the fifth article in the *Westminster Review* for October 1859.

Sextant, great value of.

In the first rank of instruments used at sea, we would place the sextant, not the old wooden quadrant, but the brass sextant, as improved by Troughton and Cary, divided to ten seconds, and capable of taking observations with a precision formerly considered inconsistent with the use of a reflecting instrument. The seaman, with such an instrument in his hands, aided by the present nautical almanac, accompanied with either of the excellent treatises on navigation, by Raper or Inman, may determine with exactness the ship's place, in the midst of a boundless ocean, a thousand miles from land. This exactness, within certain appreciable limits, distinguishes the sextant from all other nautical instruments. Its operations are connected with those of the sun, moon, and stars; and by its very construction, its

Seamanship.

principal error may often be ascertained at the very time of making the observation, and allowed for accordingly. The chronometer, which stands next in utility, is essentially a fallible instrument, and although eminently useful in the navigation branch of seamanship, can never be depended upon as the sextant. These two instruments are excellent allies, but neither is sufficient without the other to meet the requirements of modern navigation. A chronometer may, and often does, change its rate, and thus it may deceive; and though the chances of its doing so without detection is much lessened by taking two or three more chronometers in conjunction, still there never can be positive certainty in the result. On the other hand, for all practical purposes, the errors of a sextant lie within the reach of detection and appreciation.

We consider a seaman, who is provided with a modern sextant, with a stand to which it can be fixed, an artificial horizon, and a watch with a compensation balance, or *hack* chronometer, has a portable observatory, by which he can ascertain the rates of his chronometers with the utmost precision, and that without moving them from their places on board. (For full description and use of the sextant, chronometer, and other nautical instruments, see article NAVIGATION, and also CLOCK and WATCH-WORK.)

Chronometer, importance of.

The next in order of importance in the list of nautical instruments, after the sextant, is the chronometer, an instrument to which modern seamanship is indebted for very great service. We are old enough to remember when chronometers were only supplied in the navy to ships about to proceed on voyages expressly scientific, and to those ships which bore an admiral's flag. In the merchant service, the East India Company were the only shipowners who supplied chronometers. Certainly at that time a good chronometer cost from L.100 to L.150, the price is now about L.40, with all the modern improvements; but still, when we consider the number of valuable vessels and lives lost by the want of this instrument, all must agree it was a miserable saving. A great change has now taken place; all men-of-war, and we believe all merchant-vessels employed in the foreign trade, are now furnished with chronometers.

Patent sounding machine and patent log.

There are two important instruments used in navigation, not in the department of nautical astronomy, which have been introduced within the last fifty years, and to which we shall merely allude. We mean the patent sounding machine and the patent log. By the patent sounding machine the seaman is enabled to determine the depth of water up to 60 fathoms, whilst the ship may be still going about 6 knots through the water. By the patent log, if sufficient care be taken, the exact distance that a ship has gone through the water in a given time may be ascertained with accuracy. No doubt, the common log, supposing it carefully hove, and the officer of the watch attentive to any change of the ship's way during the intervals of heaving the log, will give the distance gone with tolerable accuracy, as long as the ship is under sail alone; but when the steam is used, the common log is not to be depended upon; the seaman must then look to his patent log.

Mariner's compass.

Not many years ago, the compasses, on which depended the safety of the ship, on board our men-of-war, were consigned to the charge of the boatswain, and were kept in his store-room, with little more attention given to them than to such articles as twine, canvas, &c.; and in merchant-vessels they even fared worse. At present great pains are taken in the construction of the mariner's compass, and a proper closet is fitted up for their reception. The importance of such care is manifest, when it is recollected that when magnets are placed in proximity to each other, and like poles are laid together, the effect is seriously to impair the magnetic power.

What is called the local deviation of the compass, caused by the iron on board of the ship, is now well understood. Professor Barlow invented a plan of counteracting the effect of the iron of the ship upon the needle, by fixing a circular iron-plate in a vertical position abaft the compass. Professor Airy suggested, to answer the same purpose, placing two large and powerful magnets in the deck, near the compass. But these plans have only partially succeeded, and all men-of-war, and most large merchant-ships, have now their local deviation for each point of the compass, before proceeding to sea, ascertained by actual experiment. A table of these deviations is thus formed, which the seaman uses to correct his courses. The manner of doing this is by taking advantage of a calm day, when the ship is at anchor, and, by means of hawsers, swinging her head round to each point of the compass, noting at the same time the bearings shown by a compass on shore, where there is no local deviation, and by one on board the ship. The differences between the two compasses will show the local deviation, which must be tabulated. (See *Mariner's Compass* in article NAVIGATION; also Johnson *On the Deviation of the Compass*, second edition, 1852.)

Marine barometer and aneroid.

Amongst the scientific instruments which have within this century been introduced into the art of seamanship, the marine barometer occupies a high and important place. Formerly the only kind of barometer used at sea was the mercurial one. This barometer has the advantage, if properly constructed, of being, from its very nature, always correct; but has this disadvantage, when the ship has much motion, its reading off becomes extremely difficult, from the pumping of the mercury up and down the tube. To remedy this defect, about ten years ago, the aneroid, a French invention, was introduced. This instrument is not the least affected by the motion of the ship, and can be read off at all times with the greatest accuracy. It has, however, a defect, which is this. Although it marks with the utmost precision the relative rising and falling, according to the state of the atmosphere, there may be an error in its positive height, which requires correction from time to time. (See article BAROMETER, in which the principle both of the mercurial marine barometer and the aneroid is fully explained.)

Use of barometer at sea.

The use of the barometer at sea consists in giving the seaman information, beforehand, of the changes likely to take place in the direction as well as force of the wind; or, which is sometimes as useful, to let him know, in spite of appearances to the contrary, that there will be no change. But the seaman must recollect that this instrument, as a prognosticator of weather, varies in its degree of utility in different parts of the world. For instance, it is only serviceable in those parts of the tropics which are subject to hurricanes, as it is not affected at all in those regions, except when those great tempests are coming on, and then it suddenly falls about an inch. In this country it often rises, if the wind be easterly, although bad weather may be approaching. On the contrary, off the Cape of Good Hope implicit reliance may be placed upon the rising or falling of the barometer, and the seaman must act accordingly.

Charts.

We must not forget, amongst the modern improvements in seamanship, the great advantage of correct charts. Any one aware of the dangers which really exist, but which are omitted in the old charts, wonders how ships in those times ever escaped destruction; and, on the other hand, he finds the sea so covered with rocks, shoals, and those vague "vigias," as they are called, now known to have no existence, that his admiration is great at the boldness of navigators who could sail on at all during the night.

The government of most civilized countries—and here we are pleased that we are enabled to say that the English government has led the way—have taken up this matter in earnest, and sent their surveyors abroad; the result has been that the world has been put in possession of charts of all those harbours, coasts, and seas which are most fre-

quented. At the same time much remains to be done; but if the present progress in marine surveying be continued for a few more years, so accurate will be the construction of charts, that ships duly provided with nautical instruments will seldom incur the danger of running on shore, except by stress of weather, or experience any difficulty in finding safe passages amongst sand-banks, coral reefs, or any other description of submarine dangers, the terror of old navigators.

It would lead us beyond our limits were we to go into further detail, in order to point out the various minor improvements which have been introduced into the practice of navigation. For the same reason, we must omit all mention of the improvements that have taken place in the rope, canvas, rigging, and fitting out of ships.

Numerous wrecks of British merchant-vessels.

But with all this that is so favourable, there is still a dark side to the question. By official returns it appears that, in spite of all these improvements, there are annually lost upon our own coasts, upon an average of seven years, about 1200 British merchant-vessels. The number of British seamen drowned, excluding fishermen, and those wrecked in foreign voyages, taking the same average, amount to 760. It also appears that a large proportion of these wrecks arises from causes that might have been easily avoided. The causes are, chiefly going to sea with rotten masts and sails, either bad or no charts on board, not heaving the lead, or not taking an observation, and the ignorance or drunkenness of those in charge of the navigation of the vessel. Surely such a reckless destruction of life and property conveys a very urgent lesson upon all persons in authority, that they should not only foster every improvement connected with our mercantile naval service, but that they should also enforce upon all who are concerned the responsibility they incur to make these experiments effectual.

There are still two topics remaining on which we must be allowed to touch before bringing this article to a close. One is the importance of discipline on board ships, and the amelioration in the moral character of all the seamen of the country. The other is the change which has taken place in the armaments of ships of war, and the alterations and improvements in the training of our seamen, which are now required in consequence of this change. As both of these points have become part and parcel of the seamanship upon which our prosperity as a nation mainly depends, we cannot on this occasion pass them over in silence.

Discipline, importance of.

There can be no good seamanship without discipline, for it is as essential to the correct working of a ship that there should be a clearly understood subordination established on board, as it is to the correct going of a chronometer that all the wheels and pinions be made to fit, and be so placed as to work properly into one another.

This well-defined system of discipline and organization is doubly necessary in the navy. In that service large bodies of men are thrown together, and must be governed by the strict application of martial law, which is essentially peremptory in its action, and requires immediate obedience. We are happy to be able to state, that within the last few years the practical and working system has been, that whilst a rigid law must always be kept up, yet the main dependence for bettering the habits and improving our seamen has been based more decidedly on religious and moral training. To this training has been added the plan of giving extra pay for good conduct, and providing pleasant reading for our ships' companies. We are old enough to remember the time when coercion was considered the only means of having an evolution quickly performed. Now, another element is introduced, namely, emulation; and the consequences are these, that in performing evolutions in the fleet, the officers oftentimes are not only spared the necessity of urging their seamen and marines to exertion, but actually have to restrain their ardour to prevent accidents.

All ships commanded by a captain have now chaplains appointed, joined to which are also the seaman's schoolmaster, to teach the boys, and those of the ship's company who wish to avail themselves of his instructions; and we can also add, as we have already stated, a small library of books is now always supplied, including a sufficiency of Bibles, Testaments, prayer-books, and religious tracts.

Religious instruction.

Something has been done also for our merchant-sailor, but much yet remains to be done for him. Cut off as so many of these seamen are from all religious instruction for a great portion of their lives, it is much to be desired that more active exertions were made at our large seaports to bring a knowledge of Christianity to meet their wants. All that is done to raise the seaman's character, and to give him habits of sobriety, is so much added to the prosperity of the country.

Merchant-seamen not good riggers.

It is now, we are sorry to say, almost the universal practice, for a merchant-ship to be fitted out and rigged by those hired for the express purpose; the crew not going on board until the vessel is on the very point of sailing on her voyage. Following that plan, as soon as the ship returns, the crew are landed. The effect has been, that a large proportion of merchant-sailors at the present time are unable to rig a ship. Now, as no seaman who is not a competent rigger can expect to rise above an able seaman in the navy, that is one reason why it has become very rare for any person arrived at full manhood, and who has been brought up in a merchant-ship, to enter the royal navy. He sees his inferiority to the regular man-of-war sailor, and the two professions are in consequence now almost completely disjoined.

Improved method of throwing shells.

About the year 1827, the maritime nations of the world commenced gradually increasing the size of their ships of war, and adding to the weight of metal of the great guns. Soon after this period the use of shells, fired horizontally, was introduced. The shells are not, as formerly, fired from mortars only, but are thrown from the long guns used in ordinary warfare, and treated the same as round-shot. Within the last few years the quantity of shells supplied to each ship has so much increased that a large proportion is now allowed to each gun on board our men-of-war, and no doubt will now become the principal weapon that will decide the fate of naval warfare. This change in the armaments of our ships required a superior training to be given to both our officers and seamen. An express gunnery department was established for the purpose of instruction, and the manner in which it has been carried out in our ships of war has produced a marked effect in the knowledge of gunnery in the seamen throughout the fleet. We have no hesitation in saying, that a large proportion of the regular men-of-war sailors of the present day are the most perfect artillerymen that the world has ever seen. Such being the case, without a long previous training, it is quite evident, that in the event of a battle, the uninstructed merchant-sailor hastily joining a man-of-war would be of little more service than a landsman, indeed not so much as a landsman who had received any former training at the great guns. It must also be recollected, that the next naval engagement will be fought by ships propelled by the screw, and that the sails will be furled. It will then be found, that the great battle which has to decide the fate of empires will not be so dependent on seamanship as heretofore. It will hang upon the conjoined action of men well trained and well disciplined, but the necessity still remaining of fighting under the direction of able officers, and stimulated by the influence of national sentiment.

Notwithstanding the changes which have taken place within the recollection of many now alive, we cannot foresee all that modern science, skill, and enterprise may effect. A recent invention in the construction of a new species of war-vessel, with sides plated with metal, and carrying the maximum of steam-power with the minimum size of sails,

may produce changes even greater than those to which we have already referred, and may cause a still greater demand for men well conversant in artillery practice; a practice which in these vessels will be of more importance than skill in seamanship.

Further changes probable.

Further changes seem also to be at hand in the mercantile navy. By the introduction of such immense vessels as the Great Eastern, provided with such powerful machinery, it is obvious that the sails cannot hold the same place which they have done in smaller vessels; and whether this may ultimately diminish the demand for seamen generally, or in some degree change the character of seamanship itself, is a problem which we must leave to time and future experience for solution.

The following are approved works on seamanship in English:—Falconer's *Marine Dictionary;* Darcy Lever's *Seamanship;* Griffith's *Practical Hints;* Captain Glassock's *Naval Officers' Manual;* Lieutenant Fordyce's *Outlines of Naval Routine; Professional Recollections on Seamanship*, by Captain F. Liardet; Clerk's *Naval Tactics; Naval Warfare with Steam*, by Sir Howard Douglas, 1858. Useful hints may be derived from James's *Naval History*, and also from the chapter on "Making the Land" in Raper's *Navigation; The Seaman's Manual*, by R. H. Dana, junr., 8th ed., 1859; *A Manual of Naval Tactics*, by James H. Ward, commander U.S. navy, 1859; these two last are by American authors. In French, Pere Hoste and Grenier; also, *Reglement sur le service interieur à bord des Batiments de la Flotte.* This work has been translated into English by Captain Phillimore. *Decret sur l'organisation du personnel des equipages de la flotte; Tactique Navale*, 1857. (W. R.)

SEBASTIAN, Dom. See Portugal.

SEBASTIANO, an eminent Venetian painter, whose family name was Luciano, frequently called Fra Sebastiano del Piombo, from his office of keeper of the Papal signet, was born at Venice in 1485. His first profession was music, in which he attained to great excellence in his youth. Conceiving early a taste for the painter's life, he went to Bellini, who was then an old man, and learned from him the first rudiments of his art. Sebastiano next attached himself to Giorgione, with whom he remained till he had mastered the manner of that artist. His first painting of any note, executed for the church of San Giovanni Crisostomo, in Venice, gives abundant evidence of this, as it has been frequently mistaken for the work of Giorgione. Induced by the representations of Agostino Chigi, merchant at Siena, to go to Rome, Sebastiano on arriving there immediately set to work, and produced some very excellent paintings in the Venetian manner, which were much esteemed by the art-patrons of the capital. Raffaëlle was now rising into great fame as a painter, and, according to Vasari's account of it, Michel Angelo, jealous of his illustrious rival, set up Sebastiano as a fit competitor to the famous artist of Urbino. The whole story is doubtless a fabrication, arising probably from the fact of Michel Angelo having contracted a liking for the exquisite judgment and beautiful colouring of Sebastiano, and from his having undertaken, on that account, to aid him in the art of designing, of which he is universally recognised to be the chief. Be this as it may, it is beyond doubt that Sebastiano simply painted after the designs of Michel Angelo for a number of years, and upon these paintings his reputation as a historical painter chiefly rests. The exquisite beauty of the colouring in those paintings, combined with their rich grandeur of design, if they did not rival Raffaëlle's divine productions, at least excited a great interest in the art-lovers of Rome, and have not ceased since to be the objects of universal applause. The pieces in question were a "Pieta" for the church of the Conventuale at Viterbo; the "Transfiguration" and "Flagellation," in San Pietro in Montorio; and the "Raising of Lazarus," which is esteemed his masterpiece. On the death of Raffaëlle, Sebastiano was accorded the first place in painting, and he continued in his provokingly sluggish manner to design and paint as the fit seized him. Vasari says his peculiar walk was portrait-painting; and assigns as evidence of the statement the beautiful representations of Marcantonio Colonna, Vittoria Colonna, Ferdinando, Marquis of Pescara, Pope Adrian VI., San Micheli, Pope Clement VII., and Anton Francesco degli Albizzi. This last portrait has astonished all eyes who have looked on it. The head and hands are "a sort of miracle," and the portrait did not seem to be painted but living. "No one has ever equalled," says Vasari, "the delicacy and excellence of this work." Perhaps the most striking portrait executed by this artist is that of Giulia Gonzaga. It is declared by Vasari to be "a most divine one." This picture, and the "Raising of Lazarus," are now in the National Gallery, London. Sebastiano was greatly patronized by Pope Clement VII., who conferred upon him the office of keeper of the Papal signet. This post induced him to assume the monk's habit, and to adopt the title of Fra or Frate del Piombo. Vasari complains heavily against the painter, in his garrulous way, for neglecting to prosecute his sublime art now that he had "sufficiency to live on." Sebastiano was fond of ease, as other men of genius have been, both before and since, which induced him to crack pleasant jokes on those who made themselves busy in upbraiding him for his sloth. "I think," he would say, in his satirical tone, "I think, indeed, that if I live much longer I shall find that everything has been painted which it is possible to paint; and since these good people are doing so much, it is upon the whole well that there is one who is content to do nothing, to the end that they may have all the more to do." Vasari adds, however, "a better or more agreeable companion than himself, of a truth, there never lived." Fra Sebastiano del Piombo died at Rome in 1547, aged sixty-two years.

SEBASTOPOL, or Sevastopol. An account of this place, as it was before its siege by the allied armies in 1854–5, is given in the article Crimea; and a narrative of that siege in the historical portion of the article Russia. The whole of the city south of the harbour was laid in ruins, with the exception of parts of the cathedral, and of some other buildings. These have since been restored, and the whole city is being rebuilt after a new plan. It was consecrated in July 1856 by the Archbishop of Cherson and Taurida; and, in January 1857, 380 houses had been built or restored. The population, according to the Russian Almanac for 1859, is 6213.

SEBENICO, a town of the Austrian empire, in the kingdom of Dalmatia, circle and 42 miles S.E. of Zara, on a bay of the same name, at the mouth of the Kirka. It is built in the form of an amphitheatre, rising up the side of a hill from the sea to the summit, which is occupied by two forts. Old walls surround the town; and another fort, new and strong, commands the entrance of the bay. The most conspicuous building is the cathedral, in the Lombardic style, which has a very grand interior and a lofty dome. There is here also an old Venetian town-hall, several churches, and convents. Wine and oil are obtained in abundance in the surrounding country. Distilling is carried on in the town; and there is a considerable trade. In 1855 there entered the port 1704 vessels, tonnage 78,342; and there cleared 1542, tonnage 76,159. Pop. 5500.

SECANT. See Geometry and Trigonometry.

SECEDERS. See Presbyterianism.

SE-CHUEN, or Szu-Chuan, the largest of the pro-

vinces into which China is divided, lying between N. Lat. 26. and 33., E. Long. 101. and 110.; bounded on the N. by the provinces of Kau-soo and Sheu-se, E. by those of Hou-nan and Hou-pe, S. by those of Kwi-choo and Yan-nan, and W. by Tibet. Area, 167,055 square miles. Almost the whole of this province, except a plain of some size near the centre, is rugged and mountainous. The immense river Yang-tse-kiang traverses the country in a tortuous course, from S.W. to N.E., and receives many of its chief affluents here. The productions of the province are silk, sugar, musk, rhubarb, china root, iron, tin, lead, salt, and horses. Pop. (1812) 21,435,678, (1843) 22,000,000.

SECKENDORF, Veit Ludwig von, a statesman, theologian, and historian of Germany, was born at Herzogenaurach, near Erlangen, on the 20th December 1626. He was sprung from a noble family of Franconia, and his father, who had held a good position in the army of Gustavus Adolphus during the Thirty Years' War, was executed by a Swedish court-martial in 1642. The lad began his studies at the gymnasium of Coburg in 1638, and was subsequently removed to the gymnasium of Gotha, at the request of the Duke of Gotha, who, after his father's death, showed him great kindness. At the University of Strasburg he applied himself with great zeal to nearly all the exercises of the place; and, on the completion of his studies, he was taken into the service of his patron, where he rose through the various grades of office, till, in 1664, he was made privy councillor and chancellor. Seckendorf took an important share in every educational and in every religious movement which agitated the duke's dominions during the time he held office under him. For some private reason or other he left the duke's service in 1664, and entered that of Moritz, duke of Zeit, where he was appointed to his former offices. Here Seckendorf exhibited the same popular qualities which had hitherto characterized him; but by some mischance he became involved in some squabbles with the clergy, which induced him, on the duke's death, to resign. He retired to his country-house of Meuselwitz, near Altenburg. Having accepted an invitation from Frederic, elector of Brandenburg, in 1691, to enter his services as privy councillor at Berlin, and chancellor of the University of Halle, Seckendorf died the following year.

The principal works of Seckendorf are as follows:—*Deutscher Fürstenstaat*, Gotha, 1665; *Compendium Historiæ Ecclesiasticæ*, Leipzig, 1666; *Christenstaat*, Leipzig, 1685; *Jus Publicum Romanorum*, Frankfurt, 1686; *Commentarius Historicus et Apologeticus de Lutheranismo*, Frankfurt, 1692. The Life of Seckendorf was written by Schreber, Leipzig, 1734.

SECKER, Thomas, Archbishop of Canterbury, and the friend of Bishop Butler and of Bishop Berkeley, was born at the village of Sibthorn, in Nottinghamshire, in 1693. Designed originally for the dissenting church, of which his parents were members, he laboured with great assiduity to perfect himself in all liberal arts. He made uncommon progress in every study to which he directed his attention, and by the time he had reached the age of twenty-three, he was one of the best read men of his years in England. His mind being in suspense regarding some of the speculative doctrines of Christianity, he resolved in 1716 to study medicine. With this intention he went to London and Paris; but he had not long resided abroad when an offer came to him from Joseph Butler, whose school-fellow he had been, and who was now preacher at the Rolls, to enter the Church of England. Secker, after some deliberation, complied with his friend's proposal, and he arrived in England in August 1720. He went to Leyden next year and took his degree of M.D., and on his return was made Bachelor of Arts of Exeter College, Oxford. Secker now spent a considerable part of his time in London, where he became acquainted with Dr Clarke and with Bishop Berkeley. Bishop Talbot being appointed to the see of Durham in 1726, Secker accompanied him in 1723 and received the rectorship of Houghton-le-Spring. In 1725–26, Butler published his celebrated *Sermons*, and Secker seems to have revised them previous to publication. In 1727 he exchanged his situation for that of prebendary of Durham and rector of Ryton, and in 1732 he was made chaplain to the king. Secker was now rising rapidly into notice as a preacher and a divine, and in 1733 he was transferred to St James's as rector. He went to Oxford the same year and took his degree of LL.D., and two years afterwards he found himself Bishop of Bristol. In 1737 he was chosen Bishop of Oxford on the promotion of the learned Dr Potter to Canterbury. In 1750 he was installed dean of St Paul's, and eight years afterwards he was elevated to the see of Canterbury. From this period Archbishop Secker resided constantly in his palace at Lambeth. He had been afflicted with gout for many years, which now proved almost intolerable. It threw him into a fever, of which he died on the 3d of August 1768.

SECT, according to some from the Latin *seco*, I cut; and according to others from *sequor*, I follow; is a word of common use, denoting those who follow some teacher or leader, or who unite in holding sentiments different from the majority. It is employed to characterize religious, philosophic, political, and literary bodies, but the term is generally limited to the first of these.

SECTOR, is a part of a circle comprehended between two radii and an arc of the circle. Sector is also a mathematical instrument, of use in finding the proportion between quantities of the same kind; as between lines and lines, surfaces and surfaces, &c., whence the French call it the *compass of proportion*. The great advantage of the sector above the common scales is, that it is made so as to fit all radii, and all scales. By the lines of chords, sines, &c., upon the sector, we have lines of chords, sines, &c., to any radius between the length and breadth of the sector when open. The sector is supposed to have been invented by Guido Baldo, or Ubaldo, about the year 1568. The first printed account of it was in 1584, by Gaspar Mordente, at Antwerp, who says that his brother, Fabricius Mordente, invented it in 1554. Treatises on its use have been written by Daniel Specle at Strasburg, in 1589; also by Thomas Hood at London, in 1598; and by Lewin Hulse at Frankfort-on-the-Maine, in 1603, who says that it was invented long before by Justus Byrgius. But the honour of the invention was claimed by Galileo, who wrote on its use in 1607, and by Balthasar Capra of Milan. There are also treatises on it by our countrymen Gunter, Forster, and others. Before the invention of logarithms, practical men were more easily contented with approximate solutions than they are at present. Now, however, the sector is not much used, although it is commonly reckoned one of a complete set of mathematical instruments.

For treatises on its use, see Bion on *Mathematical Instruments*, translated by Stone; Robertson's *Treatise on Mathematical Instruments*; and Adam's *Geometrical Essays*.

Any one possessing a sector will easily understand its theory and use from the 14th problem of the fifth section of our treatise on Geometry, where it is taught how to find a fourth proportional to three given lines.

The Astronomical Sector, or Equatorial Sector, is an instrument for taking the difference of right ascensions and declinations of such stars as, on account of their great difference of declinations, will not pass through a fixed telescope.

The Zenith Sector is an instrument employed in extensive trigonometrical surveys. Its use is to determine with great accuracy the zenith distances of stars whose declinations differ but little from the latitude of an observer.

SECUNDERABAD, a town of India, in the Nizam's

territory, 6 miles N. of Hyderabad, and 398 N.W. of Madras. It stands on the N.E. side of an artificial lake called Hoosain Sagur, 3 miles in length by 2 in breadth, and in the midst of isolated granite hills and rocks. It consists of a British military cantonment, regularly laid out, and a native town, with crooked, narrow, and irregular streets. In the former part there are, besides commodious barracks, several bazaars, a large and handsome church, and an hospital. Pop. 34,357.

SECUNDUS, JOANNES NICOLAIUS, an elegant writer of Latin poetry, was born at the Hague in the year 1511. His descent was from an ancient and honourable family in the Netherlands; and his father, Nicolas Everts, or Everardus, who was born in the neighbourhood of Middleburg, seems to have been high in the favour of the Emperor Charles V. On what account our author was called Secundus is not known. It could not be from the order of his birth, for he was the youngest son. Perhaps the name was not given him till he became eminent; and then, according to the fashion of the age, it might have arisen from some pun, such as his being *Poetarum nemini Secundus*. Poetry, however, was by no means the profession which his father wished him to follow. He intended him for the law, and when he could no longer direct his studies himself, placed him under the care of Jacobus Valeardus; but it does not appear that Secundus devoted much of his time to legal pursuits. Poetry, and the sister arts of painting and sculpture, had engaged his mind at a very early period. Secundus, being determined to comply as far as possible with the wishes of his father, quitted Mechelen and went to France. At Bourges he studied the civil law under the celebrated Andreas Alciatus. Having spent a year under this eminent professor, and taken his degrees, Secundus returned to Mechelen, where he remained only a very few months. In 1533 he went into Spain, with warm recommendations to the Count of Nassau and other persons of high rank; and soon afterwards he became secretary to the Cardinal-Archbishop of Toledo, in a department of business which required no other qualifications than those he possessed in a very eminent degree, a facility in writing with elegance the Latin language. It was during his residence with this cardinal that he wrote his *Basia*, a series of wanton poems, of which the fifth, seventh, and ninth *carmina* of Catullus seem to have given the hint. Secundus was not, however, a servile imitator of Catullus. His expressions seem to be borrowed rather from Tibullus and Propertius; and in the warmth of his descriptions he surpasses everything that has been written on similar subjects by Catullus, Tibullus, Propertius, C. Gallus, Ovid, or Horace. In 1535 he accompanied the Emperor Charles V. to the siege of Tunis, but gained few laurels as a soldier. Having now quitted the service of the Archbishop of Toledo, Secundus was employed in the same office of secretary by the Bishop of Utrecht; and so much had he hitherto distinguished himself by the classical elegance of his compositions, that he was soon called upon to fill the important post of private Latin secretary to the emperor, who was then in Italy. This was the most honourable office to which our author was ever appointed; but before he could enter upon it, death put a stop to his career of glory. Having arrived at Saint Amand, in Tournay, he was, upon the 8th of October 1536, cut off by a violent fever, in the very flower of his age, not having quite completed his twenty-fifth year. He was interred in the church of the Benedictines, of which his patron the bishop was abbot; and his near relations erected to his memory a marble monument, with a plain Latin inscription.

The works of Secundus have gone through several editions, of which the best and most copious is that of Scriverius, Leyden, 1631. It consists of *Julia*, eleg. lib. i.; *Amores*, eleg. lib. ii.; *Ad Diversos*, eleg. lib. iii.; *Basia*, styled by the editor *incomparabilis et divinus prorsus liber; Epigrammata: Odarum liber unus; Epistolarum liber unus; Epistolarum liber alter, heroico carmine scriptus; Funerum liber unus; Sylvæ et Carminum fragmenta; Poemata nonnulla fratrum; Itineraria Secundi tria; Epistolæ totidem, soluta oratione.* They are prefixed by recommendatory notices from many eminent men, particularly Lelius Greg. Gyraldus, the elder Scaliger, and Theodore Beza.

SECUTORES. See GLADIATORS.

SÉDAN, a town of France, capital of an arrondissement in the department of Ardennes, on the right bank of the Meuse, 160 miles N.E. of Paris. It stands on uneven ground, and is surrounded by walls, moats, and other fortifications, so as to be an important place for the defence of France on the side of Belgium. The castle, which stands on a hill to the S.E. of the town, contains an arsenal, and near this and in other parts there are three large barracks. The streets are mostly broad and clean, and the houses well built of stone. There are several fine public walks and fountains; and the chief buildings are Roman Catholic and Protestant churches, a theatre, public library, and hospital. Sédan is an important manufacturing town, its principal productions being broad-cloth and other woollen fabrics. Linen, leather, hosiery, hardware, firearms, &c., are also made here. The town has given its name to the vehicles called sedans, or sedan-chairs, which were first made here. They were introduced into this country in 1581, and came into general use about 1649. An active trade is carried on in corn, cattle, hemp, flax, and manufactured goods. The town has law-courts, a chamber of agriculture, and a college. The celebrated Marshal Turenne was a native of this place. Pop. (1856) 13,304.

SEDBERGH, a market-town of England, in the West Riding of Yorkshire, in a secluded vale enclosed by hills, 64 miles N.W. of York. It consists chiefly of one street, lined with stone-houses, and has an ancient parish church; Independent, Wesleyan, and Quaker places of worship; a free grammar school, national school, and poorhouse. Cotton and woollen fabrics are manufactured here. Pop. of the parish, 4574; of the town, about 2000.

SEDGEFIELD, a market-town of England, in the county and 11 miles S.E. of Durham. It is an old-fashioned town, built on a hill, with a large square containing a market cross. The parish church is cruciform, in the early English style, and has some interesting monuments. There are also places of worship for Wesleyans and Roman Catholics, a free grammar school, alms-houses, &c. Many of the people are employed in shoemaking. Pop. of the parish, 2192.

SEDITION, among civilians, is used for a fractious commotion of the people, or an assembly of a number of citizens without lawful authority, tending to disturb the peace and order of society. This offence is of different kinds. Some seditions more immediately threaten the supreme power, and the subversion of the present constitution of the state; others tend only towards the redress of private grievances. Among the Romans, therefore, it was variously punished, according as its end and tendency threatened greater mischief. (See lib. i. *Cod. de Seditiosis*, and *Mat. de Crimin.* lib. ii. n. 5, *De Læsa Majestate.*) In the punishment, the authors and ring-leaders were justly distinguished from those who, with less wicked intention, joined and made part of the multitude.

The same distinction holds in the law of England and in that of Scotland. Some kinds of sedition in England amount to high treason, and come within the statute 25 Edward III. as levying war against the king. And several seditions are mentioned in the Scotch acts of parliament as treasonable (Bayne's *Crim. Law of Scotland*, p. 33, 34). The

Sedley || Seetzen.

law of Scotland makes riotous and tumultuous assemblies a species of sedition. But the law there, as well as in England, is now chiefly regulated by the Riot Act, made 1 Geo. I.; only it is to be observed, that the proper officers in Scotland to make the proclamation thereby enacted are sheriffs, stewards, and bailies of regalities, or their deputies; magistrates of royal burghs, and all other inferior judges and magistrates; high and petty constables or other officers of the peace, in any county, stewartry, city, or town. In that part of the island, the punishment of the offence is anything short of death which the judges, in their discretion, may appoint.

SEDLEY, Sir Charles, an English poet and wit, the son of Sir John Sedley of Aylesford, in Kent, was born about the year 1639. At the Restoration he came to London to join the general jubilee, and was so much admired that he became a kind of oracle among the poets, which made King Charles tell him, that nature had given him a patent to be Apollo's viceroy. The productions of his pen were some plays, and several tender amorous poems, in which the softness of the verses was so exquisite as to be called by the Duke of Buckingham Sedley's witchcraft. Less pleasing opinions, however, have been expressed by others. "There were no marks of genius or true poetry to be descried, say the authors of the *Biographia Britannica;* "the art wholly consisted in raising loose thoughts and lewd desires, without giving any alarm; and so the poison worked gently and irresistibly. Our author, we may be sure, did not escape the infection of his own art, or rather was first tainted himself before he spread the infection to others." Whilst he grew in reputation for wit and in favour with the king, he became poor and debauched; his estate was impaired, and his morals were corrupted. One of his frolics, however, being followed by an indictment and a heavy fine, Sir Charles took a more serious turn, applied himself to business, and became a member of parliament, in which he was a frequent speaker. We find him in the House of Commons in the reign of James II., whose attempts upon the constitution he vigorously withstood; and he was very active in bringing about the Revolution. This was thought more extraordinary, as he had received favours from James. But that prince had taken a fancy to Sir Charles's daughter, though it seems she was not very handsome, and, in consequence of his intrigues with her, he created Miss Sedley Countess of Dorchester. This honour, so far from pleasing, greatly shocked Sir Charles. A witty saying of Sedley's on this occasion, is recorded. "I hate ingratitude," said Sir Charles; and "therefore, as the king has made my daughter a countess, I will endeavour to make his daughter a queen;" meaning the Princess Mary, married to the Prince of Orange, who dispossessed James of the throne at the Revolution. He lived till the beginning of Queen Anne's reign, and his works were printed in two volumes 8vo, 1719.

SEELAND. See Zealand.

SÉES, a town of France, in the department of Orne, on the Orne, 13 miles N. by E. of Alençon. Its most conspicuous building is the cathedral, which is one of the finest in Lower Normandy, a building in the Gothic style of the thirteenth and fourteenth centuries. Sées has also an episcopal palace, several schools, and cotton factories. Pop. 5205.

SEETZEN, Ulrich Jaspar, a German traveller of some note, was born near Jever, on the 30th January 1767. He received an excellent education, first at Jever and subsequently at the University of Göttingen. Here he studied medicine, the natural sciences, agriculture, and political economy. He formed an acquaintance with Alexander Von Humboldt, who became afterwards such a distinguished traveller. Seetzen likewise gained the friendship of Heyne, Gatterer, Eichhorn, and Blumenbach, who encouraged him in his design of making the field of his enterprise Asia and Africa. He was recommended by Blumenbach to the notice of Baron Von Zach, who subsequently introduced him to the Duke of Gotha, by whom he was fitted out for his future travels, and had an annual sum allotted him for the prosecution of them. Seetzen accordingly set out on the 13th June 1802, with the intention of gathering all available information respecting the mathematical and physical sciences, the arts, statistics, geography, and archæology. He directed his route by Vienna and Constantinople, at which cities he spent nearly a year in active preparation for his coming expedition. Having made his way as far as Haleb in the end of 1803, he there spent fifteen months in the study of Arabic. From Haleb he proceeded to Damascus, through Syria and Palestine, until he gained the deserts of Arabia. Thence proceeding northward he visited the region of Lebanon, and directed his course to the country east of the Jordan. We find him at Acre towards the end of 1806, whence he made excursions into Palestine, and finally crossed the isthmus of Suez and entered Egypt, where he remained for the next two years. Here he continued to collect, with his accustomed industry, manuscripts, archæological, mineralogical, botanical, and zoological specimens for the museum of Gotha. Having externally espoused the Mohammedan faith, he next thought of visiting those places in Arabia to which Mohammedans alone have access. After various unsuccessful attempts, he at last succeeded in gaining Mecca and Medinah, where he spent some time in executing drawings and plans. Early in the year 1810, he set out for Mocha. A letter, dated November 17th of the same year, and addressed to Lindenau of Gotha, was the last authentic news received of this enterprising traveller. Mr Buckinghim, in a letter to Von Hammer, dated from Mocha 1815, said that Seetzen had died suddenly at Taes in 1811, and it was currently reported that the unfortunate traveller had been removed by poison by order of the Imâm of Sana. Nearly the whole of Seetzen's diary and collections were subsequently recovered, and were placed in the hands of Professor Kruse of Dorpat with a view to their publication.

Segesta.

SEGESTA, by Attic writers called Egesta, an ancient city of Sicily, stood at the head of a deep bay on the north coast near the western extremity of the island, 6 miles from the sea, and 34 W. of Panormus. It seems to have occupied the summit of a small hill overlooking a ravine, through which flowed a river. The situation is very bleak and exposed. Laying aside the traditionary legends which ascribe the foundation of the city to emigrants from Troy, we may ascertain, on more certain grounds, that it was neither founded by the natives of Sicily nor by Greek colonists; although from intercourse with the Greek cities in the vicinity, it early acquired a civilized character, quite different from the barbarous natives. Segesta was for a long period engaged in almost perpetual conflicts with Selinus, on the south coast of the island. These petty feuds would have been little worthy of mention, had they not led indirectly to a most important event in Greek history, the fall of the Athenian power in the Peloponnesian War. For the event that more than any other led to the fatal issue of that war was the disastrous result of the great Athenian expedition to Sicily (416–413 B.C.), and that was undertaken at the request of the Segestans, when their enemies of Selinus were hard pressing them, having obtained the assistance of Syracuse. After the Athenian fleet and army had been annihilated in the fruitless siege of Syracuse, the Segestans, unable to contend single-handed with their foes, made an alliance with Carthage. The troops of that nation speedily landed in Sicily in 410 B.C.; took and destroyed Selinus and Himera, and established firmly the power of their country in the west of Sicily. For a long time Segesta adhered firmly to the Carthaginian interest,

and resisted a siege by Dionysius of Syracuse in 397 B.C., while, though it was taken ninety years after by Agathocles, it afterwards regained its liberty. But, on the first breaking out of war between Carthage and Rome 264 B C., it was one of the cities that earliest deserted the cause of the former. Hence it was always treated with especial favour by the Romans. No important event in subsequent history brings into notice the name of Segesta; it gradually fell into decay, and was finally abandoned on account of the ravages of the Saracens. Except some vestiges of the walls, the only remains now to be seen of the city are a temple and a theatre.

SEGMENT of a circle, is that part of the circle which is contained between a chord and an arc.

SEGNI, Bernardo, a Florentine historian, was born at Florence about the end of the fifteenth century. He studied law at Padua, pursued merchandise at Aquila, returned to Florence, where he was employed in state affairs by Duke Cosimo I. Segni translated the Rhetoric, Ethic, Politic, and the treatise on the Soul, of Aristotle into Italian, and subsequently engaged in a *Storie Fiorentine dall' anno* 1527 *all' anno* 1555. As he kept his history secret during his life, it was remarkable for the conscientious spirit in which it was written, and Segni will go down to posterity as one of the very best writers which Italy has produced. His history is decidedly superior to those of Varchi, Nardi, and Nerli, who have treated of nearly the same period. Segni died in 1559.

SEGO, the chief town of the kingdom of Bambarra, in Western Africa, on both sides of the Niger or Joliba; N. Lat. 13. 5., W. Long. 5. It consists of four separate parts, unwalled, two on each side of the river. The houses are, in general, built of clay, square and flat roofed. There are a palace and numerous mosques. Pop. 30,000.

SEGORBE, a town of Spain, Valencia, province of Castellon-de-la-Plana, at the foot of a valley between two hills, above the Palancia, in a rich country laid out chiefly in gardens, 29 miles N.N.W. of Valencia. It has ancient walls; and on the summit of the hill above stands a castle. There are broad streets, several squares, and many fountains. The principal building is the cathedral, which contains some good paintings, but is not very remarkable for its architecture. Segorbe has several other churches, an episcopal palace, a large court-house, a theatre, various schools, hospitals, convents, &c. Earthenware, paper, starch, brandy, &c., are made here; marble is quarried in the vicinity, and two fairs are held annually. Pop. 6005.

SEGOVIA, a province of Spain, in Old Castile, bounded on the N. and N.E. by those of Burgos and Soria, S.E. by those of Guadalajara and Madrid, S.W. by that of Avila, and N.W. by that of Valladolid. Area, 2670 square miles. The surface of the country is much varied; it belongs to the central table-land of Spain, and has a considerable extent of level plains, especially in the central and northern portions. Along the south-eastern boundary extend the lofty snow-clad mountains, here known as the Sierra Guadarrama and the Somosierra, separating Old from New Castile. The province is watered by numerous affluents of the Douro, which take their rise in these mountains, and flow in a north-westerly direction. The largest of them are the Riaza, Duraton, Cega, and Eresma. The average height of the plain in this province is not less than 3000 feet above the sea. Its appearance is dull and monotonous in the extreme, being entirely destitute of meadows and trees. It is, however, a good agricultural country, in which wheat, rye, barley, peas, hemp, flax, vines, &c., are raised. On the lower slopes of the mountains there are considerable pine-forests; and on the mountain-pastures, sheep, cattle, mules, pigs, &c., are reared. Mines have been wrought in some parts of Segovia, but not with much success, or to any large extent. There are also quarries of granite, limestone, and chalk. The majority of the inhabitants are employed in agricultural or pastoral pursuits. Weaving is carried on to some extent, as also is paper-making, tanning, and the manufacture of earthenware. Pop. (1857) 162,082.

Segovia, the capital of the above province, stands on a long rocky knoll, at the confluence of the Eresma with the turbulent rivulet Clamores, 45 miles N.W. of Madrid, 3300 feet above the level of the sea. It is surrounded by dilapidated old walls, with round towers; and has long, narrow, irregular streets, lined with quaint old-fashioned houses. Above the meeting of the waters rises the ancient Alcazar, or castle, on the summit of the cliff. It contains some fine halls, and is now used as a school of artillery. The cathedral is one of the finest in Spain, and the last of those in the pure Gothic style. It was begun in 1525, the former one having been almost destroyed in a popular rising in favour of the Reformation. The tower, which is 330 feet high, commands a magnificent view. The most interesting erection about Segovia, however, is the ancient aqueduct, supposed to have been built in the time of Trajan. It conveys water to the town from the Sierra Fonfria, as that of the river is difficult of access and not very wholesome. That part which is raised on arches is 847 yards in length, consisting of two tiers of arches, built of granite blocks, without any cement. The height at the centre where it is highest is 102 feet. This great work is in very good preservation; and for simplicity, grandeur, and utility, is well worthy of admiration. Besides the edifices already mentioned, Segovia possesses numerous churches, a mint, where only copper is now coined, various schools, a picture gallery, theatre, several hospitals, &c. It was formerly a very prosperous town, on account of its manufacture of woollen cloth; but it has never recovered from the blow inflicted by the French, who took the place in 1808; and though no resistance was offered, sacked it. They continued to occupy the town till 1814. Some insignificant manufactures are still carried on; leather, paper, and earthenware, being the chief articles. Pop. 13,100.

SEGUIDILLA, the Spanish name of a quick and animated melody in $\frac{3}{4}$ time, much used in Spain in singing and in dancing.

SEIFHENNERSDORF, a town of Saxony, in the circle of Bautzen, near the Bohemian frontier, 9 miles N.W. of Zittau. It has a fine church, several schools, extensive manufactories of linen and nankin, bleach-fields, &c. Pop. 5868.

SEIGNIOR, or Signior, is, in its general signification, the same with lord, but is particularly used for the lord of the fee or of a manor, as seigneur among the feudists is he who grants a fee or benefit out of the land to another. Having granted away the use and profit of the land, the seignior still retains within himself the property or dominion.

SEIGNIORAGE is a royalty or prerogative of the king, by which he claims an allowance of gold and silver brought in the mass to be exchanged for coin. See Coinage.

SEIGNIORY is borrowed from the French *seigneurie*, which means *dominatus, imperium, principatus*, and signifies with us a manor or lordship, *seigniory de sokemans*. *Seigniory in gross* seems to be the title of him who is not lord by means of any manor, but immediately in his own person; as *tenure in capite*, by which one holds of the king, as of his crown, is *seigniory in gross*.

SEINE (anc. *Sequana*), a river of France, rises in the department of Cote d'Or, in the heights of Langres, which separate it from the valley of the Saône. The general direction of its course throughout is towards the N.W.; but it has many curves and windings. It traverses the departments of Aube, Seine-et-Marne, Seine-et-Oise, Eure,

Seine.

and Seine-Inférieure; and falls into the English Channel by a wide estuary, south of Havre. Its whole length is 470 miles, though the distance in a straight line from its source to its mouth is only 270. The river is navigable for large vessels up to Rouen, and for boats as far as Méry, below Troyes, 380 miles from its mouth; but by means of a canal, vessels may ascend as far as Troyes. There are falls at Nogent-sur-Seine; but these are surmounted by locks. The waters of the Seine are connected by means of canals with those of the Rhone, the Loire, and the Scheldt. The chief affluents of the rivers are, from the right, the Aube, the Marne, with its tributary the Ourcq, the Oise, and the Epte; and from the left the Yonne, Loing, Eure, and Rille. It flows through a rich and beautiful region of hill and dale, studded with many splendid mansions, picturesque villages, and busy towns. The principal of the latter that stand on its margin are Chatillon, Bar-sur-Seine, Troyes, Nogent-sur-Seine, Melun, Paris, Mantes, Rouen, and Havre. None of the rivers of France are more abundantly stocked with fish. The elevation of the Seine at its source is 1426 feet above the sea, and the greater part of its fall takes place in the upper part of its course; for at Troyes it is only 330 feet above the sea. Its width at Paris is from 300 to 500 feet, and at its mouth about 7 miles. Owing to the comparatively small incline of its course, the Seine flows with a smooth gentle current, and is not subject to violent inundations. Its estuary is somewhat encumbered with shifting sand-banks; and like that of some other rivers, is exposed every tide to a huge perpendicular wave from the sea, called the barra or bore. In a commercial point of view the Seine is most important, as it greatly facilitates the supply of the capital both with articles of rural produce from the country in the upper part of its course, and with foreign merchandise from its mouth.

SEINE, the metropolitan department of France, and in consequence the most populous, though the smallest of the whole, lying between N. Lat. 48. 43., and 48. 58.; E. Long. 2. 10., and 2. 35.; bounded on all sides by that of Seine-et-Oise. It is compact, and nearly circular in form; 18 miles in length, 16 across at the widest part; and 183 square miles in extent. Of this area, 103 square miles are included within the fortifications of Paris. The surface is, in general, level or undulating; the highest elevations being those of Montmartre and Chamont, the former of which is 346 feet above the sea. The rivers Seine and Marne, the latter of which joins the former within the department, flow, with many bends and sinuosities, through the country. In geological structure the department belongs to the tertiary formation, and contains limestone, gypsum, and marl. Good building-stone and porcelain-clay are also obtained. There are some mineral-springs within the limits of the department. The soil is throughout fertile; and its natural productiveness is increased by a plentiful supply of rich manure from the capital. It is carefully cultivated, and only a few acres out of nearly 120,000 are altogether waste. There are in the department 73,227 acres of arable land, 3857 of meadows, 6960 of vineyards, 3385 of forests, and 625 of heaths. Near Paris fruits and vegetables are the principal crops raised; wine is made, but not of a very good quality; and in the outskirts of the department all the ordinary kinds of corn are grown. There are also extensive meadows, on which sheep and cows are reared. The sheep are, in general, of a common but improved breed, and there are many flocks of merinos. The department is calculated to contain 38,000 horses, 18,000 head of horned cattle, 30,000 sheep, 4000 pigs, &c. Portions of the department are occupied with pleasure-grounds belonging to the capital; such as the park of Vincennes to the east, and the Bois de Boulogne to the west of the city. The manufactures and commerce of the department are most extensive and varied. They are all concentrated in the capital, and are noticed in the article PARIS. Internal communication is facilitated by the two navigable rivers, four canals, and numerous roads and railways, which diverge from the metropolis in all directions. Many of the roads are lined with double rows of lofty trees, and thus form magnificent approaches to the city. Seine forms the diocese of the archbishop of Paris; it is included in the jurisdiction of the Imperial Court at Paris, and contains a civil court, formed of eight chambers, and a tribunal of commerce. It is in the first military division. The arrondissements are as follows:—

	Cantons.	Communes.	Pop. (1856.)
Paris	...	1	1,174,346
Saint-Denis	4	37	356,034
Sceaux	4	43	197,039
Total	8	81	1,727,419

Seine-et-Marne.

SEINE-ET-MARNE, a department of France, lying between N. Lat. 48. 8. and 49. 8., E. Long. 2. 24. and 3. 32.; bounded on the N. by the departments of Oise and Aisne, E. by those of Marne and Aube, S.E. by that of Yonne, S. by that of Loiret, and W. by that of Seine-et-Oise. Length from N.N.E. to S.S.W., about 74 miles, greatest breadth 45; area, 2273 square miles. The surface is broken by no mountains or even hills, but consists of a wide-spread undulating country, with many extensive plains. It is watered by two important rivers, the Seine and its affluent the Marne; the former traversing the south, and the latter the north of the department, both in the same direction, from east to west. There are three other navigable rivers, the Ourcq, the Grand Morin, and the Yonne; the first two falling into the Marne, and the latter into the Seine, all having parts of their courses in the department. Of less size and importance are the Loing, Petit Morin, and Yêres, the last having its source in this department. In the centre and east of the country are many artificial ponds for the breeding of salmon. The geological structure of the south-eastern parts of Seine-et-Marne is cretaceous, in the other portions the tertiary strata prevail. Many valuable minerals are obtained in different places. Such are the sandstone of Fontainebleau, the fine millstones of Ferté-sous-Jouarre, the building-stone of Chateau London, the potters' clay of Montereau, &c. The country, however, is chiefly agricultural; and in this respect it is inferior to none of the other departments of France. It possesses a rich soil, and is diligently cultivated. About two-thirds of the whole area, or 917,500 acres, are under the plough; 82,000 acres are occupied by meadows, 47,500 by vineyards, and 200,000 by forests. Of corn, the principal kinds raised here are wheat and barley; rye and oats not to so great an extent. Potatoes, pulse, vegetables, hemp and flax, are also raised. The wine produced is abundant in quantity, but not very excellent in quality. A large extent of ground is occupied by gardens and orchards. Cider is extensively made. The forests abound in game, and supply excellent timber, especially oak. On the meadows and uninclosed pastures, large numbers of live stock are fed. The number of horses in Seine-et-Marne is estimated at 36,000; of horned cattle, 85,000; of sheep, 75,000; of pigs, 23,000; of goats, 2000; of asses and mules, 3600. The sheep, which are mostly of the Merino breed, furnish an important part of the wealth of the country. There are also a large number of cows; and this department contributes to supply Paris with milk and cheese. The manufactures are various, but of no great importance. Among them are the pottery of Montereau, the paper of Marais, calico, leather, hardware, and other articles. Many of the people are employed in the quarries. An active trade is carried on in this department in the agricultural produce of the country, which is sent to Paris; also in cheese, timber, wool, manufactured goods, &c. Besides its

Seine-et-Oise.

five navigable rivers, the department is traversed by three railways, leading from Paris to Strasburg, Mulhouse, and Lyons, respectively, as well as by numerous roads. Seine-et-Marne forms the diocese of Meaux, and is under the jurisdiction of the Imperial Court at Paris. It contains 5 primary courts and 3 tribunals of commerce; 4 colleges, and 577 elementary schools. It is included in the first military division. The capital is Melun, and the five arrondissements are as follows:—

	Cantons.	Communes.	Pop. (1856.)
Melun	6	106	62,164
Fontainebleau	7	104	78,167
Meaux	7	161	91,515
Coulommiers	4	80	53,876
Provins	5	106	55,660
Total	29	557	341,382

Seine-et-Oise, a department of France, lying between N. Lat. 48. 18. and 49. 10., E. Long. 1. 29. and 2. 24.; bounded on the N. by the department of Oise, E. by that of Seine-et-Marne, S. by that of Loire, S.W. by that of Eure-et-Loire, and N.W. by that of Eure, entirely surrounding that of Seine. Length from N.W. to S.E. 70 miles; greatest breadth, 52; area, 2164 square miles. It consists of a beautiful expanse of country, rising in some places into hills of moderate elevation, with gentle slopes and level plains in other parts; the whole being richly cultivated and studded with stately forests, magnificent parks, noble castles, and quiet hamlets, with the placid stream of the Seine meandering through the land, and uniting with that of the Oise from the N.E. The other rivers are of smaller size, such as the Yêres and Epte, Essonne, and Orge, falling into the Seine. In its geological structure the greater part of the department belongs to the tertiary basin, in which Paris stands; but a narrow strip in the west is composed of chalky formations. Sandstone, paving-stone, millstones, chalk, plaster, potter's clay, and other minerals, are found in the department. There are sulphuric springs at Enghien, and at some other places within the limits of Seine-et-Oise. The climate is salubrious and temperate. The soil, not remarkably fertile by nature, has been rendered productive by careful cultivation. Agriculture is the principal source of wealth. Corn and wine are produced in superabundance. Potatoes, pulse, beet-root, and rape are also raised; and there are many orchards and forests which furnish large quantities of fruit and timber. The department contains 917,500 acres of arable land, 50,000 of meadows, 42,500 of vineyards, 195,000 of forests, and 27,500 of heaths and waste land. On the meadows are reared large numbers of live stock, especially sheep. The sheep-folds of Rambouillet, in this department, are celebrated. It is calculated that there are in Seine-et-Oise 70,000 cows, 520,000 sheep, 30,000 pigs, 55,000 horses 10,000 asses, &c. Poultry and fish abound in the department, but game has become exceedingly scarce. Besides agricultural and pastoral employments, many of the inhabitants are engaged in manufactures of various kinds. The celebrated porcelain of Sèvres is one of the most important of the articles manufactured; and among the others are cotton and linen cloth, hosiery, paper, fire-arms, gunpowder, &c. In these articles, as well as in corn, wool, and timber, an active trade is carried on. Besides three navigable rivers, the Seine, Marne, and Oise, there are in the department a canal and numerous roads; while all the railways that diverge from Paris traverse it for a longer or a shorter distance. Seine-et-Oise forms the see of Versailles, and is subject in legal matters to the Court of Appeal at Paris. It has a lyceum, two colleges, a normal seminary, and 1100 elementary schools. The capital is Versailles, which has a population of about 36,000, and there are six arrondissements, as follows:—

	Cantons.	Communes.	Pop. (1856.)
Versailles	10	114	162,449
Mantes	5	126	57,328
Rambouillet	6	119	66,840
Corbeil	4	94	61,557
Pontoise	7	165	95,256
Etampes	4	60	40,749
Total	36	678	484,179

Seine-Inférieure.

Seine-Inférieure, a department of France, lying between N. Lat. 49. 15. and 50. 4., E. Long. 0. 2. and 1. 49.; bounded on the N. and W. by the English Channel, S. by the department of Eure, and E. by those of Oise and Somme. Length from E. to W. 76 miles; greatest breadth, 45; area, 2326 square miles. A low branch of the Ardennes traverses the country from east to west, terminating on the sea at Cape La Hève, which is the most westerly point of the department, and the only considerable headland on its coast. This chain of hills separates the waters of the Seine from those that flow into the Channel; on either side of it are extensive plains, furrowed by valleys of no great depth, which are bordered with low sloping hills. The coast is almost entirely formed of chalk cliffs, interrupted only where the rivers fall into the sea. These cliffs attain their highest elevation, 700 feet above the sea, at Fécamp, nearly opposite Beachy Head, in Sussex. The principal river in the department is the Seine, which pursues its tortuous course along the southern boundary, and receives many small affluents from the north. The largest of these are the Epte and the Andelle, which have their sources, and the upper part of their streams, in Seine-Inférieure. Of the rivers that flow directly into the Channel, the principal are the Bresle, the Yères, and the Arques, with its affluents, the Eaulne and the Béthune. The country belongs entirely to the cretaceous formation. Many valuable minerals are obtained, such as marble, building-stone, marl, chalk, potter's-clay, sand for glass-works, peat, &c. There are mineral-springs in several places, but those of Forges alone are frequented. The climate is moist, and in general colder than that of the opposite coast of England. Although the department contains many very rich tracts of ground, yet as there are large portions of a very different character, it is on the whole not remarkable for fertility. But agriculture is in a flourishing state; improved modes of cultivation and manuring are employed; and the farms are in general distinguished by the neatness of their homesteads and gardens. Along the sea-shore there are many swampy and sandy tracts; among the hills much ground adapted only for pasture; and in the south of the department many large forests. The extent of arable land is 945,000 acres; of meadows, 70,000 acres; of forest, 170,000 acres; and of heaths, 45,000 acres. Wheat is the principal kind of corn raised. Pulse, turnips, rape, potatoes, hemp, and flax, are also among the crops grown. Much of the ground is laid out in gardens and orchards, which yield various kinds of fruit. The horses of the country are good for draught; the cattle and sheep are of inferior breeds. It is calculated that the department contains 90,000 horses, 150,000 head of cattle, 550,000 sheep, and 60,000 pigs. The Seine abounds in salmon, sturgeon, soles, and other fish; and there are also, along the coast, productive fisheries, which supply the Parisian market with herring, mackerel, and oysters. The department is celebrated for its manufacturing industry, which is actively carried on in every part, and especially in the large towns. There are a great number of bleach-fields, which give to cloth a superior whiteness above those of other parts of the kingdom. All sorts of cotton and woollen manufactures are also carried on, the former especially at Rouen; leather, silk, glass, pottery, bricks, sugar, and chemical substances are among the other goods manufactured. There are twelve ports in the department, the chief of which are Dieppe,

Fécamp, Havre, Harfleur, and Rouen. Through these a considerable trade is carried on with England and other countries; and by means of the Seine commercial intercourse is kept up with Paris. The department is traversed by two railways, from Paris to Havre, and from Rouen to Dieppe. Seine-Inférieure forms the diocese of Rouen, and contains several law-courts, subordinate to the Court of Appeal at Rouen. There are a lyceum, 5 colleges, a normal seminary, 4 upper and 1128 elementary schools. The chief town is Rouen, and the department is subdivided into 5 arrondissements, as follows:—

	Cantons.	Communes.	Pop. (1856.)
Rouen	15	155	265,602
Dieppe	8	168	112,769
Les Havre	9	122	175,014
Neuchatel	8	145	81,339
Yvetot	10	170	134,726
Total	50	760	769,450

SEISIN. See INFEFTMENT.

SEISTAN, formerly called *Segestan*, and sometimes *Nimroz*, a khanat or principality of Asia, forming the southwest portion of Afghanistan, bounded on the north by Herat, east by Kandahar, south by the Great Desert, which separates Afghanistan from Beloochistan, and west by Persia. It lies between N. Lat. 30. 30. and 32. 0., E. Long. 61. 0. and 62. 30., and is nearly oval in form, about 100 miles in length from N. to S., and 60 in breadth, with an area of about 5000 square miles. Though this region is raised to a height of probably not less than 2500 feet above the sea, it is, in comparison with the surrounding country, very much depressed. From the southern foot of the great Caucasian Mountains, which traverse Afghanistan from E. to W., a vast expanse of desolate ground stretches to the S.W., gradually sloping downwards, till it is met on the west by a chain of hills extending southwards, and on the south by the elevated desert of Beloochistan. In the lowest part of this vast slope lies Seistan. The whole country is an extensive plain, except one small hill near the eastern shore of the Great Lake, or Hamoon. This is merely a sheet of shallow water, or swamp, into which the rivers flow from the surrounding countries, for none of the streams that enter Seistan can flow out from it again. They consequently stagnate in the more depressed places, and form shallow lakes, which are constantly changing their form and size. The largest of these is the Great Hamoon, about 70 miles long, and from 15 to 20 wide. The principal rivers that flow into Seistan are the Helmund, the Khash Rood, and the Ibrahim Joi, from the east; the Furrah Rood and Adruscund from the north; and the Bundau from the west. All these, even the largest, are rather mountain-torrents than perennial rivers, rushing down at one time with a full volume of muddy water, and at another with merely a small stream in the bottom of the channel, which, in the case of the smaller rivers, is left dry altogether. Most of the lakes and morasses are imbued with salt, so that the water is frequently not drinkable. The soil in some parts is rich and fertile, and along the banks of the Helmund it is well cultivated; but the climate is excessively hot, and the atmosphere unhealthy. Wheat, rice, and other grains, as well as cotton and tobacco, are grown. There are no forests here, but dense jungle of tamarisks cover, in many parts, the face of the country. Beasts of prey, such as leopards, wolves, jackals, hyænas, &c., abound here; there are also many wild-asses, wild-boars, deers, porcupines, hedgehogs, &c. Domestic animals do not thrive well here; horses cannot be kept, and cows are subject to a great mortality. The majority of the inhabitants are of Persian origin, but there are also many Afghans and Beelooches, and a few Hindus. They live in felt tents, and are mostly employed in hunting and fishing. Their language is a broken Persian, and their religion Mohammedanism. They are governed by a khan who resides at Dovshak, but who has little power on account of the numerous petty chieftains in the country. Seistan was once a fertile and flourishing country, full of large and magnificent cities, whose ruins still lie strewed for miles over the plain. The rivers were embanked, and the soil enriched by a careful system of irrigation. All this prosperity was destroyed by the conquest of the country in 1383, by Tamerlane, who exterminated the inhabitants, and laid the towns in ruins. The present population is from 50,000 to 60,000.

SEJANT. See HERALDRY.

SEJANUS, LUCIUS ÆLIUS, an infamous tool of the Emperor Tiberius, was a native of Vulsinii, in Etruria, and was son of Seius Strabo, a Roman knight who flourished during the reign of Augustus and the beginning of that of Tiberius. After spending a very immoral youth, Sejanus at length gained the favour of the reigning sovereign, Tiberius. Once the wily youth had the emperor in his grasp, nothing could part them but the death of either, as it subsequently proved. Possessed of a body capable of enduring the most unheard of fatigues, endowed with a mind fit for the highest species of subtlety and cunning, of manners the most polite and insinuating towards his equals, the most cringing towards his superiors, and the most haughty and imperious to those beneath him, the weak emperor, in opening his bosom to Sejanus, disclosed himself unwarily to a most subtle intriguer. On the death of Augustus, in A.D. 14, Sejanus was sent by Tiberius, together with his son Drusus, to quell the insurgents in Pannonia. On the father of Sejanus being sent to Egypt, the son was chosen sole commander of the prætorian cohorts. He urged upon Tiberius the propriety of concentrating these bands all in one place, and he instructed him not to divide their powers of effective action by scattering them throughout the city. The emperor complied. The object of Sejanus was to popularize himself with the soldiery, and he succeeded to admiration. He dealt out honours to the prætorian guard with lavish hand, which came back to him in statues and busts in the public places of Rome. It was evident Sejanus aspired to the purple. There was, however, more than one obstacle in his path, which he resolved silently to remove. Drusus, the son of Tiberius, and the children of Germanicus, all stood in his way. He seduced the wife of Drusus, and by promising her immediate marriage, and a participation in the imperial power to which he aspired, induced her to poison her husband. Sejanus now divorced his wife Apicata, and solicited the emperor to permit him to wed the wife of the murdered Drusus. The emperor couched his answer in ambiguous language. Sejanus now required to act with caution. After various manœuvring, he induced the emperor to shut himself up in the island of Capræa, where he had full scope for his machinations. The death of Livia, the mother of Tiberius, was soon followed by the banishment of Agrippina, the wife of Germanicus, and her two sons, Nero and Drusus. The path was now clear before Sejanus; yet Tiberius, who possessed more than his share of cunning, began to suspect him. The emperor had duplicity sufficient to conceal his suspicions. He made the tyrant joint consul with himself, and elevated him and his son to a pontificate. Sejanus felt the ground giving way under him, but what could he do to prevent it? Sertorius Macro was sent to Rome to assume the command of the prætorian cohorts, with a letter from Tiberius which he was to read to the senate. The emperor could never express himself clearly when he wished to say anything dangerous to the imperial power. The senate and the populace caught the drift of the royal epistle, however, which was plainly to have done with Sejanus. No word of consolation was spoken for the great criminal. He was conducted to prison, amid the hootings and yellings of the multitude,

who tore down his statues and busts as he passed them by. Next day his body was dragged through the streets of Rome, and what remained of it was flung into the Tiber. The chief authorities for the history of Sejanus are Tacitus, Suetonius, and Dion Cassius.

SELBY, a market-town of England, in the West Riding of Yorkshire, on a flat spot on the right bank of the Ouse, 14 miles S. by E. of York, and 175 N.N.W. of London. It is well though irregularly built, consisting of four principal streets, meeting in a central market-place, in which stands an old Gothic cross. The most conspicuous edifice is the noble old parish church, which originally formed part of a Benedictine abbey, founded by William the Conqueror in 1068. It is cruciform in plan, partly in the Norman and partly in the early English styles; its dimensions are 267 feet by 100. In it are some fine specimens of stained glass and carved stone-work. The other places of worship in the town belong to Wesleyan and Primitive Methodists, Independents, Baptists, Quakers, Roman Catholics, and Unitarians. Among the public buildings of Selby there are also a town-hall, and another hall for public meetings, erected in 1841. There are various schools and libraries, a mechanics' institution, and a news-room. The manufacturing establishments include boat-building yards, iron and brass foundries, breweries, tanneries, sailcloth and rope manufactories. The river is navigable up to Selby for vessels of 200 tons, and is crossed here by a moveable wooden bridge. A considerable trade is carried on in corn and cattle, as well as in the produce of the manufactures. Besides weekly markets, several annual fairs are held here. Pop. (1851) of the town, 5109; of the parish, 5340.

SELDEN, JOHN, one of the most learned men of his time, as well as a distinguished statesman and lawyer, was born at Salvington, in Sussex, on the 16th December 1584. His father was John Selden, a minstrel, and his mother, whose heart the minstrel is said to have won by his proficiency in music, was Margaret Baker, a descendant of a knightly family of that name in Kent. Their son John received his early education at the free grammar school of Chichester, where he progressed so rapidly in his studies, that he was removed to Hart Hall, Oxford, at the early age of fourteen. After remaining there for four years, he entered himself at Clifford's Inn for the study of law, and in 1604 he removed to the Inner Temple. "After he had continued there," says Wood, "a sedulous student for some time, he did, by the help of a strong body and a vast memory, not only run through the whole body of the law, but became a prodigy in most parts of learning, especially in those which were not common, or little frequented or regarded by the generality of students of his time. So that in a few years his name was wonderfully advanced, not only at home, but in foreign countries, and was usually styled the great dictator of learning of the English nation." His reputation for learning, particularly on all subjects connected with law, must speedily have gained him a lucrative practice, though he was more employed as a conveyancer and chamber counsel than as a pleader. Indeed, judging from what of his speeches remain, eloquence cannot be said to have been one of his distinguishing qualifications. His earliest work, the *Analecton Anglo-Britannicon*, a chronological digest of records relating to the history of England previous to the Norman invasion, was finished in 1607, but was not published till eight years afterwards. In 1610 appeared his *England's Epinomis*, and *Jani Anglorum facies altera*, both illustrative of the state and progress of English law; and the same year he published an essay on *The Duel* or *Single Combat*. In 1614 appeared his largest English, and in the opinion of some his best, book, on *Titles of Honour*, a work which is still regarded as an authority upon that subject. In 1617 he published the first edition of his celebrated work, *De Diis Syris*, and the following year his *History of Tithes*. In the latter of these works, while maintaining the legal, he denied the divine right of the clergy to receive tithes; and in consequence was summoned before the High Commission Court, when he had to make a public acknowledgment of his sorrow for having published his opinions, though he did not in any way recant them.

In 1621, Selden, though not then a member of the House, was sent for by the Commons to give his opinion on the questions in dispute between them and the Crown. On that occasion he advised them so strongly to maintain their rights and privileges, that he was committed to prison; but through the influence of the bishop of Winchester, he was liberated after an incarceration of five weeks. In 1624 he sat in Parliament as one of the representatives of the borough of Lancaster, but took no prominent part in the business of that session. The same year he was chosen reader of Lyons Inn, but refused to accept the office, which so offended the benchers that they ordered him to be fined, and to be for ever disabled from being called to the bench. This order, however, was subsequently rescinded, and Selden was called to the bench in 1632. In the first parliament of Charles I., which met in 1625, Selden sat as one of the representatives of Great Bedwin, and declared himself so warmly against the Duke of Buckingham, that when, in the following parliament, his Grace was impeached by the House of Commons, he was one of the members appointed to prepare the articles and to manage the prosecution. In the parliament which met in March 1628, Selden again represented the town of Lancaster, and took a very prominent part in the proceedings. He rendered very efficient aid in the preparation of the celebrated Petition of Rights, and was one of the speakers appointed to confer with the Upper House in order to obtain its concurrence in an address to the king. The result was, that the measure, having the support of both Houses, at length received the reluctant assent of the king. Selden was also one of those that drew up a remonstrance to the king for the removal of Buckingham, and demanded that judgment be given against him upon the impeachment of the last parliament; and also a remonstrance declaring that the impost of tonnage and poundage was no prerogative of the crown. In all these matters Selden's vast learning was of the utmost importance. His knowledge of the laws and constitution of the country furnished him with numerous authorities, and enabled him to support his arguments with an unanswerable mass of facts and precedents. It was in this that he was chiefly distinguished as a debater.

During the recess he applied himself to literary pursuits, and gave to the world his *Marmora Arundeliana*, an account of the Arundelian Marbles, which had lately been brought to England. Parliament again met in January 1629, and Selden appeared more active than ever in the popular cause. The violent opposition of this parliament to the measures of the court speedily brought about its dissolution, and Selden with several others were committed to the Tower. At first their treatment was extremely harsh and rigorous, being denied even the use of books or writing materials. At length, after a confinement of eight months, they were brought up before the King's Bench, and offered their liberty upon granting security for their good behaviour. This, however, was refused; and, though the strictness of their confinement was more and more relaxed, till it became little more than a name, it was not till May 1631 that Selden, through the influence of the Earls of Arundel and Pembroke, was liberated on bail, and not till the beginning of 1634 that he received a free discharge. In 1646, parliament voted L.5000 to be paid to each of these gentlemen, or their heirs, for the losses they had sustained on this occasion. Among the fruits of this period were his two learned works, *De Successionibus in Bona*

Defuncti ad Leges Hebræorum, and *De Successione in Pontificatum Hebræorum.*

In 1635 was published his *Mare Clausum*, a work written a good many years before in answer to Grotius's *Mare Liberum*, and now published at the request of the king, in consequence of a dispute with the Dutch regarding their fisheries on our shores. It was dedicated to his majesty, and this has been regarded by many as indicating a change in Selden's views regarding the court party. Be this as it may, we do not find that he was so frequently or prominently opposed to the court party as formerly. The next four years of Selden's life yield us nothing of interest; but at the end of that period he published his *De Jure Naturali et Gentium juxta Disciplinam Hebræorum.* It is not a little remarkable that Selden does not appear to have taken any part in the great Ship-money case of 1638, although his services would have been of the utmost value on behalf of Hampden. It may be that he declined to interfere, or perhaps the Hampden party saw reason to suspect him of an inclination towards the court party.

In 1640 he was unanimously chosen to represent the University of Oxford in the Long Parliament, and we now find him not only less violently opposed to the Crown party, but very frequently supporting their measures. He gave his opinion with the king as to the right of the bishops to a seat in parliament; and though he was one of the members named by the House to prepare the accusations against the Earl of Strafford, he was not one of those appointed to conduct the prosecution, and voted against the majority who condemned the earl. He also opposed the resolutions of the House which led to the exclusion of the bishops from parliament. The Lord Keeper Littleton having displeased the king, Charles wrote to Lord Falkland requiring that the great seal be taken from the present keeper, and given either to Banks or Selden. That this offer was made by the king from a belief that Selden was in his interest, may be readily supposed, seeing that afterwards, when Selden opposed in the House the king's Commission of Array, his majesty was much troubled, and desired Lord Falkland to write a friendly letter to Selden on the subject. Selden acknowledged that he had spoken all the more strongly against the commission, in order that he might be able to speak the more freely against the ordinance of the parliament for the militia, to which he was equally opposed, and which was to be brought up for discussion on a subsequent occasion. This he also did his utmost to overthrow, but unsuccessfully. In 1643 he was appointed one of the lay members to sit in the Assembly of Divines at Westminster, and the same year he was appointed by the House of Commons keeper of the records in the Tower. In 1644 he subscribed the Solemn League and Covenant, and the following year he was one of the twelve commoners chosen Commissioners to the Admiralty. The same year he was chosen Master of Trinity Hall, Cambridge, an honour which he declined; and in 1647 he was appointed one of the parliamentary visitors of Oxford University.

When Selden found that there was no possibility of a reconciliation being effected between the king and the parliament, he seems to have withdrawn himself from the arena of political strife. His name does not appear among those members who were imprisoned or expelled by the army, nor yet among those who continued to assume the office of legislators. He took no part in the arraignment of the king, and it does not even appear what his opinion was on that transaction. Cromwell seemed desirous to secure his services, and is said to have applied to him, personally and through mutual friends, to answer the *Eikon Basilike*, but he declined. Whatever opinion may be formed of Selden's conduct latterly, it is no small argument in favour of his consistency and uprightness, that he retained the confidence and good-will of both parties at a time when party feeling ran so high. The true explanation seems to be, that, foreseeing the calamities of a civil war, to which the violent proceedings of the popular party were evidently leading, he did what he could to check them. He died, on 30th November 1654, at White Friars, the house of the dowager Duchess of Kent, with whom he lived as legal adviser, and to whom he is said by some to have been married. "Mr Selden," says Lord Clarendon, "was a person whom no character can flatter, or transmit in any expressions equal to his virtue. He was of so stupendous learning in all kinds, and in all languages (as may appear in his excellent and transcendent writings), that a man would have thought he had been entirely conversant amongst books, and had never spent an hour but in reading and writing; yet his humanity, courtesy, and affability was such, that he would have been thought to have been bred in the best courts, but that his good nature, charity, and delight in doing good, and in communicating all he knew, exceeded that breeding. His style in all his writings seems harsh, and sometimes obscure, which is not wholly to be imputed to the abstruse subjects of which he commonly treated, out of the paths trod by other men, but to a little undervaluing the beauty of a style, and too much propensity to the language of antiquity; but in his conversation he was the most clear discourser, and had the best faculty of making hard things easy, and presenting them to the understanding, of any man that hath been known." Among his later works may be mentioned *De Anno Civili et Calendaris Reipublicæ Judaicæ; Uxor Hebraica seu de Nuptiis et Divorciis; De Synedriis et prefecturis Juridicis veterum Hebræorum; De Nummis.* A complete edition of his works, with a Memoir of the Author, by Dr David Wilkins, appeared in 6 vols. folio, 1726. Selden's name is best known in the present day by his *Table-Talk*, a work published thirty-five years after his death by Richard Milward, who had acted as his amanuensis for twenty years. It is a collection of his remarks and opinions on various subjects, especially relating to religion and politics.

SELEUCIA, or SELEUCEIA (Σελεύκεια), several ancient cities founded by Seleucus Nicator, king of Syria, and called after his name. The most important are the following:—

SELEUCIA PIERIA, the seaport of Antioch, on the north side of the Bay of Antioch, at the foot of a mountain anciently called Coryphaeum, now Jebel Musa, about 8 miles N. by W. of the mouth of the Orontes. It was strongly fortified with a double line of defences, connected with a castellated fort on the summit of the hill. The harbour was well suited for the galleys of the ancients, and of its substantial piers considerable portions still remain. Besides the outer port, formed by two piers, there was an inner basin, to which an entrance was cut through the solid rock, and defended by a tower on each side. For supplying water to the harbour a great work was constructed, consisting partly of tunnels and partly of deep cuttings, for a distance of 1088 yards. Of all these structures, as well as of several temples, an amphitheatre, and many tombs in the rocks, considerable remains are yet to be seen, confirming the accuracy of the description that Polybius gives of the city. Seleucia was a place of much importance in the wars between the Syrian and Egyptian monarchs. It was taken by Ptolemy Euergetes during his invasion of Syria, and retained by the Egyptians until the time of Antiochus the Great. This monarch led an army against the city, and by taking the suburb and arsenal, forced it to surrender, about 220 B.C. Seleucia afterwards passed into the hands of the Romans, and received from Pompey the dignity of a free city. It is noted in Scripture history as the place where Paul set sail on his first missionary journey (Acts xiii. 4).

SELEUCIA TRACHEOTIS, an important town of Cilicia, in

a fertile plain on the left bank of the Calycadmus, about 68 miles S.W. of Tarsus. It was well built, much superior in style to the other towns of the country, and attracted many to it on account of the beauty of its situation, as well as an oracle of Apollo which it possessed, and an annual festival which was held here. No historical event of any importance is connected with the name of Seleucia Tracheotis. Extensive remains of the ancient city still exist at a place called Selefkieh. Among these may be traced a theatre, temple, and other large buildings.

SELEUCIA-ON-THE-TIGRIS, so called from its position, in order to distinguish it from the other towns of that name, stood at the point where an artificial canal connected the waters of the Euphrates and Tigris, 40 miles N. of Babylon. It was a large and important city, containing, it is said, in the time of its prosperity, a population of 600,000 souls; and it was second in commercial importance only to Alexandria. Having been the capital of the Macedonian possessions in the East, Seleucia still retained, after the fall of that empire, an independent position, and a thoroughly Greek character. It was governed by a senate of 300, was strongly fortified, and thus able to defy the power of the Parthians, whose empire reached almost to the gates. The oriental city of Ctesiphon rose on the other side of the Tigris, only three miles off, and finally supplanted Seleucia in the power and splendour which it had inherited from the old Babylon. It was the Romans, however, who took and sacked Seleucia, notwithstanding its hostility to their enemies, 165 A.D. From this blow the city never recovered; and the place relapsed into a marshy desert.

SELEUCIDÆ, or the Syro-Macedonian era, is a computation of time, commencing from the establishment of the Seleucidæ (by Seleucus Nicator), a race of Greek kings, who reigned as successors of Alexander the Great in Syria, as the Ptolemies did in Egypt. This era we find expressed in the books of the Maccabees, and on a great number of Greek medals struck by the cities of Syria. The Jews call it the era of contracts, and the Arabs the era of the two horns. According to the best accounts, the first year of this era falls in 311 B.C., being twelve years after Alexander's death.

SELEUCUS I. and his successors. See SYRIA.

SELIM. See TURKEY.

SELIMNO, SELIMNIA, or ISLEMJE, a town of European Turkey, Rumelia, in the eyalet, and 70 miles N. by W. of Adrianople, at the south foot of the Balkan Hills. It is enclosed by walls, and contains three mosques. Here are extensive plantations of roses, and manufactures of the essence of roses, of cloth, and of highly-prized fire-arms and gun-locks. Large fairs are held here; and it is one of the most important places of trade in Turkey. The inhabitants are almost all Bulgarians. Pop. 20,000.

SELINUS, the most westerly, as well as one of the most important, of the Greek colonies in Sicily, on the south coast of that island, at the mouth of a small river, 4 miles W. of the Hypsas. The original settlers came partly from Megara Hyblaea, on the east coast of Sicily, and partly from Megara in Greece, the parent city of that colony. The date of the settlement is not exactly known, but was probably about 628 B.C. It derived its name (from σελινὸς, wild parsley) from the quantities of that herb which grew in the vicinity, and adopted a sprig of it as the symbol of the city. Selinus rapidly rose to a high degree of power and prosperity; but was involved in frequent contests with the aborigines and the Carthaginians. The city of Segesta, too, was a formidable rival, and frequently an enemy. Selinus was in alliance with Carthage when Hamilcar undertook his expedition against Sicily in 480 B.C., but rendered no effectual aid to that general. But at the time of the Athenian expedition against Syracuse, Silenus had enjoyed half a century of peace and prosperity, and acquired great military resources and large stores of wealth. In the disputes between Selinus and Segesta, the former called in the aid of Syracuse, and the latter that of Athens. Hence the Athenian siege of Syracuse. After its failure, the Selinantines pressed their enemies to extremities, and so led them to call in the aid of Carthage. With this assistance they defeated the forces of Selinus in 410 B.C; and in the following spring an army of 100,000 Carthaginians, under Hannibal, son of Gisco, landed in Sicily, and before any of its allies could send succour, laid siege to Selinus. Notwithstanding a desperate resistance, the place was taken, after ten days' siege. The walls were destroyed; and though permission was given to the inhabitants to occupy the city, as subjects of Carthage, Selinus never recovered its former prosperity. During the first Punic war the Carthaginians destroyed the city, and removed its inhabitants to Lilybaeum. Selinus was never rebuilt, and its site is now completely desolate, and overgrown with brushwood. The remains of the ancient walls may be traced on a small hill near the sea, and within their limits the ruins of three Doric temples lie. Outside the walls, which enclose a comparatively small area, are traces of two edifices, whose character is unknown; and on a hill to the east stood three temples, which must have been among the largest and most magnificent in the ancient world. The place is now called *Torre dei Pulci.*

SELJOOK. See ASIA, § *Turkish Tribes.*

SELKIRK, ALEXANDER, whose adventures gave rise to Defoe's well-known historical romance of *Robinson Crusoe*, was born at Largo, in Fifeshire, Scotland, about the year 1676. He was bred a seaman, and went from England, in 1703, in the capacity of sailing-master of a small vessel, called the Cinque-Ports Galley, Charles Pickering captain. In September of the same year he sailed from Cork, in company with another ship, called the St George, commanded by the celebrated navigator William Dampier, intended to cruise against the Spaniards in the South Sea. On the coast of Brazil Pickering died, and was succeeded in the command by his lieutenant, Thomas Stradling. They proceeded on their voyage round Cape Horn to the island of Juan Fernandez, whence they were driven by the appearance of two French ships, of 36 guns each, and left five of Stradling's men there on shore, who were taken off by the French. From this they sailed to the coast of America, where Dampier and Stradling quarrelled, and separated by agreement, on the 19th of May 1704. In September following, Stradling came again to the island of Juan Fernandez, where Selkirk and his captain had a difference, which, with the circumstance of the ship's being very leaky, and in bad condition, induced him to determine upon staying there alone; but when his companions were about to depart, his resolution was shaken, and he desired to be taken on board again. The captain, however, refused to admit him, and he was obliged to remain, having nothing but his clothes, bedding, a gun, and a small quantity of powder and ball; a hatchet, a knife, and a kettle; with his books, and mathematical and nautical instruments. He kept up his spirits tolerably till he saw the vessel put off, when, as he afterwards related, his heart yearned within him, and melted at parting at once with his comrades and all human society.

Thus left sole monarch of the island, with plenty of the necessaries of life, he found himself in a situation which was hardly supportable. He had fish, goats' flesh, turnips and other vegetables; yet he grew dejected, languid, and melancholy, to such a degree as to be scarcely able to refrain from doing violence to himself. Eighteen months passed before he could, by reasoning, reading his Bible, and study, be thoroughly reconciled to his condition. At length he grew happy, employing himself in decorating his huts, chasing the goats, which he equalled in speed, and scarcely

ever failed in catching. He also tamed young kids, laming them to prevent their becoming wild; and he kept a guard of tame cats about him, to defend him when asleep from the rats, that were very troublesome. When his clothes were worn out, he made others of goat-skins, but could not succeed in making shoes, with the use of which, however, habit, in time, enabled him to dispense. His only liquor was water. He computed that during his abode in the island he had caught a thousand goats, of which he had let go five hundred, after marking them by slitting their ears. Commodore Anson's people, who were there about thirty years afterwards, found the first goat which they shot upon landing was thus marked, and, as it appeared to be very old, concluded that it had been under the power of Selkirk. But it appears by Captain Carteret's account of his voyage in the Swallow sloop, that other persons practised this mode of marking, as he found a goat with his ears thus slit on the neighbouring island of Mas-a-fuera, where Selkirk never was. He made companions of his tame goats and cats, often dancing and singing with them. Although he constantly performed his devotions at stated hours, and read aloud, yet, when he was taken off the island, his language, from disuse of conversation, had become scarcely intelligible. In this solitude he continued four years and four months, during which time only two incidents happened which he thought worth relating, the occurrences of every day being in his circumstances nearly similar. The one was that, pursuing a goat eagerly, he caught it just on the edge of a precipice which was covered with bushes, so that he did not perceive it; and he fell to the bottom, where he lay, according to Captain Rogers's account, twenty-four hours senseless; but, as he related to Sir Richard Steele, he computed, by the alteration of the moon, that he had lain three days. When he came to himself, he found the goat lying under him dead. It was with great difficulty that he could crawl to his habitation, whence he was unable to stir for ten days, and did not recover of his bruises for a long time. The other event was the arrival of a ship, which he at first supposed to be French. And such is the natural love of society in the human mind, that he was eager to abandon his solitary felicity, and surrender himself to them, although enemies; but upon their landing he found them to be Spaniards, of whom he had too great a dread to trust himself in their hands. They were by this time so near that it required all his agility to escape, which he effected by climbing into a thick tree, being shot at several times as he ran off. Fortunately the Spaniards did not discover him, though they stayed some time under the tree where he was hidden, and killed some goats just by. In this solitude Selkirk remained until the 2d of February 1709, when he saw two ships come into the bay, and knew them to be English. He immediately lighted a fire as a signal; and on their coming to shore, found they were the Duke, Captain Rogers, and the Duchess, Captain Courtney, being two privateers from Bristol. He gave them the best entertainment he could afford; and as they had been a long time at sea without fresh provisions, the goats which he caught were highly acceptable. His habitation, consisting of two huts, one to sleep in, and the other for dressing his food, was so obscurely situated, and so difficult of access, that only one of the ship's officers would accompany him to it. Dampier, who was pilot on board the Duke, and knew Selkirk very well, told Captain Rogers that, when on board the Cinque-Ports, he was the best seaman in the vessel, upon which Captain Rogers appointed him master's mate of the Duke. After a fortnight's stay at Juan Fernandez, the ships proceeded on their cruise against the Spaniards; plundered a town on the coast of Peru; took a Manilla ship off California; and returned by way of the East Indies to England, where they arrived on the 1st of October 1711—Selkirk having been absent, on the day of his arrival in London, eight years, one month, and three days, more than half of which time he had spent alone on the island. The public curiosity being excited respecting him, he was induced to put his papers into the hands of Defoe, to arrange and form them into a regular narrative. These papers must have been drawn up after he left Juan Fernandez, as he had no means of recording his transactions there. Captain Cooke remarks, as an extraordinary circumstance, that he had contrived to keep an account of the days of the week and the month; but this might be done, as Defoe makes Robinson Crusoe do, by cutting notches in a post, or many other methods. From this account of Selkirk, Defoe adopted the notion of writing a more extensive work, the famous romance of *Robinson Crusoe*. After his return to England, Selkirk waited in London till he got his effects realized, and then proceeded, in the spring of 1712, to his native village of Largo. For a few days he enjoyed the society of his relatives and friends; but, from long habit, he soon felt averse to society, and was most happy in being alone. In the upper part of the garden attached to his father's house he formed a kind of cave or grotto, which commanded an extensive and delightful view of the bay of Largo, and the shores of the Forth. In musing here, or wandering through a secluded and solitary valley called Keil's Den, and fishing in the bay, he spent the greater part of his time. How long he remained here cannot be ascertained, but he eloped some time afterwards with a girl of the neighbourhood, named Sophia Bruce, and proceeded with her to London. He never returned to Largo, and but little is known of him during the latter part of his life. Sophia Bruce appears to have died between 1717 and 1720; for in the latter year he again married Frances Candis, who survived him. Selkirk died lieutenant on board his Majesty's ship Weymouth, some time in the year 1723; and it is believed that he had no children by either of his wives. (See *Life and Adventures of Alexander Selkirk*, by John Howell, Edinburgh.)

SELKIRK, an ancient royal burgh, and chief town of the county of Selkirk, in Scotland. It is situated on an elevation overlooking the valley of the river Ettrick, 33 miles S.S.E. of Edinburgh, and commands an extensive view. It consists chiefly of one street, which expands at the market-place into an open space; in which is a fine monument and statue of Sir Walter Scott. The town has not increased in size or importance for centuries; but it has been much improved of late years, and now contains many good houses, with a town-hall, having an elegant spire 110 feet in height, and containing apartments for the burgh and sheriff courts. There are five places of worship—one belonging to the Established Church, one to the Free Church, two to the United Presbyterians, and one to the Episcopalians. A new prison has been erected at the north side of the town; and it also possesses several excellent schools, a savings bank, three libraries, and a reading-room. Selkirk was formerly famed for the manufacture of shoes, in which it had an extensive trade; but it has now no manufactures of any consequence, except those of tweeds, blankets, and hosiery; which have been recently introduced here from Galashiels. The burgh is governed by a provost, two bailies, and twelve councillors; and it votes with the county in returning a member to Parliament. During the wars between England and Scotland, the citizens of Selkirk were famed for their courage. A party of them, under the command of the town-clerk, William Brydone, fought with much gallantry at the battle of Flodden. Brydone was afterwards knighted for his conduct; and the town received from James V. a grant of a thousand acres, as a recompense for the courage of the burghers; but it was totally burned by the English, in revenge for the bravery displayed by its citizens. A mile north from the town is Philiphaugh, where the celebrated Marquis of Montrose was defeated

Selkirkshire.

by the Covenanters under General Leslie. Pop. (1851) 3314.

SELKIRKSHIRE, a county of Scotland, situated between 55. 2. and 55. 42. N. Lat., and between 2. 48. and 3. 20. W. Long. It has Mid-Lothian or Edinburghshire on the N.; Roxburghshire on the E. and S.E.; Dumfriesshire on the S.; and Peeblesshire, or Tweeddale, on the W.; the line which separates it from these counties being on all sides, but especially the south, exceedingly irregular. Its extreme length, from N.E. to S.W., is 28 miles, its extreme breadth 16, and its area 264½ square miles, equal to 169,280 English acres. It includes only three entire parishes, Yarrow, Kirkhope, and Ettrick—the parishes of Selkirk and Galashiels being partly in Roxburghshire. These may be said to form the county, although small parts of the parishes of Ashkirk, Innerleithen, Peebles, Roberton, and Stow, are also included in it.

This is almost entirely a pastoral district, and in many respects bears a resemblance to the higher parts of the contiguous county of Roxburgh. Like the latter county, the general declivity of the mountain range is from west-south-west to east-north-east, and all its streams discharge themselves into the Tweed. The rocks are of the transition series, and are chiefly graywacke, graywacke-slate, and clay-slate. On the borders of Peeblesshire extensive layers of porphyry, alternating with thin strata of slate and granite, are to be found. The hills are generally ridge-shaped, and rounded on the tops, with acclivities of from 10° to 30°. The secondary valleys are small, since the Ettrick and Yarrow run nearly parallel, and at no very great distance from each other; but where the Yarrow and Tweed diverge, the valleys increase in magnitude, as they are then drained by larger streams. Several of the hills are above 2000 feet in height—such as Windlestraw Law (2295), at the northern extremity of the county, on the confines of Mid-Lothian; Blackhouse Heights (2370); Minchmoor (2280), on the borders of Peeblesshire; and Ettrick-pen (2200), on the south-west boundary. The lower hills are for the most part green, and afford good pasturage for sheep; but heath prevails on many of the higher grounds, especially towards the south-west.

The rivers are—the Tweed, which crosses the north side of the county in its course from Peeblesshire on the west to Roxburghshire on the east; the Gala, which for some distance forms the boundary with Roxburghshire on the north-east, and falls into the Tweed, from the north, a little below Galashiels; the Cawdor, a very beautiful stream, which also joins the Tweed from the north; the Ettrick and Yarrow, which have their sources on the confines of the county of Dumfries, and, flowing north-east almost parallel to each other, join their streams above Selkirk, and afterwards, under the name of Ettrick, passing to the west of that town, and for a short distance along the boundary with Roxburghshire, enter the Tweed; the Ale, which rises in the south-east, and soon after passes into Roxburghshire; and also the Borthwick, which washes the south-eastern boundary. Next to the Tweed, the most considerable waters are the Ettrick and the Yarrow, which receive, in the first instance, nearly all the other streams that traverse this district. The scenery on the Yarrow is exceedingly romantic and delightful. Soon after its rise, it passes through two lakes, the Loch of the Lows and St Mary's Loch; the latter, which is separated from the former only by a narrow neck of level ground, is three miles long, having its banks partly covered with coppice-wood, and is the finest piece of water in the south of Scotland. From thence the Yarrow flows for eight or nine miles, through sheep-walks, without wood or cultivation; but afterwards the sides of the lofty hills in its course are covered with wood to a considerable height, and its valley is embellished with a variety of bushes and wild-flowers. Ettrick, the larger stream, has a wider and more cultivated valley; and a little before it receives the Yarrow, natural wood begins to appear on its banks. It afterwards flows for four miles through a rich tract, sheltered by plantations on the hills. From this river the whole district has been sometimes called Ettrick Forest; but the name of Forest here, as elsewhere, has long since ceased to denote the existence of extensive woodlands, of which, whatever may have been the case formerly, scarcely any traces now remain. Besides the two lakes we have mentioned, a great many smaller ones are scattered over the east and south-east quarters, of which the more considerable are Loch Alemoor, the principal source of the Ale, and Loch Oakermoor, noted for the vast quantity of marl which it contains.

This county is deficient in coal, limestone, and sandstone, and it lies under the same disadvantages as Roxburghshire, from its great distance from markets where coal and lime are to be had. The arable land lies at an elevation of from 280 to 800 feet, and does not much exceed one-tenth of the whole county. It is light, dry, and easily cultivated; and it produces wheat, oats, barley or bere, turnips, and potatoes. Wheat is regularly grown in the lower parts of the county, and even in the higher it has been raised at the height of 700 feet, yielding a good return; and it may be said that agriculture is as well understood and followed out in this as in any other of the Scotch counties. Many improvements in the mode of cultivation and the farming implements have been introduced into Selkirkshire. The houses of the tenants are now better than formerly, and the general condition of the people has been ameliorated.

The total extent of country under a rotation of crops in 1857 was 14,441 acres; of which 261 acres were occupied by wheat, 949 by barley, 4162 by oats, 29 by beans and peas, 75 by vetches or tares, 2625 by turnips, 222 by potatoes, 30 by rape, 65 by fallow land, and 6012 by grass and hay. The county is, however, on account of the dampness of the climate, more suited for pasture than for agriculture. The cattle are, for the most part, of the Teeswater and Highland breeds. Many of the sheep are black-faced, especially in the upper regions; but Cheviots and Leicesters have been introduced into the county. There were, in 1857, 763 horses, 2449 cattle, 145,732 sheep, and 474 swine—in all, 149,418 live stock in Selkirkshire. The lochs and rivers abound in various kinds of fish; pike, perch, and trout being obtained in the former, and salmon, trout, barbel, &c., in the latter. The only manufactures of the county are concentrated in Galashiels and Selkirk. Woollen fabrics are the articles principally made in both of these places. Until a comparatively late period, the county suffered many inconveniences from the want of roads; but it is now well provided for in this respect. The road from Edinburgh to Carlisle traverses the county for 11 miles; another from Glasgow to Kelso and Berwick crosses the northern portion; and others lead up the vale of Ettrick and Yarrow to Moffat. The Hawick line of the North British Railway runs for a short distance along the border of Selkirkshire; and has a station at Galashiels, from which there is a branch to Selkirk. The whole number of places of worship in Selkirkshire, according to the census of 1851, was 15; of which, 10 contained 3413 sittings. Of the former, 5 belonged to the Established Church, 5 to the Free Church, 2 to the United Presbyterians, 1 to the Independents, 1 to the Glassites, and 1 to the Evangelical Union. The number of public schools at the same date was 15, and of private schools 9. The number of proprietors in the county is 498; and the valuation of rental for 1857–58 was L.61,028. One member is returned to Parliament, by a constituency amounting in 1858 to 861.

The country now occupied by Selkirkshire formed, in the earliest historical period, a part of the territory of the Gadeni. It was occupied by the Romans during their

possession of our island; and after their departure was overrun by the Anglo-Saxons. At that time, however, it was covered with dense forests, and had few settled inhabitants. Very few remains of the Roman or Saxon times have been preserved in Selkirkshire. When the southern part of Scotland was given up by the Anglo-Saxon kings of England, Selkirk was frequently a residence of the Scottish monarchs; and the county was formed probably about the reign of Alexander II. In the fifteenth century it belonged principally to the Douglas family. The largest proprietor now is the Duke of Buccleuch, to whom about two-thirds of it belong. The principal seats in the county are—Thirlestane, belonging to Lord Napier; Ashestiel, once the residence of Sir Walter Scott, now belonging to Sir James Russell; and Borthwickbrae, to A. E. Lockhart, Esq., M.P. There are several old castles, the chief being that of Newark, near Selkirk, the scene of the *Lay of the Last Minstrel*. The most distinguished natives of Selkirkshire have been Mungo Park, the African traveller, and James Hogg, the Ettrick Shepherd. Pop. of the county, (1801) 5388; (1811) 5889; (1821) 6637; (1831) 6833; (1841) 7990; (1851) 9797.

SELLASIA, an ancient town of Laconia, in the valley of the Œnus, at the point where the roads from Sparta to Argos and Tegea separate. It is only remarkable for an important battle that was fought here B.C. 221. During the war between Sparta and the Achæan League, the latter having obtained the assistance of Antigonus the Macedonian monarch, Cleomenes, king of Sparta, apprehending an invasion, took up a strong position near Sellasia with 20,000 men. His right wing, under his own command, occupied Mount Olympus, and his left, under his brother Eucleidas, Mount Evas; while the whole line was defended by intrenchments. Antigonus approached from the north with a much superior force; but seeing the strength of his adversaries' position, hesitated for some days before venturing an attack. At length he assaulted with his right wing the position of Eucleidas; and, favoured by an error of that general, and a timely charge of Philopœmen with the Megapolitan cavalry, gained a complete victory. Cleomenes then advanced to retrieve the day; but, after a desperate conflict, was repulsed with great loss. Antigonus thereafter captured Sparta, and Cleomenes took refuge in Egypt.

SELVA, a town of Spain, Catalonia, in the province and 9 miles N.W. of Tarragona. It stands in a fertile plain; and contains two churches, two suppressed convents, potteries, oil-mills, and distilleries. Pop. 4250.

SEMENDRIA, or SMEDEREWO, a town of European Turkey, in Servia, on the right bank of the Danube, 24 miles S.E. of Belgrade. It is fortified and defended by a citadel. Formerly the residence of the kings of Servia, Semendria is still the seat of a bishop. On the hills that encircle the town to the S. and S.W. lie many vineyards, celebrated for the excellence of their grapes and wine. Fishery, trade, and navigation, are carried on here. Pop. (1854), exclusive of the Turkish garrison, 3829.

SEMI-ARIANS, a branch of the ancient Arians, who arose during the fourth century, and denied the consubstantiality (ὁμοούσιον) of the Son with the Father, but admitted their (ὁμοιούσιον) similarity of substance. The leaders of this party were George of Laodicea and Basil of Ancyra.

SEMICIRCLE is that figure which is comprehended between the diameter of the circle and half its circumference.

SEMICOLON. See PUNCTUATION.

SEMIDIAMETER, half the diameter or radius of a circle.

SEMIPALATINSK, or SEMIPOLATINSK, a district of Asiatic Russia, bounded on the north by the government of Tomsk, E. by Chinese Songaria, S. by Independent Turkestan, and W. by the Kirghise lands. Area, 164,682 square miles. Almost the whole of the district, especially the east and south-east portions, is traversed by lofty ranges of mountains, those towards the north being offshoots of the Altai Mountains, and those towards the south, of the Mustagh or Thian-Shan range. The names of the principal chains in the district are the Kalbin-Tagh, Tchingis-Tagh, Ala-Tagh, and Tarbagatai. Numerous rivers rise in these mountains, and flow in all directions. The chief of these are the Irtish, an affluent of the Obi; the Ili, which flows into Lake Balkhash; the Tchar-Gurban, falling into the Irtish; the Tjunduk, the Aisi-Su, the Kokbekty, the Bakanas, and the Ajagus. There are also many lakes in the district; of which the largest are Balkhash, Issik-Kul, Sasyk-kul, Ala-Kul, and Saisan. Lake Balkhash and the Ili are navigated by steam-vessels. The country is chiefly inhabited by Kirghises of the Great and Middle Hordes, and by Russians; to whom there have been added, in recent times, a people who conceal their origin, but call themselves *Tchala Asaki*, or wanderers from Central Asia. There are also a number of merchants from Kazan, Troizk, and Petropaulowski; and many strangers from the adjacent countries of Central Asia. The chief occupation of the settled population is the keeping of cattle and sheep; the Kirghise, on the other hand, live by hunting and fishing. At some places in the district there have been established gold washeries, silver mines, lead and copper works. An important trade is carried on through the districts by means of caravans, which proceed along the roads that traverse the country in different directions. On some of these there have been erected post-houses and inns for the convenience of travellers. Cotton fabrics, cloth, metals, and furs, are exported from Russia to Turkestan and Songaria, in exchange for raw silk and cotton, carpets, tea, &c. Semipolatinsk was erected into a district in 1854. It is divided into four circles, and had in 1851 a population of 121,300; though at present it is much more populous.

SEMIPALATINSK, the capital of the above district, on the right bank of the Irtish, 400 miles S.S.E. of Omsk. It is a fortified place, in the midst of a fertile plain covered with gardens; and derives its name, signifying "the seven palaces," from certain buildings which the Russians found there on the conquest of Siberia. Many of the inhabitants are employed in fishing; and a considerable trade is carried on. Pop. (1850) 7593.

SEMI-PELAGIANS, a sect who differ from the Pelagians in maintaining the necessity of divine grace towards the saving of the soul; but conceive, at the same time, that this grace may be obtained by an effort of the will. (See PELAGIUS.)

SEMIRAMIS, queen of Assyria, reigned about five generations before Nitocris, and constructed some wonderful works to restrain the waters of the Euphrates within its banks. Almost everything known regarding her is bound up with fable; and except the fact that she was the founder of the Assyrian monarchy, everything else is open to doubt. Diodorus gives a more detailed account of her, which is copied principally from Ctesias. Omitting the fabulous statements respecting her youth, we there find that she had a son, Ninyas, from Ninus; and that after her husband's death she thought herself capable of governing the empire. She founded the city of Babylon, which she surrounded by walls of immense strength, and adorned by very wonderful buildings. On the top of the temple of Belus she placed three statues of massive gold, and from the middle of the temple rose a tower higher than the highest pyramid of Egypt. Some have thought that this was the tower of Babel. She made warlike expeditions against the Medes, Persians, Libyans, and Æthiopians. She is said to have executed many wonderful works in

different parts of her kingdom, changing mountains into plains, and constructing canals and palaces. Hearing of the riches and power of India, she determined to make war on that kingdom, and prepared an immense army; but she was in a great measure unsuccessful, and returned with the loss of nearly her whole army. When she reached Babylon, her son laid snares for her; and as it had been predicted by the oracle of Jupiter Ammon that she would disappear from the world when this took place, the prediction was fulfilled. Semiramis was no more seen, having died in the sixty-second year of her age, and the forty-second of her reign. Such is the common account of Semiramis. Much of it is doubtless fabulous. The Semiramis of Herodotus (i. 184) is palpably different from the Semiramis of Ctesias. Some connection, however, is supposed to exist between the queen and Nabonassar, as well as between her and Pul. (See Rawlinson's *Herodotus*, vol. i., p. 50; also, Colonel Sir H. Rawlinson's communications to the *Athenæum*, Nos. 1377 and 1381.) Cuneiform inscriptions found at Wan, which is called by the Armenians "the City of Semiramis," are said to relate to the history of the Eastern queen. As these inscriptions are now being recovered and placed in the British Museum, they will no doubt ere long be deciphered and made public by a highly competent translator.

SEMITONE. See Music.

SEMLER, Johann Salomon, a theological writer of considerable influence in Germany during his day, was born at Saalfeld on the 18th of December 1725. He was the son of an archdeacon of Saalfeld, and was early initiated into the doctrines of the Pietists, which, however, he ultimately exchanged for the rising Rationalism of the time. He was educated at Halle, where he greatly distinguished himself, and was appointed to a professorship at Coburg in 1749. Next year he was made editor of the *Coburg Zeitung*, and was removed to Altdorf as professor of history and poetry. He was chosen, in 1751, professor of theology at Halle, where he delivered a course of exceedingly popular lectures, betraying extensive reading, but deficient in order and arrangement. In 1757 he was made director of the theological seminary, which he held till his dismissal in 1779 by the minister Zedlitz. He spent much of his time in theological controversy, and attacked his opponents with considerable bitterness. His adoption of the Prussian edict regarding religion, in 1778, exposed him to the charge of inconsistency, and embroiled him in unceasing feuds, which were ended only with his life. He died on the 14th of March 1794. Semler was an industrious writer, and produced numerous works during the course of his life, of which the principal are his *Abhandlung von der Untersuchung des Canons*, 4 vols. 1771; *Apparatus ad Liberalem Veteris Testamenti Interpretationem*, 1773; *Institutio ad Doctrinam Christianam*, 1774; *De Demoniacis*, 1760; *Umständliche Untersuchung der dämonischen Laute*, 1762; *Versuch einer biblischen Dämonologie*, 1776; *Selecta capita Historiæ Ecclesiasticæ*, 1767–69; *Commentationes Historicæ de Antiquo Christianorum Statu*, 2 vols. 1771–72; *Versuch Christlicher Jahrbücher*, 2 vols. 1783–86; *Observationes Novæ*, 1784; and his *Autobiographie*, 2 vols. 1781–82.

SEMLIN, or Zemlin (Hung. *Zimony*), a town of the Austrian empire, in the Military Frontier, on the left bank of the Danube, just above its confluence with the Save, on the other side of which stands Belgrade on Turkish ground. It consists of an inner town, and a suburb called Franzenthal. The former contains some good streets and substantial houses; but the place, as a whole, is mean and wretched, especially the quarter called Zinkaberg, which is inhabited by gypsies. Among the edifices are five Roman Catholic and two Greek churches, a synagogue, an hospital, a theatre, and several schools. Semlin has a very important trade, as it is the great emporium for commerce between Turkey and the Austrian empire, and the principal quarantine station on the frontier. Woollen cloth, porcelain, and glass are sent to Turkey; and yarn, leather, skins, honey, and meerschaum-pipes obtained in return. The town is fortified, and is occupied by a military community, consisting chiefly of Slavonians, Croatians, Servians, and Greeks. Pop. 12,978.

SENAC, Jean Baptiste, called also by Haller, in his *Bibliotheca Anatomica*, Pierre, a distinguished French physician, was born in the diocese of Lombez in 1693. Having taken his medical degree at Rheims, he subsequently practised physic with great applause. He was made first physician to the king in 1752, and a member of the Royal Academy of Sciences of Paris. In addition to his contributions to the *Mémoires de l'Academie*, which began as early as 1824, he likewise published anonymously a *Traduction* of the *Anatomie* of Heister, with additional *Essais de Physique sur l'Usage des Parties de Corps Humain*, Paris, 1724, 1735, 1755, 3 vols. 12mo. His next work, which appeared under the assumed name of Julien Morrison, entitled, *Lettres sur le Choix des Saignees*, Paris, 1730, had great sale. His *Traitê de la Structure du Cœur*, 2 vols. 1748, was regarded as his greatest work, and has been since published at Paris, with additions and emendations by M. Portal. He likewise published another book full of profound knowledge, *De Recondita Febrium Natura et Curatione*, 1759.

SENATE (*Senatus*, from *senex;* Γερουσία from *γέρων, a man advanced in years*), in all the republics of antiquity, was an assembly of the elders, chosen from among the nobles of the nation. This was the meaning borne by the ancient Roman senate, and it was likewise the signification of the Spartan *γερουσία*. In the old republics, the number of senators always bore a determinate relation to the number of tribes included under the nation. Thus, when Attica was divided into four tribes the number of senators was 400; and when Cleisthenes increased the tribes to ten, he made the number of senators 500. When Rome, in very early times, consisted of but a single tribe, the Roman senate consisted of 100 members; and when, by the addition of the Sabine tribe, the nation became increased, the senate then consisted of 200 members. Again, when the Luceres became incorporated with the Roman state, the Roman senate was increased threefold, and numbered 300. Tarquinius Priscus, who added new senators to the old assembly, distinguished between those of his own formation, and those who had held office before, by designating the former by the appellation of *patres minorum gentium.* Under Tarquin the Proud, the senate is said to have been greatly diminished by the death and exile which the tyrant sent into their ranks. (See Niebuhr's *Hist. of Rome*). The vacancies thus occasioned were subsequently filled up by noble plebeians of the equestrian rank; and hence they bore the designation of conscript fathers, or of *patres et conscripti.* The numbers being thus raised again to the original 300, the senate remained for many centuries altogether unaltered.

A change of some kind was proposed on the number and the constitution of the senators, by C. S. Gracchus, but of what precise kind does not appear. Under the tribuneship of Livius Drusus, 300 equites were added to the original senate, which swelled out its numbers to 600. This law was abolished, however, by the senate itself on the death of its originator, and its numbers again stood at the old figure of 300. Vacancies occurred during the progress of the civil war between Marius and Sulla; and it is supposed that the latter raised the Roman senate to between 500 and 600. (Cicero *ad Att.* i. 14). The first of the Cæsars raised their number to 900, and exalted to the dignity common soldiers, freedmen, and peregrini. (Suetonius, *Cæs.* 80.) This opening

Senate.

of the door to the vulgar was imitated after Cæsar's death, when the senators seem to have been augmented to the number of 1000. Augustus cleared the senate of these *Orcini Senatores*, as they were called (Suetonius, *Aug.* 35), and limited their number to 600, which seems to have continued constant during the early centuries of the empire. The number of senators must have been greatly diminished during its latter years. The several periods of the history of Rome afforded progressive changes in the election of persons to the senatorial dignity. It was an old opinion, founded on a passage in Livy (i. 8), and another in Festus (*Præteriti Senatores*), that in the early period of the history of the Roman people, the choice of senators lay exclusively with the kings. Niebuhr (*Hist. of Rome*, i.) has cast doubt on this belief, without being able to substantiate the conviction to which he adheres—namely, that the *populus* was the sole power, who chose kings and senators alike to act as their representatives in the high councils of the nation. Almost all the old authorities adhere to the opinion that the senators were chosen by the sole voice of the king, and their testimony cannot be fairly set aside on such slender evidence as Niebuhr employs. Nothing more is known respecting the time of life at which a man could become a senator during the kingly period than is specified by the title itself (*senator*, from *senex*); that is, that he must be advanced in years. A man could not become a senator most probably before the age of thirty-two. The age was finally fixed by Augustus at twenty-five, which seems to have continued the law throughout the entire existence of the empire. The senate itself seems to have had some voice in the election of members to join its body, for we find it raising objections against a person just elected (Dionys. vii. 55). The entire senate was divided into decuries, each of which corresponded to a curia. Originally, when the senate consisted of 100 members, there were in all ten decuries, and one senator chosen from each decury made ten senators, which constituted the *decem primi*, who represented the ten curies, and who gave their votes first. The principal senator was chosen by the king, and was the first among the *decem primi* to give his vote.

On the establishment of the republic at Rome, the election of senators, which had hitherto rested with the king, fell to the magistrates, consuls, consular tribunes, and finally to the censors (Livy ii. and Festus, as above). The censors had the sole power to choose or refuse new members to the senate, from among the ex-magistrates, from the institution of the censorship in Rome. We must likewise distinguish between real senators and official senators, or those who merely took their seats in the senate-house, and were permitted to speak but not to vote. These were the persons who held the office of curule magistrate. (Gellius, iii. 18; Festus, *Senatores*). The senate-house was now gradually changing its character into a popular assembly. From the time that the public and private offices of state became equally accessible to plebeians as well as to patricians, the senate gradually changed, until in a short time the dignity was regarded as one that properly belonged to the *populus* to confer. Yet it did not degenerate into a mere democratic gathering; for its members of all classes belonged to the *nobiles*, whether they were of plebeian or patrician origin. The office of *princeps senatus* was usually given to the oldest ex-censor, or to any other on whom their electoral regards happened to alight. The fixing of a definite income for senators was limited entirely to the age of the empire. Augustus first laid it down at 400,000 sesterces, and subsequently it rose as high as 1,200,000 sesterces. Those senators who were found deficient, received grants from the emperor, and those who had wasted their estate by vice and prodigality were sternly reminded that their presence could thereafter be dispensed with. No senator was permitted to engage in any mercantile pursuit, although it is plain from what is recorded by Cicero (*Verres*, v. 18) that this law was often violated. A new element was likewise introduced into the senate by the admission of municipal, colonial, and provincial functionaries. These officials, of course, were required to fix their residence at Rome, or in some part of Italy; and they were not permitted to remove to their native districts without special permission from Augustus, or from the reigning emperor. Regular meetings of the senate took place on the calends, nones, and ides of each month. The right of convocation was limited during the monarchical period to the king or the *custos urbis*; during the republic it was extended first to the curule magistrates, and subsequently to the tribunes; during the empire it was confined to the emperor, and was likewise dispensed to the consuls, prætors, and tribunes. The places where the senate held their meetings were always opened by the augurs. The most ancient senate-house was the Curia Hostilia; and during the successive changes which the government of the country underwent, it was transferred to different buildings, until at last it was by no means uncommon to find it held in the house of the consul. During the early history of the senate the patrician power was quite unlimited, except by the kingly authority; and when a perfect equality came at length to be established between the patricians and the plebeians, the Roman senate witnessed its best days of freedom. Under the despotic government of the emperors, which succeeded, it became the plastic tool of the *princeps senatus*, who was very commonly the emperor. And not only did the emperor gather up into his own hands all the power formerly possessed by the magistrates, he likewise controlled, in the most absolute and irresponsible manner, all the deliberations and all the determinations of the senate.

Under the palmy days of the Roman senate, that body had the supreme superintendence of everything connected with religion, war, and finance. It decreed to what provinces consuls and prætors were to be sent. It determined what commissioners were to be despatched from Rome to settle the administration of a newly acquired country. It settled all treaties of peace, and other political negotiations, between the parent country and other foreign states. It took special cognizance of all crimes, such as treason, conspiracies, poisoning, and murder. It gave and received the representations of ambassadors, and heard the complaints of subject or of allied nations. In short, everything, whether within or without the republic, of which Rome chose to take cognizance, was committed to the care of the senate. A decree of the senate was called a *senatus consultum*. When Byzantium was made the second capital of the Roman empire, a second senate was likewise instituted there as well as at Rome, and continued to perform its part in the legislation of the empire down to the ninth century.

The more distinguished badges and privileges enjoyed by the Roman senators were as follows:—The tunica, with a broad purple stripe in front; and a short boot, with the letter C on the front of the foot, supposed to be the initial of the word *centum*, in allusion to the early senate of Rome, which consisted of 100 members; the right of occupying the orchestra of theatres and amphitheatres; the right of a senatorial feast, when the public sacrifice was offered to Jove in the capitol; and the right of free embassage (*libera legatio*), made up the whole of the more important benefits enjoyed by the senators of Rome.

Seneca.

SENECA, M. Annæus, a famous rhetorician, father of the philosopher. He was born in the old and flourishing colony of Corduba, in Spain, a country which at this time exercised a powerful influence on the politics and literature of Rome. His family was of equestrian rank, and had never attained to any of the curule honours (Tac. *Ann.*) Whether

the gens Annœa was of Spanish or Italian origin, and whether the names Annœus and Seneca have any connection with the words "aunus" and "senex" (as Lipsius thinks), is uncertain. Clinton places the date of Seneca's birth about B.C. 61, as may be inferred from his own statement, that but for the civil wars he might have heard the eloquence of Cicero, who was the only great orator of that day to whom he had not listened.[1] After spending some time at Rome, and making acquaintance with many of his most eminent contemporaries, he returned to Cordova, and married Helvia, a Spanish lady of amiable character and great accomplishments. By her he had three sons, all of whom acquired great celebrity—viz., Novatus, the eldest, who afterwards took the name of Junius Gallio, and on whom the Christian world has bestowed an unenviable notoriety, by proverbially misapplying an expression of St Luke;[2] Seneca, the philosopher; and Mela, the father of the poet Lucan. After a sojourn in Spain, he once more went to Rome with his family; and no further particulars are known about him, except that he lived in wealth and reputation, probably till the close of the reign of Tiberius.

Parts of two works written by Seneca in his old age are extant—the *Controversiæ* and *Suasoriæ*. Both of them are collections of mere rhetorical exercises; the first on imaginary cases, such as might have occurred in real life; the second on historical events and circumstances in the lives of great men. As literary productions they are nearly worthless, in spite of the author's retentive memory and polished style; they are only valuable as indications of the temper and taste which began to be prevalent in the early days of the empire. The greatest minds, debarred from the real eloquence which is only compatible with political freedom, sought some rest for their wounded spirits in the "resigned yet militant" philosophy of the Porch—a philosophy which, as has been well remarked, "almost enveloped its votaries in an atmosphere of Christianity." But those who, like M. Annœus, despised or disliked[3] philosophical pursuits, were forced to take refuge in oratorical puerilities, the practice of which gave them a mechanical facility which they mistook for fluency, and a verbiage which they confounded with eloquence. We have, however, in the elder Seneca, only the germs of that affected style which afterwards characterized the silver age of Roman literature. He is not, indeed, entirely free from the growing degeneracy; but he belonged to another period, and remembered a better taste.[4]

The best edition of the *Suasoriæ* and *Controversiæ* is that of Andr. Schottus, Paris, 1607, which contains all the notes of N. Fabrr, Gruter, Lipsius, Opsopæus, &c. (F. W. F.)

SENECA, *L. Annæus*, the most prominent and interesting man of his time, was the second son of Seneca the rhetorician. He was born at Cordova, B.C. 3 (about the same time as the Apostle St Paul), and brought to Rome by his family when an infant in arms.[5] From the first he was of a feeble constitution. His life, like that of Pope, was "a long disease;" and he was liable from infancy to nervous shivers, asthma, fever, and fainting.[6] But in a delicate and languid body lived a daring and restless soul, to which, perhaps, his Spanish descent had given a touch of "phantasy and flame." The intense and characteristic ardour of his studies tended still more to undermine his health. Although his father mainly urged him to the pursuits of rhetoric, philosophy attracted him with superior charms; and he gladly turned from the dull platitudes of artificial eloquence to the spiritual guidance of Demetrius the Cynic, and Sotion the Pythagorean. He found a sublime pleasure in carrying their precepts into daily practice; like Attalus, he learned to lie on a hard mattress, and like Sextus he became a vegetarian in diet and subjected himself to daily[7] self-examination. The worthy rhetorician, his father, regarded these vagaries of philosophic asceticism with strong intellectual dislike; but he persuaded Seneca to abandon them, rather on the ground that they laid him open to the suspicion of adopting those oriental superstitions the proselytes of which had recently been banished from Rome by an edict of Tiberius. Seneca, however, never quite forgot the Stoic precepts of temperance and sobriety. In the bosom of opulence he remained an enemy of the Ionian luxuries of baths and perfumes; he slept lightly, and drank but little wine; and whatever may have been the value or splendour of his 500 cedar and ivory-footed tables, they were rarely spread with any entertainment more sumptuous than water, vegetables, and fruit.

Turned by filial respect into less congenial pursuits, he threw his whole mind into public and forensic duties. He was elected quæstor, and soon won a brilliant reputation at the bar. His fame and ability excited the jealousy of the Emperor Caligula, who himself pretended to eloquence, and had a deadly hatred of superior genius. Domitius Afer had already saved himself from the tyrant's spiteful fury, by an acknowledgment of inferiority.[8] Seneca only owed his life to his ill health; for Caligula was assured by one of his mistresses that so sickly a subject could not last long. The emperor accordingly contented himself with contemptuous descriptions of Seneca's style, which he called "sand without lime."[9]

Forced by this danger to change his plans, Seneca once more began to devote himself to philosophy, and mastered with great assiduity the voluminous treatises of Plato, Aristotle, Zeno, Chrysippus, and Epicurus. This was probably the period of his greatest intellectual activity, because he was living in the closest intercourse with all the literary men of the day, undisturbed by any public or professional duties. If he ever travelled in Egypt, where his uncle had been præfect for sixteen years, it must have been about this time. But the journey is very doubtful; and the fact that he travelled at all, although eagerly believed by those who wish to attribute some of his knowledge to Jewish or Christian information, is a mere precarious inference from the title of a lost treatise on India.[10]

Upon the death of Caligula, Seneca was free to resume his political ambition, but a sudden check was put to his splendid career. He was accused of adulterous intercourse with Julia, the beautiful and infamous sister of the late emperor, whom Claudius had recalled from her banishment in the island of Pontia. The charge was brought by Messalina, who both hated and feared her haughty kinswoman; but the guilt of the accuser is not sufficient to exonerate Seneca from participation in the crime. Because Messalina was a licentious and cruel woman, it does not follow that Seneca was an innocent man; and it seems to us unlikely that he should have been fixed upon for punishment, without some adequate grounds of suspicion. Considering the weakness, the deplorable weakness, of Seneca's character, the laxity of the age in such matters, and the certainty that this and similar charges[11] clung to him through life, there is reason to fear his guilt. We do not think that this would have deterred such a woman as Agrippina from subsequently making him the tutor of Nero. Even in the nineteenth century, and in Christian countries, we do not find men precluded from filling the most exalted and responsible stations from the notoriety of their immoral lives.

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1 Sen. *Præf. in Controv.*, lib. i.
2 Acts xviii. 12.
3 Sen., *Ep.* cviii., "Philosophiam Oderat."
4 Niebuhr's *Rome*, iii. 192, ed. Schmitz.
5 *Consol. ad Helv.* xvi.
6 *Ad Helv.* xvii.; *Ep.* liv. 78.
7 *Ep.* cviii., cix.; Aubertin's *Sénèque et St Paul*, p. 156.
8 Dion. lix. 19.
9 Suet. *Calig.* liii.
10 Plin. H. N. vi. 17.
11 Tac. xiii. 41; Dio. lxi. 10.

Seneca.

Claudius appears to have mitigated[1] the original severity of the sentence passed by the senate, and Seneca was banished to the island of Corsica, without any confiscation of his property (B.C. 41). Barbarous, and savage, and terrible as the rocks of Corsica appeared to the exile, this eight years' banishment was to him an unmixed blessing, and was the period of his life on which we can dwell with the most pleasure. It mollified the virulence of the envious, and excited the compassion of the good; it increased his real reputation, while it diminished his obvious dangers. Above all, it gave him a season of calm and safety for the growth and nurture of his character and genius. In the intoxication of prosperity and power, he never forgot the sobering lessons of humiliation and misfortune; and perhaps, while the seas and stars and winds were supplying food for his philosophic contemplation, he was nearer happiness than while he was the prey of anxiety and suspicion in the midst of gardens and villas that an emperor might have envied.

Two works, which resulted from his residence at Corsica, are extremely curious illustrations of his wavering impulses, the *Consolatio ad Helviam* and the *Consolatio ad Polybium*. The former was written to comfort his mother with the thought that he was raised by the study of philosophy above the need of pity. He eloquently praises the glories of nature, and the delicious reveries of intellectual solitude; and some, at least, of his arguments bear the impress of sincerity. Yet, in the *Consolatio ad Polybium*, he implores an unprincipled freedman to procure his acquittal even at the cost of his character, and he endeavours to gain the repeal of his sentence by the grossest adulation to the "divine and merciful" emperor. The admirers of Seneca have always wished to prove this work spurious; but it is merely another example of a fact which is sufficiently obvious to any impartial judge, that Seneca was a philosopher in name alone. Let us remember, too, that such language, however little it could have been used by a Thrasea or an Helvidius, was all but universal in that enslaved, degraded age. It meant a great deal less than it seems to mean; and such epithets conveyed quite as little impression of flattery to a Roman ear as our own terms "religious and gracious," when applied to a Charles II. or a George IV.

We now come to the third stage of Seneca's eventful life. Messalina being dead, her successor Agrippina determined, by a stroke of policy, at once to gain a first-rate adviser and to secure popular applause, by persuading the easy emperor to recall the philosopher, elevate him to the prætorship, and make him the tutor of the young Nero (A.D. 49). Seneca was not superior to the splendid temptation of such a proposal, though, even with *his* marvellous reputation, he could hardly have hoped for much legitimate influence in such a court, composed as it was of an uxorious dotard, insolent freedmen, and licentious women. He may have had an honest desire to serve his generation, or he may have been unable to decline the proffer; but at any rate he must have been aware, that in undertaking the duties of the position, he was entering a region perilous alike to his rectitude and his peace.

From this time the biography of Seneca must assume the form of an apology rather than of a panegyric. The philosopher is merged in the courtier, and we see the Stoic transformed in his public life into a minister both supple and complaisant. The "comitas honesta" which Tacitus attributes to him can only be an euphemism for unworthy subservience. It was, perhaps, impossible for him to instil anything noble into the weak and degraded mind of Nero; but Seneca must certainly incur the blame of signal failure in the management of his pupil. A loose and ignorant youth, initiated from infancy into all the mysteries of iniquity, the son of vile parents, and the heir to boundless expectations, was not likely to become either wise or good. But if Seneca had guided him with a firmer will and a stronger hand, might he not have been saved from developing into a monster? If Nero had seen in his tutor a man of high aims and stainless integrity, is it possible that he could ever have formed a cherished[2] belief that all men, however successful their hypocrisy, were at heart as degraded and as infamous as himself? The treatise which Seneca addresses to him on clemency, and the appeal,[3] in which he reminds his pupil of past expostulations, are indeed proofs that the philosopher could give admirable advice in a graceful and dignified manner; but advice alone, even when accompanied by good example, would have been as ineffectual with Nero as it was with the sons of Eli; and, unhappily, it will be seen that Seneca, while yielding to the pleas of expediency, belied the precepts of his philosophy in the weakness of his life.

No sooner was Claudius poisoned than Seneca wrote the flowery official oration in which Nero pronounced his funeral eulogium, and a satire against his foibles, overflowing with the deadliest contempt. It is possible that the oration, which was received with laughter, was merely an audacious piece of irony. The satire has come down to us, and displays the "divine and merciful" emperor in all his wretchedness. The very name[4] by which it was commonly known conveys the bitterest sarcasm; it involves a comparison between Claudius and one of "those bloated gourds which sun their speckled bellies before the doors of the Roman peasants." His deification, according to Seneca, should have been called gourdification. "The senate decreed his divinity; Seneca translated it into pumpkinity."[5] This fragment of antiquity is very curious and interesting: it begins with spattering mud on the despised memory of the divine Claudius; it ends with a shower of poetic roses over the glory of the diviner Nero!

It was a terrible court for a Stoic to live in. Seneca and his somewhat stolid, but far more virtuous, colleague, the soldier Burrus, had to combine their courteous wisdom and military bluntness, in order to check at once the insolent ambition of Agrippina and the mad passions of her son. Whatever may have been Seneca's public obligations to Agrippina, or his private intrigues with her, he sided unhesitatingly with Nero. At first the new government gave an illusory hope of justice and clemency. Nero delivered many harangues full of promise, which it was well known that Seneca had written, either, says Tacitus, "to prove[6] that his counsels were beneficial, or to show off his intellectual power." We might have hoped that Seneca had a nobler object in view, but it is sad to find that Tacitus gives no hint of it; and we cannot but fear that he had far more accurate means of estimating the character of the philosopher than we can pretend to have. Seneca did, however, succeed for a time in restraining the savage canine nature of his pupil from the taste[7] of human blood. He was less successful in governing Nero's licentiousness, and was forced not only to connive at, but even to encourage the youth's unworthy amour with the freedwoman Acte.

Blacker events followed. Nero murdered his young and innocent brother, Britannicus, and Seneca was more than suspected of having had his share of the largesses by which the murderer sought to remove the odium of the[8] deed. Nor must we forget that the treatise *de Clementia*, in which he expresses such hysterical admiration of the young em-

[1] Ad Polyb. xxxii.
[2] Sueton. *Vit. Neron.*
[3] *Ann.* xv. 6.
[4] *Ludu de Morte C. Cæsaris*, or Ἀποκολοκύντωσις, Dion. lx. 35.
[5] Merivale's *Roman Empire*, v. 601.
[6] Tac. *Ann.* xiii. 11.
[7] *Schol. ad Juv.* v. 109.
[8] Tac. *Ann.* xiii. 18.

peror's goodness of heart, was written after the commission of this most atrocious crime. Nero next caused the assassination of his mother, and Seneca, even if ignorant of the first attempt upon her life, of which Dion[1] Cassius charges him with being the instigator, was the first to break the hideous silence,[2] in sanction of the expediency which demanded the completion of the murder. Besides this, he was the author of the letter in which Nero at once blackened his mother's memory, and gave an account of her death too ridiculously false to gain a moment's credence. It is awful to think of this patron of virtue sitting down to adorn with his usual[3] graces of style the defence of an incestuous matricide, by imputations which he knew to be groundless and an assertion which he knew to be a lie.

In spite of the dark whispers of the people, and the open charges which had been brought against him by[4] Suilius, Seneca was now at the summit of his fame. His overgrown wealth was the reward of his guilty connivance. Two of his greatest contemporaries, Juvenal[5] and Tacitus, call him "prædives," "the too wealthy." His enemies accused him of increasing this wealth by the basest arts of the legacy-hunter and the parasite; but even if this be false, he certainly did increase it by enormous usury, which "exhausted Italy and the provinces." Dion,[6] who omits no opportunity of aspersing his memory, even accuses him of having caused the war with Britain, by suddenly recalling the enormous sum of 4,000,000 sestertii. The terms in which he himself alludes to his income leave no reason to doubt that it amounted to 300,000,000 sestertii, and his single[7] defence, that he owed it all to Nero's bounty, is very lame and unworthy. His wealth was unquestionably dishonourable to him. "The business of a philosopher," says Lord Macaulay,[8] "was to declaim in praise of poverty with two millions sterling out at usury, to meditate epigrammatic conceits about usury in gardens that moved the envy of sovereigns, to rant about liberty while fawning on the insolent and pampered freedmen of a tyrant, to celebrate the divine beauty of virtue with the same pen that had just before written the defence of the murder of a mother by a son."

His riches hastened his ruin. Burrus died, perhaps by poison, in A.D. 63, and was succeeded by Rufus and Tigellinus, both of whom excited the jealousy and suspicion of Nero against the hated philosopher. Feeling his danger, he demanded an interview with the emperor, and begged leave to resign his vast possessions, and after his fourteen years of service, to retire into private life. Nero declined the offer with treacherous caresses, and the strongest asseverations of regard; but Seneca, under the pretence of study and ill health, withdrew from affairs of state, reduced his princely establishment, and avoided publicity by every means in his power.[9]

Not long after, when Nero began to add sacrilege to his other crimes, Seneca once more asked permission to leave Rome, and, on a second refusal, feigned a severe illness, and confined himself to his chamber. It was thought that an attempt of Nero to poison him by the instrumentality of his freedman Cleonicus, was only defeated by the confession of the accomplice, or by the abstemious habits of the philosopher, who now took only bread and fruit as his food, and quenched his thirst only out of the running stream.[10]

Under circumstances such as these, we should hardly be surprised if he turned conspirator. His popularity and wealth made him not only a tempting prey, but a dangerous and dreaded rival. Even in A.D. 63, he had been suspected of a treasonable correspondence with Piso, and in A.D. 66, he was actually charged with a knowledge of Piso's political intrigues. The evidence brought against him was of the feeblest character, but there was a report to which Juvenal,[11] as well as Tacitus, seems to allude, that Subrius Flavus had, with Seneca's knowledge, entertained a design of murdering Piso, in case of his conspiracy succeeding, and of then offering the imperial power to Seneca himself. The rumour is at least a proof of Seneca's dangerous popularity; and Nero, long disgusted by the tacit reproach of his hated tutor's mere existence, determined, with great alacrity, to get rid of him. After giving a futile hint, the tribune Granius Sylvanus was sent expressly to command his suicide. Seneca was supping with his young wife Paulina in a villa five miles from the city, and not being allowed to see his will, prepared at once to put the order of death into execution, consoling his friends with the too complacent observation, that he would at least leave to them the legacy of a noble example. Checking their tears and lamentations, and reluctantly yielding to his wife's[12] desire to share his death, he caused his own veins and those of Paulina to be opened at one blow. His blood flowed so slowly, in consequence of age and feebleness, that it was afterwards necessary to open the veins of his legs; and his torments were so prolonged and excruciating that he was forced to separate from Paulina, in order to spare her the pain of witnessing them. Paulina's life was saved by the order of Nero, though her white face showed ever after how much she had endured. Meanwhile, Seneca having swallowed in vain a draught of hemlock, was placed in a warm bath, and as he entered it, sprinkled his slaves with the water, saying, that it was a libation to Jupiter the Liberator. Finally, growing impatient of the useless agony, he was carried into a sudatorium, and stifled by the warm vapour A.D. 65. He was at this time about seventy years of age. His friends afterwards published the eloquent messages which he had delivered to them during his dying moments, and which they had taken down at his own request. His body was privately burned without any ceremony, according to the directions which he had left in his will, written in the days of his prosperity and power.

Lipsius and others have made the character of Seneca a theme for extravagant admiration; but they do so by omitting all those black and ugly particulars which mark the period of his elevation. So admirable is his theoretic morality, that the forged correspondence between him and St Paul was long accepted as genuine, and on the strength of it he has been quoted as an authority by fathers and councils, and almost spoken of as a Christian by Tertullian and St Jerome.[13] Yet, at the best, his life is a melancholy spectacle; it was one long conscious inconsistency; one continual surrender of real duty to fancied expediency. Some of his worst acts may find a parallel in the lives of greater and better men; but his defence of Nero's matricide is many shades more disgraceful than Bacon's apology for the execution of Essex, or Milton's arguments for the murder of Charles I. Even if we judge him, independently of his philosophic pretensions, he presents a somewhat despicable appearance. Niebuhr's judgment of him is quite just. "He was an accomplished man of the world, who occupied himself very much with virtue, and may have considered himself to be an ancient stoic. He certainly believed that he was a most ingenious and virtuous philo-

[1] lxi. 12. [2] *Ann.* xiv. 12. [3] Quinct., *Inst. Orat.* viii. 5, 18. [4] *Ann.* xiii. 42. [5] *Juv.* x. 16.
[6] lxii. 2. [7] *Ann.* xv. 53; Sen., *de Benef.* iii. 18. [8] *Essay on Lord Bacon.*
[9] *Ann.* xiv. 56. [10] xv. 45. [11] Sat. viii. 212.
[12] Dion's account, as usual, has a more malignant colouring (lxi. 10; lxii. 25); but in this instance his calumnious propensity is too obvious to entitle him to any regard.
[13] See the quotations in Lipsius, *Concil. Turonens,* ii. 15; Lactant., *Div. Just.* i. 4; Aug., *de Civ. Dei,* vi. 10; Tertull., *de Anim.* i.; Jerome, *de Script. Eccl.* c. 12.

sopher; but he acted on the principle that, as far as he himself was concerned, he might dispense with the laws of morality which he laid down for others, and that he might give way to his natural propensities."[1] This judgment may sound harsh, but in point of fact Seneca never professes for a moment to rise in practice to the level of his philosophic aspirations. He was, he tells us, not virtuous, but a lover of virtue; not a philosopher, but a student of philosophy. "I am pre-occupied," he says, "with vices.[2] All I require of myself is, not to be equal to the best, but only to be better than the bad."

As a philosopher, Seneca has no great claims on our attention. He abounds, indeed, in those noble and advanced ethical conclusions whose wide dissemination made them the *avant-couriers*[3] for the reception of Christianity, and which seem to have resulted from the profound thoughtfulness forced upon the greatest intellects by the desperate condition of the times. But we find in him no approach to a consistent system; he expresses the thoughts of the moment with eloquence and precision, but perhaps in the next treatise we find him contradicting and refuting them. His intellect[4] has an encyclopædic character, and like some modern writers, he united the claims of orator, poet, philosopher, geographer, historian, and naturalist. In all these branches of learning he shows conspicuous cleverness, but does not rise in any of them to first-rate eminence. Caligula was not far wrong in criticising his intellectual efforts as "commissiones meras," isolated and unsubstantiated displays. Seneca had successively experienced the weariness of exile, the luxury of power, and the bitterness of retirement and disgrace, and it is no wonder that his works contain many inconsistencies, because they are strongly marked by the impress of the period of his life at which they were written. For instance, in his book *De Constantiâ Sapientis*, glowing in all the fervour of philosophic intolerance, he eloquently praises the quietism and ἀπαθέια of Stilpo; whereas in the *De Animi tranquillitate*, and in the *De Otio Sapientis*, published after his recall from exile, he departs widely from the principles of stoicism, and pronounces with equal enthusiasm in favour of an active life.[5] The treatise, *De Vita Beatâ*, composed at a later period of his court career, becomes almost Epicurean in its estimate of worldly advantages, and in some places sounds like a personal apology for those actions of Seneca which were most open to adverse criticisms. In a similar manner we can trace in the wavering and often contradictory conclusions of his other writings the immediate influences by which he was surrounded.

Besides the works which we have mentioned, Seneca wrote excellent little treatises on Providence and on the Shortness of Life; three books on Anger, which, according to Valerius Maximus, was a prevalent vice of the Roman character; a Dissertation on Clemency, addressed to Nero at the commencement of his reign; and seven books on Benefits, in which he takes care to prove that, in spite of the boundless gifts which Nero had heaped upon him, the favours of a tyrant are wanting in all the requisites which invite or necessitate a feeling of gratitude. But his two best works are the *Letters to Lucilius* and the *Natural Questions*. In the *Letters*, written during his old age and retirement, he stores up the mellow maxims of a long and chequered experience; laying aside the pedantry of the philosopher, he gives free and natural expression to the hopes and emotions of the man. Foreseeing the ultimate necessity of suicide, he looks forward to it with calm and steady pleasure, as a happy release from the insolence of power and the plots of crime. The seven books of *Naturales Quæstiones* were commenced during his exile, but finished and revised in his later years. They contain many fine passages and curious conjectures. But Seneca studies physical science only for the sake of its moral applications. If he speaks of the composition of mirrors, he takes occasion to denounce the abuse of them for the purposes of vanity and vice; if he is treating of poisons he bursts into an eloquent digression against the refinements of Roman sensuality. The main object of his work is to remove superstitious errors and empty fears, and his work may be regarded as a religious continuation of the atheistic speculations of Lucretius.[6]

Whether the wretched epigrams attributed to Seneca are genuine is uncertain; that the ten tragedies which pass under his name are so is generally admitted, and could perhaps never have been doubted but for the distinction which Sidonius Apollinaris makes between Seneca the tragedian and Seneca the philosopher. The isolated testimony of such an author cannot outweigh the evidence of Quinctilian,[7] and other writers who were almost Seneca's cotemporaries. These tragedies are adapted not so much for the stage as for recitation, and are not to be compared with the great dramas of the Greek poets; but they contain many beauties, and do not at all detract from our high estimate of Seneca's literary abilities.

It has been said that the man who corrupts the style of his age is often as great a genius as the man who improves it. Seneca is a case in point, for to him was mainly due the inferior taste of the later Romans. The desire to say brilliant things—the antitheses and ornaments of his language—in a word, his conceits of rhetoric would, as Niebuhr has remarked, be quite intolerable if they came from a less ingenious man. Quinctilian, who was accused of depreciating him, happily observes that "he abounds in beautiful defects, and that one could have wished him to follow his own genius, and some one else's judgment."[8] Inferior writers imitated his *dulcia vitia*, without the ability which rendered them endurable; and adopted his picturesque turns of expression, without the thoughtfulness which made them valuable. He has been the special favourite of French writers; and Montaigne and Diderot have spoken warmly in his praise. He was the undoubted source of a great intellectual movement; and we may trace his influence, not only in writers like Florus and Quintus Curtius, but in Pliny, Quinctilian, and even Tacitus himself. "Tacite," says Montaigne, "ne tire pas mal à l'escrire de Sénèque;" and although the historian seems to have regarded the philosopher with a little spleen, yet he was, perhaps, indebted to him unconsciously, not only for isolated thought, but for the very idea of his historical style.

Among the editions of Seneca we may mention that of Schottus, Paris, 1607; and the Bipont edition, Strasbourg, 1809. There is a French translation by Lagrange, and an English one by Dr Thos. Lodge, Lond., 1614. (F. W. F.)

SENEGAL, a river of Western Africa, formed by the union of two branches, called the Ba Fing and the Ba Woolima. The former, which is the larger of the two, rises about N. Lat. 10. 30.; W. Long. 11. 19., in the mountains forming the south border of the elevated plain of Foota Jallon. It flows first to the east, past the town of Timbo, then turns to the north, traversing the desert of Jallon Kadoo; and after a course of more than 400 miles, unites its waters with the Ba Woolima. This river rises considerably to the N.E. of the other, near the left bank of the Joliba, or Niger, about N. Lat. 13., and W. Long. 7. 50. It flows first N.W., then W. for a distance of 300 miles, before joining the Ba Fing. The confluence takes place

[1] *Lectures on Roman History*, iii. 195.
[2] *Ep.* 75, de V. Beat. 17, quoted by Lipsius and Merivale, vi. 85.
[3] See Merivale's *Empire*, vi. 294.
[4] Aubertin, p. 169.
[5] Charpentier, *Des Ecrivains Lat.*, p. 252.
[6] Charpentier, p. 263.
[7] *Inst. Orat.* ix. 2; x. 1.
[8] *Inst. Orat.* x. 1, 129.

Senegal.

about N. Lat. 14. 10., W. Long. 10. 30. From this point the united stream runs first N.W., and then W., till it falls into the Atlantic, by two mouths, near the French settlement of St Louis. The whole length of the river is estimated at 1000 miles. Its most important affluents are the Furkooma, which joins the Ba-Fing; the Kokorro, which flows into the Ba-Woolima; and the Ba-Faleme, which falls into the united stream. In the lower part of its course the Senegal several times divides itself into branches, which enclose islands of considerable size. The navigation of the river is interrupted by the cataract of Feloo, which is 80 feet high, and nearly 600 miles above the mouth of the river, following its course, though not more than 350 in a straight line. This cataract, which is situated about 100 miles above the confluence of the Ba-Faleme, is the principal one on the river; forty miles above it is that of Govinea. The windings of the Senegal are remarkably tortuous and circuitous. As far as the rock of Feloo, the country through which it flows is a level, having so small an inclination that a very slight interruption is sufficient to divert the course of the stream, so that it frequently seems on the point of returning to its source. It is only navigable during the rainy season, which extends from June till November; and even then the navigation is very slow and tedious. At the mouth of the river there is a bar, which prevents the entrance of all vessels drawing more than 12 feet of water, although immediately within it there is sufficient depth for ships of any size. The entrance of the bar has shifted from time to time, owing to the influence of opposite currents. Were it not for the perils to be met with on this river, it would be particularly interesting to the naturalist, as the extremely picturesque banks present a rich variety of the noblest productions of the vegetable kingdom, whilst the extensive forests abound with all kinds of wild animals. Amongst others, elephants are seen in large troops. In the shallow parts of the river are a vast number of hippopotami, and caymans of prodigious size. The Senegal, like the Nile, annually overflows its banks, and spreads its fertilizing waters over the surrounding country. It forms the boundary during a great part of its course between the arid plains of the Sahara on the north, and the fertile regions of Senegambia on the south.

SENEGAL, a colonial dependency of France, on the W. coast of Africa. It consists of the island and town of St Louis, at the mouth of the Senegal; several forts along that river; the island and fort of Gorée, off Cape Verd; and Allreda, at the mouth of the Gambia (see LOUIS ST, and GOREE). The trade and navigation of these settlements is considerable. In the year 1852 there entered at St Louis 89 vessels, all French, with a tonnage of 11,451; and there cleared 69, likewise all French, with a tonnage of 7418. At Goree in the same year there entered 330, of which 309, tonnage 19,503, were French; and there cleared 280, of which 262, tonnage 16,345, were French. The following table exhibits the amount of goods of different kinds exported to France in 1855:—

St Louis.			Goree.	
Articles.	Cwt.	L.	Articles.	Cwt.
Hides	3,069	11,247	Hides	4,130
Arachis & other nuts	80,298	122,616	Yellow & brown wax	2,151
			Ivory	22
Pure gum	44,237	126,094	Arachis and other nuts	83,192
Palm oil	205	...	Caoutchouc and Gutta percha	1,181
Dye Woods	7,074	...		

The value of the whole exports from St Louis was L.283,972; and from Gorée, L.297,638. The trade seems to be gradually but steadily passing from St Louis to Gorée. The population of the settlements in 1855 was as follows:—

	Inhabitants.
St Louis	9,223
Güet-N'dar	1,796
Forts on the Senegal, viz:—Bakel, Sénoudebou, Dagana, Richard Toll, Mérinaghem, and Lampsar	4,818
Gorée (1856)	2,633
Total	18,470

Senegambia.

SENEGAMBIA, a country of western Africa, comprising, as its name implies, the regions watered by the Senegal and the Gambia. It lies between N. Lat. 10. and 17., W. Long. 8. and 17. 30.; bounded on the N. by the Sahara, E. by the Soodan or Nigritia; S. by Sierra-Leone, and W. by the Atlantic; area, about 381,500 square miles.

Boundaries and coast. Except a short distance on the southern side, the country is entirely encircled with natural limits. On the W. lies the ocean; on the N. the course of the Senegal forms a clear line of demarcation between the Sahara and Senegambia; on the E. and S.E., the mountains which divide the Senegal and Gambia from the valley of the Niger separate it from Soodan; and there is only an arbitrary line from the source of the Rio-Grande to Cape Verga, which forms the southern limit of Senegambia, and the northern of Sierra-Leone. The coast line extends from the mouth of the Senegal to Cape Roxo nearly due S., with the exception of the peninsula of Cape Verd, which stretches to the W., forming the extreme point of Africa in that direction. At Cape Roxo the direction of the coast changes to S.E., which continues till beyond the limits of Senegambia. Beside those already mentioned, the only considerable promontory along the shore is Cape St Marie, forming the S. side of the estuary of the Gambia. There are no arms of the sea running into the land, nor any indentations, except the mouths of the Senegal, Gambia, Rio-Grande, and Nuñez. The only islands along the coast are those of Senegal, Gorée, and the numerous group of the Bissão Islands. The coast of the northern part of Senegambia resembles very much that of the Sahara, of which it is a continuation. It is almost entirely low, barren, and monotonous, bordered with ridges of sandy dunes, and only interrupted in a few places by rocky cliffs and plateaus. Towards the S. of the country the appearance of the coast is somewhat different, on account of the many small rivers which enter the sea, forming islands and deltas; and bringing down a quantity of rich alluvial soil, on which a luxuriant vegetation flourishes; baobabs, mangroves, and palms growing close to the edges of the rivers and the ocean.

Surface, mountains, and rivers. From the coast there stretches inland a vast level expanse, occupying more than the half of Senegambia. This plain is about 150 miles at the S., and widens towards the N. to a breadth of 200 miles. East of this lies a mountainous region, which occupies all the rest of the country. Though not very lofty, these mountains are extensive and intricate, sending off many branches and offshoots from the principal mass. To the E. they descend steeply to the valley of the Niger; towards the south they stretch continuously into Sierra-Leone and the interior of Guinea; towards the W. they descend by a series of terraces to the plain of Senegambia; and towards the N. they extend across the Senegal for a short distance into the Sahara. In this mountainous region there are many plateaus and valleys stretching generally from S. to N., through which the rivers of the country take their course. No accurate measurements have been taken of any of the summits in Senegambia, but the N.E. portion, which is the loftiest, as well as the wildest, most impervious, and inhospitable, is not probably more than 6000 feet above the sea; while the general elevation of the table-land varies from 1200 to 1500 feet. The declivity towards the W. is steepest near the S. of the country, where the summit of Mount Sangari, not far removed from the plain, attains an elevation of be-

tween 5000 and 6000 feet. The plateau of Senegambia is in many respects analogous to that of Abyssinia, near the opposite extremity of Africa. These two regions resemble each other in the character of their mountains, the terraces by which they descend to the low ground, and the nature and productions of the soil; and they seem like two bastions at the extremities of the long level tract of Soodan. The chief rivers of Senegambia are the Senegal, Gambia, Rio-Grande, and Nuñez; all of which rise among the mountains, and fall into the Atlantic.

Geology and soil. The geological structure of the country has not yet been thoroughly investigated, especially towards the interior. The flat region along the coast is very uniform in its character. It consists of masses of sand and clay, along with a loose red soil, containing in some places numerous sea-mussels. In some places, as at Cape Verd and Cape Roxo, masses of sandstone occur; those at the latter place, by their red colour, have given the name to the promontory. Clay-slate is also met with; and here and there these Neptunian formations are interrupted by basaltic, amygdaloid, and volcanic rocks. Thus the island of Gorée consists of basalt; the Bissão Islands, of scoriæ and other volcanic substances; and a large part of the coast north of the Nuñez, of basalt and amygdaloid. The foundation of the mountains consists in some places of clay-slate, but more commonly of granite, porphyry, syenite, and trachyte. Mica slate and ironstone are also found in these regions. Excellent iron, as well as considerable quantities of gold, are obtained among the mountains. Many of the valleys in this region have a fertile soil, and so has the land along the banks of the Gambia and along the shore to the S. of that river; but in the rest of Senegambia the soil is of great sterility.

Climate. The climate is one of the hottest on the surface of the earth, and the sun's heat is so intense as to be dreaded even by the natives. On the Senegal, where for eight months in the year hot dry winds blow from the E. over the whole length of the burning soil of the Sahara, the thermometer at 6 o'clock A.M. stands at 82° or 84°; and at mid-day even in the shade rises above 89°. In the valley of the Gambia, too, the heat is exceedingly oppressive, at some places in May the thermometer stands the whole day at 104°. Even in the hilly country, as high degrees of temperature are not seldom experienced. The atmosphere, on the whole, is extremely unhealthy, especially for Europeans; some districts, and some times of the year, are more favourable than others, but these are merely degrees of insalubrity. There are two seasons, a dry and a rainy one. In the former, which lasts from November to June, the air is clear; and the lakes and standing water are dried up. The rainy season is introduced by tremendous thunderstorms; the rivers overflow the flat land, and form extensive marshes; the wind generally blows from the W. or N.W.; and all kinds of vegetation spring up with the utmost luxuriance. This season is the more unhealthy, and during its continuance a dangerous marsh fever prevails.

Vegetables. The vegetable productions of Senegambia resemble those of the other parts, especially the tropical parts of West Africa, and are not very remarkable for the variety of their forms. For a considerable distance from the sea-shore the vegetation, except along the banks of the rivers, consists entirely of long grasses, which grow up during the wet season, and when dried up are burned by the natives, so as to leave the ground entirely bare, with only here and there a few mimosa groves. On the ground inundated by the rivers, however, there grow mangroves, acacias, mimosas, oil-palms, and the gigantic baobab, or monkey bread-tree, which, though not very high, has sometimes a circumference of 77 feet. The whole flora of the maritime plain of Senegambia has a considerable resemblance to that of the E. coast of Africa, especially of Abyssinia. The productions of the interior are not so well known as those of the coast. Dense forests begin near the foot of the mountains, and clothe their acclivities up to a certain height. Above this limit grow the ceiba-palm, and the shea or butter-tree, which furnishes here, as in the neighbouring countries, an important article of food. The extent of cultivation throughout the country depends much more on the degree of civilization of the people than on the capabilities of the soil. In some places, especially near the villages of the Mandingos, there are tracts of land very well cultivated; in others, very little attention is paid to agriculture. Besides rice, maize, and other grains, cotton, indigo, tobacco, sugar-canes, manioc, yams, pistachio and arachis nuts are raised.

Animals. The animals of Senegambia also resemble, to a considerable extent, those of Eastern Africa. It abounds especially in monkeys and elephants. Large herds of the latter range the forests on the Senegal. Beasts of prey of various kinds, especially lions, panthers, and hyænas are also found; as well as antelopes, buffaloes, boars, and hippopotamuses. Fish and alligators abound in the rivers; and turtles and oysters on the sea-coast. Of domestic animals, there are horses, small, but swift and spirited; asses; horned cattle; sheep; and goats; besides a number of camels in the regions near the Sahara.

Inhabitants. Senegambia is, on the whole, well peopled, especially in the mountainous region; for the plains for the most part admit only of a migratory population. The inhabitants are divided into a great number of small tribes, differing in many cases very remarkably in their physical appearance, language, and character. With reference to these characteristics, the multitude of small states may be reduced to a few great groups; the most important of which are these three—the Jolofs, Mandingos, and Foolahs. The Jolofs once formed a powerful kingdom in the plain between the Senegal and the Gambia, and they still occupy that country, though they are divided into a number of petty states. Their bodies are strong and well proportioned; and their features regular and handsome, approaching those of Europeans. Their hair, however, is crisp and woolly; and their colour is the deepest black of any race, resembling polished ebony. They speak a language that agrees with that of the Kaffres in some peculiarities hardly found in any other tongue. In character, they are energetic and warlike. The Mandingos originally came from the mountainous district of Manding, in the extreme S.E. of Senegambia, where they are still settled; but they have spread by conquest and migration down the southern terraces of the mountains to the coast near the mouth of the Gambia. Their features have more of the negro cast, but their complexion is a shade lighter than that of the Jolofs. They are very industrious, especially the Mohammedan branches of the people, and exhibit a good deal of intelligence. The Mandingos are supposed to be the most numerous of all the races that inhabit Senegambia. The Foolahs originally occupied the small country called Foolah-du in the N.E. of Senegambia, but from that region they have spread themselves far and wide in all directions. Within Senegambia they have occupied the kingdom of Timbo in the S.E., and that of Foota-Toro in the low land, on the Senegal; and in Soodan, under the name of Fellatas, they have acquired extensive dominions. Their features and complexion approach very closely to the European type; their hair is long and silky; and in intellectual and moral character they are much superior to the other African races. They are divided into various nations of different degrees of civilization. There are various other tribes in Senegambia of less size and importance; such are the Serracolets, who carry on the trade with the French along the Senegal; the Sereres, near Cape Verd; the Jolas in the south; and many others.

Religion and government.

The religion of the Senegambians is partly heathenism and partly Mohammedanism. Christianity has made progress among the natives only at a few places along the coast. Heathenism appears under the form of fetish worship, but is not accompanied here with such bloody rites as are common in many parts of Guinea. Mohammedanism has made progress chiefly among the Mandingo and Foolah tribes; much less among the Jolofs, and hardly at all in the smaller nations. For a series of years it has made great advances in Senegambia, through the zeal of the marabouts or priests, and the erection of schools for teaching the Koran. The natives who have embraced the religion of Mahomet are favourably distinguished above the heathen tribes for industry, intelligence, hospitality, and clemency. The form of government varies considerably in the different states of the country. Among the Foolahs it is generally a despotic monarchy, the sovereign being at the same time the chief priest of the community; while in the other states the monarch is generally limited in power by the nobles or chieftains; and in some the government approaches the aristocratic, or even the democratic form. Among many of the tribes which are less civilized hardly any bond of union subsists beyond what is necessary for self-defence.

Divisions.

The names of the principal states of Senegambia are as follows:—Belonging to the Jolofs—Wallo, at the mouth of the Senegal; south of it, Cayor; further south, Baol; still further, Sin; and Jolof, east of the last two. Belonging to the Mandingos—Bambuk, between the Senegal and Ba-Faleme; Dentilia, between the latter and the Gambia; Tenda, to the west of the foregoing, along the Gambia; Wulli, north-west of Tenda; Yani, further west, on the north of the Gambia; Salum, still further west; and Barra, between Sin and the Gambia. Besides these, which all lie contiguous to each other, there are two isolated Mandingo states—Manding in the extreme east, and Kaarta north of the Senegal. Belonging to the Foolahs—Foota-Toro, south of the Senegal, near its mouth; Bondu, south of that; Kasson, north of the Senegal; Ludamar, still further north; Foolahdu between the upper branches of that river; and Foota-Jallon, south of the Mandingo tribes. Other native tribes—Galam or Kajaaga, Jallon-Kadu, the country of the Felups, of the Papels, &c. The European settlements in Senegambia belong to the British, the French, and the Portuguese. The British settlements are in the middle of the coast, about the Gambia (see GAMBIA); the French north of them, chiefly on the Senegal (see SENEGAL); and the Portuguese south of the British, comprising the Bissão Islands, and some stations near the Rio-Grande. Some commerce is carried on between Senegambia and the countries of Soodan. Salt, slaves, and gold are the principal articles of merchandise. The total population of the country is estimated at nine millions.

SENESCHAL (*Seneschallus*), derived from the German *sein*, "a house or place," and *scale*, "an officer," is a steward, and signifies one who has the dispensing of justice, as the high seneschal or steward of England; *seneschal de la hôtel de roi*, "steward of the king's household" (*Co. Lit.* 61; Croke's *Jurisd.* 102; Kitch. 83).

SENLIS, a town of France, capital of an arrondissement in the department of Oise, on the slope of a hill, 29 miles S.E. of Beauvais. It consists of an old town and three suburbs; and has narrow, crooked streets, lined with well-built houses. There are here an old castle, a small but stately cathedral, chiefly of the twelfth century, and some churches now used for other purposes. The manufactories consist of cotton mills, tanneries, printing-houses, &c. Many traces of Roman structures have been found here. Pop. (1856) 5172.

SENNA, the leaves of several species of *Cassia*, as *acutifolia*, *lanceolata*, *elongata*, and *obovata*, is a useful purgative, and was imported from Egypt, the British East Indies, the Hanse Towns, and elsewhere, in 1857, to the amount of 219,191 lb., at a total value of L.4730.

SENNAAR, a country of Eastern Africa, formerly an independent kingdom, but now a part of the Ottoman empire, belonging to the province generally known to Europeans under the name of Nubia, called by the Turks the pashalic of Sennaar, and by the Egyptians, Beled-es-Soodan, or the Land of the Blacks. Its limits are not very accurately defined; but it extends along the banks of the White and Blue Nile as far north as the confluence of these two rivers at Khartoom, and is bounded on the north by Dar Shendy, E. and S.E. by Abyssinia, S. by the country of the Nuba mountaineers, and W. by Kordofan. It lies between 12. and 15. 45. N. Lat.; has a length of about 260 miles, a breadth of nearly the same; and an area estimated at 60,000 square miles. The greater part of the country lies between the White (Bahr-el-Abiad) and the Blue Nile (Bahr-el-Azrek), but some part of it also lies to the east of the latter, between it and the Atbara, the largest of the affluents of the Nile. The surface consists of an almost unbroken plain, extending from the Atbara across the Blue and the White Nile to the borders of Kordofan. Its general elevation is from 1400 to above 1500 feet above the level of the sea; Khartoom being 1431, and Sennaar 1515 feet high. The country has thus a slight slope towards the north. Its uniformity of surface is only interrupted by a few isolated mountains, rising from 800 to 900 feet above the surrounding country. Such are Jebel, Szegeti, and Moje, to the west of the town of Sennaar, and Mandera to the east of the same place; which rise like rocky islands in the midst of the sea-like expanse of the country. The southern limit of the plain of Sennaar occurs about the latitude of Seru, on the Blue Nile, about 50 miles in a direct line above Sennaar. Beyond this rise the mountains in the districts of Roserres and Fassokl, which are offshoots of those of Abyssinia to the east. The chief summits are Fassokl (2659 feet), Kassan (3024 feet), and Akaro (3094 feet). Notwithstanding the level character of the land through which they flow, both the streams of the Nile have here a considerable fall; that of the Blue River from Roserres to Sennaar being 0·14 feet per mile, from Sennaar to Wood Medineh, 0·33 feet, and from Wood Medineh to Khartoom 0·53 feet; while that of the White Nile is still greater, being 0·87 feet between Eleis and Khartoom. The uniform character of the plain of Sennaar must be ascribed in a great degree to its geological formation. It consists, like the land of Egypt, almost entirely of regular horizontal strata of sandstone. The mountains, however, are of a totally different structure. They consist exclusively of crystalline rocks, mingled with grauwacke, clay-slate, and limestone. Most of the isolated hills in Sennaar are composed of granite; those in the districts of Roserres and Fassokl, on the other hand, consist of chlorite-slate, with veins of auriferous quartz; and the most of the mountains between the Blue Nile and its affluent the Tumat, of gneiss. Besides gold, iron is found among these mountains, and also in the desert between Sennaar and Kordofan. Salt is obtained at Khartoom, and along the White Nile; and the granite of Mount Szegeti is very excellent, being superior to that of Syene. With these exceptions there are no important minerals in the country. The soil is very fertile, especially in the region east of the Blue Nile. Along the banks of both branches of the river extend dense forests, especially of doom and date palms, baobab trees, and, in the upper parts of the river, of tamarinds. The flats between the two rivers are generally bare and parched during the dry season. After the rains they are either changed into vast grassy savannahs; or else acquire the character of muddy tracts, on which the natives

sow the dhurra seed. This grows up in a few months, and gives the country the aspect of one great corn-field; it is then cut down, and the ground reassumes its sterile appearance. This primitive mode of husbandry is the most common in Sennaar; but there are also other crops raised, such as wheat, sugar-canes in a few places, cotton, tobacco, and, of late years, indigo. The climate is excessively hot; the mean annual temperature being from 80° to 82°. In spring the temperature at noon is frequently above 100°, and in summer it attains a still greater height. This excessive heat produces opposite effects on the country, according to the nature of the soil; in some parts parching it up into an arid desert, and in others fostering a most luxuriant vegetation. The seasons are two in number, and very well defined, a dry and a rainy one. The latter lasts for four or five months in the summer, and is ushered in by tremendous hurricanes; the former continues for the rest of the year. The first indications of the annual inundation of the Nile take place in May; during June it is steadily rising; and attains its greatest height in September. The hilly parts of the country enjoy a salubrious atmosphere; but in the low, flat regions the climate is very unhealthy. Among the wild animals of Sennaar may be numbered the elephant, the rhinoceros, and the hippopotamus. In the dense forests many species of monkeys are found, beasts of prey, such as lions, leopards, hyænas, and wild-cats are numerous, as well as thousands of antelopes in the savannahs of the Blue Nile; giraffes, buffaloes, and goats are also found. Crocodiles abound in the rivers, and many kinds of serpents infest the country. Among birds the most important is the ostrich, which inhabits the desert between Sennaar and Kordofan, and whose feathers are an important article of commerce. Of domesticated animals, horses are more numerous here than in the lower valley of the Nile, while the large herds of camels and horned cattle, and the flocks of sheep, form the chief wealth of the wandering tribes in the uncultivated regions. The origin of the people of Sennaar is involved in much obscurity and doubt. Their bodies are well built, and their colour is a dark copper brown. They have long and curly, but not woolly hair; and their features are quite different from those of the negro. There are many different classes of people, somewhat differing in their characteristics from each other; some more nearly approaching to the Arab, and some to the negro type. The prevailing religion in Sennaar, as in the whole of Nubia, is the Mohammedan, except in the extreme south-east, where there are many Christians and heathens of Abyssinian origin. The kingdom of Sennaar was founded in the beginning of the sixteenth century, by a tribe of Shilluk negroes, who invaded and conquered the country; and called themselves by the name of Fungi or conquerors. For a long period this kingdom remained independent, under its own melik or king, until, in 1820, Mohammed Ali, pasha of Egypt, determined to reduce under his sway Sennaar and the adjacent countries, and undertook an expedition for that purpose. The result was the conquest of the country and its annexation to the Ottoman empire. The population of the province is estimated at a million and a half. The chief town is Sennaar, formerly the capital and residence of the monarch. It stands on the left bank of the Blue Nile, 1150 miles south of Cairo. It has extensive suburbs, about $3\frac{1}{2}$ miles in circuit. The town is ill built, consisting principally of low houses; and it contains several mosques and a ruined palace. There is some trade in basket-work, arms, and silver articles. The population has dwindled from upwards of 12,000 to 7000.

SENNERTUS, Daniel, called by some the German Galen, was an eminent physician, and was born at Breslau in 1572. In 1593 he was sent to Würtemberg, where he made great progress in philosophy and in physic. He visited the universities of Leipsic, Jena, Frankfort-on-the-Oder, and Berlin; but he soon returned to Würtemberg, where he was promoted to the degree of doctor of physic, and soon afterwards to a professorship in the same faculty. He was the first who introduced the study of chemistry into that university, and he gained a great reputation by his works and practice. He died of the plague at Würtemberg in 1637. He sought to reconcile the doctrines of Paracelsus with those of Galen, and seems, in all respects, to have been in advance of his age. He thought the seed of all living creatures animated, and that the soul of this seed produced organization. He was accused of impiety for asserting that the souls of beasts are not material, for this was affirmed to be the same thing with asserting that they are immortal; but he rejected this consequence, as well he might. The writings of Sennertus, a number of which were translated into English, were published in folio at Venice in 1645, and subsequently at Lyon and at Paris.

SENS, a town of France, capital of an arrondissement in the department of Yonne, near the right bank of the Yonne, 70 miles S.E. of Paris. It is partially encircled by old walls, and entered by nine gates, three of which are of mediæval origin. Though a small town, it is neat and well built, with broad straight streets, which are kept clean by small brooks of water from the Vanne, an affluent of the Yonne. The principal building is the cathedral, a very magnificent specimen of the early Gothic style, remarkable for its tracery and painted glass. It contains the canonical vestments of Thomas à Becket, probably genuine, as he fled hither from the anger of Henry II. The town has also an ecclesiastical seminary, hospital, theatre, public baths, and promenades. There are a large public library, a college with a museum, and courts of law. Leather, cotton, yarn, straw-hats, woollen fabrics, hardware, candles, tiles, earthenware, &c., are manufactured here; and there is a considerable trade in corn, flour, wine, wool, hemp, timber, and manufactured articles. Sens occupies the site of the ancient Agendicum, and derived its modern name from the Senones, in whose territory it stood. Under the Romans it was the chief town of Lugdumensis Quarta, and the meeting-place of several roads. Some sculptured stones, of Roman workmanship, have been built into the walls of the town. Pop. (1856) 9869.

SENSATIONALISM, or Sensualism, is a term employed to designate those systems of philosophy which either directly or indirectly deduce all our knowledge from sensation, or from the experience which sense affords. Such, for example, are the sensational philosophers of the eighteenth century.

SEPOURY, or Sipery, a town and fortress of Hindustan, province of Agra and district of Gohud, taken by the British in 1781. It is 18 miles S.W. of Narwa.

SEPOYS. See Hindustan.

SEPTEMBER, the ninth month of the year, consisting of thirty days. It took its name as being the seventh month from March, with which the Romans began their year. Since 1752 our legal year has commenced in January.

SEPTUAGESIMA, in the calender, denotes the third Sunday before Lent, or before Quadragesima Sunday. It is supposed by some to take its name from its being about seventy days before Easter.

SEPTUAGINT, a Greek version of the Old Testament, which received this name either from the supposition that it was the work of LXX. or LXXII. translators, or more probably because it received the sanction of the Jewish Sanhedrim, which consisted of that number of members. If the latter reason be correct, the title is exactly equivalent to our Bishop's Bible, so called because it was a translation recommended by the authority of the English bishops.

Archbishop Usher places the date of this version B.C.

Septuagint. 277, following the story of its origin, which was so long current under the name of Aristeas, who professes to have been an officer of Ptolemy's guard at the time when the transaction took place. The story is as follows. Ptolemy Philadelphus having heard of the Jewish law from Demetrius Phaleteus, to whom he had entrusted the care of his Alexandrian library, ordered that a copy of it should be sent for, and that it should be rendered into Greek by properly qualified interpreters from Jerusalem. Aristeas and two other nobles took this opportunity to urge on the king the liberation of the Jews who had been taken captive by Ptolemy Soter, saying that unless this was done, obstacles would be put in the way of his wish. Accordingly, at the enormous expense of 660 talents, he procured the freedom of 198,000 Jewish captives, and then, by the advice of Demetrius, wrote to the high-priest Eleazer asking for a Hebrew copy of the law, and seventy-two translators (six out of each tribe), competent to render it into Greek. Aristeas was one of the bearers of this letter and of the splendid gifts which accompanied it, and he returned to Egypt with the translators, and a copy of the law written in golden letters. On their arrival at court, the translators having proved their wisdom by impromptu answers to the seventy-two questions put to them, were conducted to the Pharos, and there by common conference completed their task in seventy-two days, whereupon the king dismissed them home with regal munificence.

Besides Aristeas, the Septuagint is mentioned by Aristobulus[1] (an Alexandrian Jew who wished to prove the foolish surmise that the Greeks had plagiarized their philosophy from Scripture); by Philo,[2] and by Josephus.[3] Philo adds the further particulars, that each translator rendered the *whole* book; that they were found at the conclusion to have agreed verbally with each other by the miraculous aid vouchsafed to them; and that a solemn anniversary was kept in honour of the occasion. Justin Martyr, following common rumour, still farther improves the story, and believed that he had actually seen the ruins of the seventy cells in which the distinct versions were miraculously made; and thus in one form or other this marvellous fiction received full credence among the ancient fathers—*e.g.*, Irenæus, Clemens Alexandrinus, Hilary, Augustine, and Cyril of Jerusalem. Epiphanius also repeats the story with variations and additions; and it was believed for centuries with the most unquestioning confidence. The obvious inference was, that the LXX. version, with all its errors and imperfections, must be regarded as inspired.

But it has now been demonstrated that the book of Aristeas is an idle forgery, a mere religious romance, written by a Hellenistic Jew to magnify his nation, and to exalt the credit of this Greek version. His whole narrative bears the stamp of Jewish exaggeration and self-complacency. The author, professing to be a heathen, uses throughout language which could only have emanated from a Jew. The questions he puts in the mouth of Ptolemy are absurdly incongruous; the sum which he makes him disburse in accomplishing his wish (amounting to some 2.000,000[4] sterling) in utterly incredible; the distinction of the twelve tribes is an historical improbability, and several of the other particulars alluded to by him are confusions, anachronisms, or Pharisaical inventions. In fact, it is now admitted that the pseudo-Aristeas furnishes ample materials for the refutation of his own fiction, and since the learned work of Dr Hody, *De Bibliorum Textibus originalibus*, we are not aware that any one has attempted to defend the genuineness of his treatise.

But the question remains, is there a single germ of truth amid this mass of fable? It is indeed difficult to arrive at any certainty, but internal evidence supplies us with some strong probabilities. For instance it is clear,

1. That the version was the work of Alexandrian and not of Palestinian Jews. This appears at once from the freedom with which the Hebrew text is treated, since the Jews of Palestine would have been far more likely to adhere scrupulously to the most literal methods of rendering; a tendency which subsequently gave rise to the version of Aquila, which was called by them the *Hebraica veritas.* The language in which the LXX. is written is that Hellenistic Greek, that κοινὴ διάλεκτος which became so general after the time of Alexander the Great, and there are a number of expressions which could only have been used by a native of Alexandria. Thus, to take a few of the instances adduced by Hody,[5] the word shekel is in the pentateuch rendered by δίδραχμος; epha by Ὀιφι, which, it appears from Phavorinus, was an Egyptian measure; Zaphnath-Paaneah, the Hebrew name of Joseph, is turned into its Egyptian equivalent ψονθομφάνηχ; in Amos v. 26 the Egyptian Ῥεφὰν is substituted for the Hebrew Ciun; and in Job viii. 11 "reed" is rendered by "papyrus." A still more curious and decisive instance of this is the fact, that Thummim, the jewelled ornament of the high-priest's robe, is translated Ἀλήθεια or "truth," though the Hebrew word means "perfection;" we should be at a loss to account for this but for the information found in Ælian,[6] that the senior priest of the Egyptian hierarchy wore round his neck, while performing his judicial functions, an ornament of sapphires called by this very name "Truth." Besides all this, the translators, in the Apocryphal additions to the book of Esther, makes express mention of Ptolemy Philometor and Cleopatra; and when we add, that the universal tradition of the Jews themselves agrees in the main with these inferences (although Aristeas says that the translators came from Palestine), we may regard the Alexandrian origin of the version as sufficiently established.

But did the impulse which originated it come from within or from without? Alexander had transplanted a vast multitude of Jews to his new city, and had there given many privileges. Finding Alexandria a desirable place of residence, and being forced to speak the Greek language, which was at that time the common medium of communication, they gradually forgot the Chaldee, as, during the Babylonish captivity, they had forgotten the Hebrew. The Chaldee interpretation of the Scriptures used in their synagogues was, therefore, as obsolete to them as the original tongue, and they would doubtless feel the want of religious teaching in a language which they could comprehend. A literary motive may well have been combined with this religious motive, and it is by no means impossible that the general desire on the subject may have owed its first accomplishment to the additional influence of a king of Egypt, who wished so curious a record as the Pentateuch to be treasured up in the Alexandrian Library. In favour of this supposition is the annual festival, at which, according to Philo, the event is commemorated. The pseudo-Aristeas attributes the design to Ptolemy Philadelphus, and he has been generally followed; but the common Jewish account referred it to his father Ptolemy Lagus, and Hody reconciles the discrepancy by supposing the work to have been commenced during the years B.C. 286–285, when father and son were associated on the throne. Ptolemy Lagus, although kind to the Jews, was yet unpopular among them, because he had carried so many of them into captivity; and this may account for the omission of his name in the fable of Aristeas. It is probable that the Pentateuch alone was first translated, both from the distinct assertions by ancient writers to this effect, and from internal evidence;

[1] Quoted by Euseb., *Præp. Evang.* vii. 13; Clem. Alex., *Strom.* i., &c. [2] *De Vit. Mos.* ii. [3] *Ant.* xii. 2.
[4] Prideaux, *Connect.* ii. 39. [5] *De Bibliorum Text.* pp. 112–120. [6] Spencer, *De Urim et Thummim,* iv. 12.

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but in any case the manuscript, if procured for the Alexandrian Library, remained totally unknown, since nothing is more certain than the complete ignorance respecting Jewish history and institutions displayed not only by earlier authors, but even by the polished writers of the Roman empire.

2. The reasonings by which Hody and others attempt to arrive at a conclusion respecting the date of other portions of the Septuagint are very uncertain. For instance, it is argued from the use of the word γαισός in Joshua (viii. 18), that this book could not have been rendered until the employment of Gallic mercenaries by the Egyptian kings, *i. e.*, some twenty years after the death of Ptolemy Lagus, because γαισός means a peculiar kind of Gallic javelin.[1] But this argument is of very slender authority, nor can we deduce any strong inference from the mention of Ptolemy Philometor in the epilogue to Esther. It is, however, most probable, from a passage in the book[2] of the son of Sirach, that the whole had been completed before B.C. 130, in the reign of Ptolemy Physcon.

3. It is quite certain that it was made at different times and by different persons, although it is impossible to decide the exact number of translators employed on it. The common story speaks of 72; Epiphanius, of 36; the Jerusalem Talmud, of 5; and some of the Rabbis, of 3. Perhaps the real number was about 12 or 15. The different translators have adopted very different methods of rendering the same word, and even different modes of spelling the same common names; sometimes these names are made indeclinable, and sometimes a Greek termination is given to them. The rendering of Hebrew names for animals, trees, precious stones, weights and measures, are not only various but even irreconcileable. Thus, כְּפִיר, "a lion," is in Job iv. 10 rendered by δράκων; תְּאוֹ, "an oryx," is in Is. li. 20 represented by σευτλίον, a vegetable; and not to give any further specimens, תַּנִּין, "a whale," is rendered κῆτος, Gen. i. 21; "a dragon," Ps. lxxiv. 16, &c.; "a siren," Job. xx. 39; "a sparrow," Jer. x. 22; "a hedgehog," Is. xvi. 22; "a bird," Is. xxxv. 7; "a fig," Neh. ii. 13; and "affliction," Ps. xliii. 19! These instances are the first that came to hand out of ten pages[3] of similar ones in Hody's learned work; and some of these which he adduces prove that even the Pentateuch was not the work of a single hand. The Pentateuch is the part which was earliest and best executed; and of the books which it contains, Leviticus is translated best, and Numbers worst. The historical books are only tolerably rendered; the book of Proverbs admirably; the Prophets (especially Isaiah) indifferently. The vision of Daniel was so incomplete and erroneous, that Theodotion's version was substituted for it; it was long lost, and a manuscript of it was only rediscovered in 1772 in the Codex Chisianus at Rome. The translator of Job was a man of fine taste, profoundly read in the Greek poets, but a poor Hebrew scholar; this has led him into the awkward habit of omitting the passages which he did not understand.

From some curious agreements of the LXX. with the Samaritan Pentateuch, in some 2000 places, Hassencamp, and others have supposed that the translators made use of a Samaritan manuscript. But although there are those remarkable agreements, and although it has been thought that some variations in the LXX. may be accounted for by different readings, originating in the shape of the Samaritan letters, yet the numerous disagreements of the two tend to show that the points in which both differ from the Masorethic text are accounted for by the operation in both of false[4] principles of criticism; as, for instance, the desire to remove objections, to reconcile discrepancies, &c. And in some of these cases, where *both* have made an attempt of this kind (*e.g.*, Gen. v. 3-28; Ex. xii. 40), the method of the Samaritan is so much the more ingenious, that it is impossible to suppose that the Greek would not have adopted it had he been aware of it. There is, therefore, no necessity to assume great interpolation, numerous glosses, wilful corruptions, or any other of the numerous hypotheses which have been suggested to account for the numerous passages in which the Samaritan and the Greek agree, while both differ from the Hebrew. It is utterly incredible that Jews would ever have persuaded themselves to translate from a Samaritan text; and Abul Phatach's rival story of the origin of the Greek version of the Samaritan Pentateuch (which, according to him, was greatly preferred by Ptolemy Philadelphus), at least proves how unlikely it would have been for the Jews to use any other than the Masorethic text.

The importance of the Septuagint for all purposes of biblical criticism can hardly be overrated; and the influence which has been exercised by it for centuries renders the study of it imperative on every theologian. The fabulous accounts of its origin show the extravagant reputation in which it was held. Josephus used it in general; Philo, being ignorant of Hebrew, used it exclusively, and believed in its inspiration. Even in the Targums there are traces of a similar belief. Undertaken as it was without any suspicion of the controversies to which the interpretation of prophecy would subsequently give rise, and executed by men for the most part candid, zealous, and competent, it forms an invaluable commentary on the Hebrew text, and an historical specimen of the early method of exegesis. By rendering the Bible accessible to the learned of every country, it was an effectual safeguard against wilful interpolation, "so as to preclude all suspicion that it could be materially altered either by Jews or Christians, to support their respective opinions as to the person and character of the Messiah; the substance of the text being by this translation fixed and authenticated at least 270 years before the appearance of our[5] Lord." It was the version from which our blessed Saviour, in all probability, was taught to read when a child at Nazareth,—the version which he loved to quote, if not to the Pharisees and doctors of the law, at least to the common people, who heard him gladly, —the version which formed the text-book of apostolic teaching; from which all the ancient versions, except the Syriac, were made; which constituted the sole Scriptures of the Old Testament for the first four centuries; from which Augustine drew his meditations and Chrysostom his homilies. "The entire phraseology of the New Testament is formed on the peculiar style of the LXX,"[6] and any one who will consult Mr Grinfield's *Scholia Hellenictica*, may see at a glance that there is scarcely a page of the Gospels or Epistles which does not bear ample testimony to the fact, that the minds of the sacred writers were imbued with the style and language of this Greek version. It is well known that this Hellenistic Greek differs widely from the classical standard; and although it is a common error to attribute to Bentley the assertion that the dialect would have been altogether unintelligible to Demosthenes, yet certainly a Greek of the age of Pericles would have found it marvellously obscure. Hence the expressions of the LXX. are the ultimate source of our theological language, and "the Hebraic or Hellenistic Greek is the *sacred idiom.*" To it we owe such words as the ἀγάπη, ἁγιωσύνη, πνεῦμα, δικάιωσις, ἐυχαριστεῖν—the very keywords of the Christian

[1] Schleusner's *Thesaurus*, s. v.; Bochart, *Hieroz.*, I., lib. ii., p. 137, &c. [2] Prol. of Ecclus. [3] *De Bibl. Text.* 204–216.
[4] See an able paper in Kitto's *Jour. of Sac. Lit.*, vol. ii., and Herzog's *Cycloped.*, art. "Alexandr. Bibelübersetzung."
[5] Graves, *On the Pentateuch*, III. v. 2. [6] Grinfield's *Apology for the LXX.*, p. 1.

 religion. "There are many words," says Bishop Pearson, "which, from the mere usage of the Greek tongue, cannot be understood; which by collation with the Hebrews and the LXX. become easily intelligible. No one knows what σάρξ, what πνεῦμα signify among the Greek authors; and if you collect all the senses in which the Greeks use these words, you will find none that reach the apostle's meaning."[1] Thus, the dissemination of the LXX. paved the way for Christianity, and prepared the minds of men for the advent of an expected Saviour.

Direct quotations from the LXX. abound in the New Testament. In St Stephen's speech alone there are no less than twenty-eight, and the language of the Epistle to the Hebrews is "a kind of Mosaic, composed of bits and fragments of the LXX." Our Lord quoted it repeatedly. Out of the thirty-seven quotations made by him from the Old Testament, thirty-three are said to agree with the Greek[2] almost verbatim. It is certainly a striking and most important fact, that the apostles quote it and argue from it *even where it differs from the Hebrew;* "et quidem iis in locis," says Dr Mill on Heb. xiii. 25, "in quibus, si reponerentur Hebrea, non modo periret vis argumentationis Apostolicæ, sed *ne quidem ullus foret argumentationi locus.*" Instances of this may be found by the student in Luke iii. 37, Matt. xv. 8, 9, Acts ii. 25, Rom. x. 18, Heb. i. 7, ii. 7, x. 5, &c.

On these grounds it has been repeatedly argued, that, in order to maintain the doctrine of verbal or plenary inspiration, it is absolutely necessary to adopt the belief of the early Christian world as to the *inspiration* of the Greek translators. We have already seen that such a supposition prevailed among the Jews; it was the express belief of Irenæus, Clemens Alexandrinus, Hilary, and many of the fathers; it was strongly and frequently asserted by Augustine, and even his stout opponent St Jerome, whose study of the original Hebrew had given him a less favourable opinion, occasionally recurs to the old prejudice, and speaks of the Alexandrian interpreters as actuated by the extraordinary influences of the Holy Spirit. Even in modern times so strange an hallucination has not been totally dispelled; and Mr Grinfield's *Apology* supports the divine authority of the version with an earnestness and ingenuity which is deserving of a better cause.

For whatever inferences may be drawn from the fact, the dignity of truth demands the statement that the Septuagint abounds in errors, transpositions, interpolations, omissions, and defects of every kind, which abundantly prove that the translators were extremely fallible. Sometimes they show an imperfect acquaintance with Hebrew, sometimes with Greek, and sometimes they have made mistakes which can be attributed to carelessness alone. Nor are these variations due solely to defective knowledge; it is tolerably clear that they sometimes arise from a distinct purpose. Even the version of the Pentateuch is not free from this literary dishonesty. "It is obvious,"[3] says an able writer, "that the translator of Exodus had a plan which he strictly followed; and for the maintenance of his design he sacrificed the original text. Sometimes it was for a philosophical, sometimes for a political reason, at another time for the sake of saving the reputation for humanity of the Jewish legislator. Often he altogether neglected to translate words from which it might have appeared that the ordinances of the Jewish law were unnecessarily severe." Thus, in Ex. xiii. 13, he wilfully changes "thou shalt break his neck," into "thou shalt ransom it;" a rendering which is in direct contradiction to Lev. xxvii. 11. In Ex. xxiv. 10, 11, "they saw the God of heaven" is, from the Alexandrian pseudo-philosophical avoidance of anthropomorphism, absurdly rendered, "they saw *the place where* the God of Israel stood." In Ex. xv. 3, "the Lord is a man of war," is, for a similar reason, changed into "the Lord brings wars to nought;" and the same influence is at work in verse 10. Ex. xxxii. 9 is altogether *omitted* by this translator as unfavourable to the Jews; and he has given us a further indication of his political bias by the remarkable way in which he has softened the harsh expression of Ex. xxxii. 22. These instances, though taken from a single book, are chosen from a portion confessedly the best executed of the whole, and are no unfair specimens of the want of due regard to the text which sometimes misled them, even when their knowledge was not at fault. They are surely amply sufficient to prove, that to attribute inspiration to these Hellenists, is nothing else than an apotheosis of partial incompetence and positive mistake. In fact, the Septuagint translation must rather be regarded in the light of a paraphrase executed from the critical and religious[4] standpoint of Alexandrian Jews some two centuries before Christ. This will account for more inaccuracies and arbitrary alterations than any other principle; although besides this, it is possible that their manuscripts were often corrupt, and certain that they were without vowel points, final letters, or any of the other aids afforded by the later method of writing Hebrew. Nor must we overlook the enormous difficulty which had to be overcome in *creating* a style which should give in Greek a tolerable expression of Hebraic idioms and modes of thought.

The Jews first began to dislike and reject the Septuagint, when they found that its renderings were peculiarly valuable for the purposes of Christian controversy. They therefore adopted in lieu of it the version of Aquila, the chief merit of which is its slavish literalism. There seems, however, to be no adaquate proof that they instituted a stated fast on the 8th of Tebet, to execrate the anniversary of its completion, as we have no authority for this statement earlier than Justin Martyr.[5] Since the Septuagint had long been used in almost all their synagogues, this condemnation of it came a little too late in the day; and the Christians, who had no means of consulting the original, prized the translation with an extravagant veneration, and accepted it as an inspired production, and even preferred it to the Hebrew text. Jerome's profound learning led him to see that such views were untenable, and in forming the design of making a fresh translation from the Hebrew, he pointed out the necessity for doing so by showing the errors of the LXX. This proposal alarmed St Augustine as much as the suggestion of a revision of our English version alarms the more timid divines of the present day; and when Jerome was driven by the Bishop's opposition into further arguments, he finally forbade the use of Jerome's translation within his diocese. Ruffinus was even more violent and unreasonable in his attacks on the proposed innovation; and, on the whole, the Septuagint maintained its high authority until the conclusion of the eighteenth century, when it began to be rated at its true value, as a version which cannot be regarded as possessing any claims to equal authority with the Hebrew text, although it is exceedingly important for all the purposes of Scriptural interpretation.

When the Greek text began to accumulate a vast number of glosses, interpolations, marginal readings, alterations, and mistakes, Origen undertook his stupendous work, the *Hexapla*, in order to compare it with the Hebrew, and restore it, if possible, to its primitive condition. This noble undertaking, which might well entitle its author to the surname of "Adamantine," occupied (according to Epiphanius)

1 Bp. Pearson's *Prefatio Parænetica.*
2 Grinfield, p. 185. Tables of quotations may be found in Horne, vol. ii., ch. iv., and Davidson's *Introduction*, ch. xxviii.
3 *Journal of Sac. Lit.*, vol. vii.
4 Fritsche in Herzog, *ubi supra.*
5 Basnage, *Hist. des Juifs* (see Jahn's *Hebr. Commonwealth*, Engl. ed., p. 255).

no less than twenty-eight years; but, in spite of its value, unfortunately increased the evil which it was intended to cure, since subsequent copyists often confounded and mixed together the various other texts which Origen had printed in parallel columns, side by side with the version of the LXX.[1]

The four chief editions of the LXX. are the Complutensian, the Aldine, the Sixtine, and the Grabian, which mainly follows the Codex Alexandrinus. A thorough revision of the text, and a good concordance, are still wanted: the lexicons of Biel and Schleusner are full of valuable information, but are still capable of very great improvement.

A vast number of books have been written on the Septuagint, and it only remains to enumerate the most important. Popular accounts may be found in Kitto's *Cyclopædia*, in Dr Davidson's *Bibl. Introduction*, in Horne's *Introduction*, vol. ii., and in Herzog's *Cyclopædia*, of which there is an English translation by Dr Bonberger. The classical book on the story of Aristeas is Hodius *De Bibl. Text. originalibus*, Oxon. 1705; and it is also examined in Gregory's *History of the LXX.*, Lond. 1664, and Van. Dale's *Dissert. super Aristeâ*, &c., Amst. 1705. An account of the disputes of Jerome and Augustin may be found in Du Pin's lives of these fathers. For further information see Pearson's *Prefatio Parænetica;* Walton's *Prolegomena*, c. ix.; Grabe's *Prolegomena;* Valcknaer, *De Aristobulo Judæo;* Thiersch, *De Pentat. Versione;* Toepler, *De Pent. Jut. Indole;* Studer, *De Vers. Alex. Origine*, &c. Important German books are, Dähne's *Judisch-Alexandr. Philosophie*, Halle, 1834, and Frankel's *Vorstudien*, Leipzig, 1841. The study of the LXX. is at present attracting much attention in England; and we have recently had valuable contributions to the literature of this subject by Mr Grinfield, Dean Howard, and Prof. Selwyn. (F. W. F.)

SEPULCHRE, Regular Canons of St, a religious order, formerly instituted at Jerusalem in honour of the holy sepulchre, or the tomb of Jesus Christ. Many of these canons were brought from the Holy Land into Europe, particularly into France, by Louis the Younger; into Poland, by Jaxa, a Polish gentleman; into Flanders, by the counts of that country; and many also came into England. This order was, however, suppressed by Pope Innocent VIII., who gave its revenues and effects to that of the Lady of Bethlehem; and this also becoming extinct, they were bestowed on the knights of St John of Jerusalem. These canons follow the rule of St Augustin.

Sepulchre, *Knights of the Holy*, a military order, established in Palestine about the year 1114. Those of this class chose Philip II., king of Spain, for their master, in 1558, and afterwards his son; but the grand-master of the order of Malta prevailed on him to resign; and when afterwards the Duke de Nevers assumed the same quality in France, the same grand-master, by his interest and credit, procured a like renunciation by him, and a confirmation of the union of this order to that of Malta.

SEPULVEDA, Juan Ginez de, a learned Spanish chronicler, was born at Pozoblanco, near Cordova, in 1490. He was educated first at Cordova, and afterwards at the university of Alcalá. Leaving the university in 1515, he set out for Italy, where he studied under the celebrated Pomponazzi, of Bologna. Having written the life of his patron, Cardinal Albornoz, he subsequently went to Rome and Naples, where he assisted Cardinal Caetano in revising the Greek text of the New Testament. He returned to Rome in 1529, and was appointed some years later chaplain and historiographer to Charles V. Leaving Italy, he now returned to his native country, and was induced to attack the celebrated bishop, Las Casas, who was then engaged in pleading the cause of the suffering Indians. But the royal council refused their imprimatur, and the world was deprived of this courtly book. Sepulveda wrote an *Apologia* in 1550; but this was unfortunately seized by order of the emperor. This learned Spaniard died in 1574. Sepulveda seems to have been a man of considerable literary merit; and Erasmus, who was no mean judge, pronounces him one of the best writers of his nation. Besides a number of works, which still lie in manuscript, his published writings were re-edited in 1780, in 4 vols. folio, by the Royal Academy of History of Madrid. This edition contained a sketch of the life and writings of the author.

SEQUANI, a Celtic nation of ancient Gaul, occupying part of the upper valley of the Saône or Arar, separated on the E. by the Jura range from the Helvetii; on the W. by the Arar from the Aedui, having the Leuci and the Lingone on the N., and the Allobroges and Ambarri on the S. They thus occupied the northern departments of Ain, Jura, and Doubs, with parts of those of Saône-et-Loire and Côte d'Or. Besides the Arar, the country was watered by the Dubis (Doubs), on which stood their chief town Vesontio, now Besançon. They fed large numbers of hogs, and exported ham and bacon to Rome. Before the conquest of Gaul by Cæsar, the Arverni and Aedui, the two most powerful nations of that country, were in a state of hostility; and the Sequani allied themselves with the former. In order more effectually to crush their enemies, these two nations hired a large body of Germans, under Ariovistus, from over the Rhine. With their assistance they totally defeated the Aedui; but the Germans seized for themselves a third part of the territory of the Sequani; and would have made further encroachments, had not Cæsar defeated them, and expelled them from the land. Though driven across the Rhine at that time, the Germans seem to have returned at a subsequent period.

SEQUESTRATION, in common law, is setting aside the thing in controversy from the possession of both the parties that contend for it. In this sense it is either voluntary, as when done by the consent of the parties; or necessary, as where it is done by the judge, of his own authority, whether the parties are inclined or the reverse. (See Bankruptcy.)

SEQUIN, or Zecchino, a gold coin of Venice, value about 9s. 6½d.

SERAGLIO (Persian *seraw*, or Turkish *serai*, both of which signify *a house*), is commonly used to express the house or palace of a prince. In this sense it is frequently used at Constantinople, where the houses of foreign ambassadors are called seraglios. But it is commonly employed by way of eminence for the palace of the grand signior of Constantinople, where he keeps his court, where his concubines are lodged (properly called *hareem*), and where the youth are trained up for the chief posts of the empire.

SERAING, a town of Belgium, on the right bank of the Meuse, in the province and 3 miles S.W. of Liège. It is chiefly remarkable for its immense iron-works, among which is probably the most extensive manufactory of machinery in the world. It occupies the former palace of the bishops of Liège, which has thus lost all its palatial and ecclesiastical aspect. Seraing has also iron-furnaces, forges, and coal-mines, employing from 3000 to 4000 hands, and a large number of steam-engines. Pop. 4857.

SERAMPORE, a town of British India, in the presidency of Bengal, and district of Hoogly, on the right bank of the Hoogly, 18 miles N. of Calcutta. It is a neat, clean, well-built place, somewhat like a European town. The principal building is the court-house, which was the government-house while the Danes possessed the town; and the chief manufacture carried on here is that of paper, which is

[1] For accounts of this great work see Fritsche in Herzog's *Cyclopædia*, "Alexandr. Bibelüber.," &c.

of good quality. Serampore belonged to Denmark till 1845, when it was purchased by the British, as it had proved very inconvenient by affording a refuge to swindlers and insolvent debtors from Calcutta. The place attracted more attention than it would otherwise have obtained, as being the seat of the first mission-station from Europe in India. It was founded by Wiliam Carey towards the close of the last century, and has since been removed to Calcutta. Pop. of the town and suburbs, 13,000.

SERAPIS. See Mythology.

SERES, a town of European Turkey, Macedonia, in the eyalet and 35 miles N.E. of Salonica, on the Strymon, in a plain rich in cotton and rice, and studded with numerous villages. It is well built and clean, with fine palaces, mosques, and gardens, large bazaars, and public gardens. Cotton-spinning is actively carried on here; and there is an extensive trade in corn, tobacco, and cotton. Seres is one of the most important commercial towns in Turkey. Pop. 30,000.

SERGEANT, or Serjeant-at-Law, or of the Coif, is the highest degree taken at the common law, as that of doctor is of the civil law; and as these are supposed to be the most learned and experienced in the practice of the courts, there is one court appointed specially for them to plead in, namely, the Common Pleas, where the common law of England is most strictly observed. But they are not restricted from pleading in any other court, where the judges, who cannot have that honour till they have taken the degree of sergeant-at-law, call them brothers.

Sergeant-at-Arms, or Mace, an officer appointed to attend the person of the king, to arrest traitors, and such persons of quality as offend, and to attend the lord high-steward when sitting in judgment on a traitor. There are four other sergeants-at-arms, created in the same manner; one, who attends the lord-chancellor; a second, the lord-treasurer; a third, the speaker of the House of Commons; and a fourth, the lord mayor of London on solemn occasions.

Common Sergeant, an officer in the city of London, who attends the lord mayor and court of aldermen on court days, and is in council with them on all occasions, within and without the precincts or liberties of the city.

Sergeant, in war, is a non-commissioned officer in a company of foot or troop of dragoons, armed with an halbert, and appointed to see discipline observed, to teach the soldiers the exercise of arms, and to improve their discipline. He receives the orders from the adjutant, which he communicates to his officers. Each company has generally two sergeants.

SERGEL, Johann Tobias von, an eminent Swedish sculptor, was born at Stockholm on the 8th of September 1740. He was at first apprenticed to a stone-mason, and was engaged in that capacity at the royal palace of Stockholm, where he had the good fortune to draw upon himself the notice of the sculptor L'Archeveque, who at once took him as a pupil. After assisting his master for some years he obtained, in 1767, a travelling pension, when he went to Rome, and remained there for twelve years. During his stay in Italy he executed numerous works of great merit; and, on his visiting Paris, his "Othryades," or the figure of a wounded Greek soldier, now placed in the Luxembourg, gained him admission to the Academy of the Fine Arts. He had just reached London when he received an offer from Gustavus III. of Sweden of the office of court sculptor. He lost no time in reaching Stockholm, and in 1784 accompanied his majesty to Rome, and induced him to purchase the celebrated "Endymion" for the royal museum of Stockholm. Catherine II. of Russia was anxious to secure the services of Sergel, and made him very flattering offers to go and reside at St Petersburg. But the sculptor was too much attached to his master to think of leaving him; and when, in a few years, the untimely end of Gustavus cast a gloom over all the court, it plunged Sergel in so deep a melancholy that he is reported never to have recovered. He died in his native city on the 26th of February 1814, in his seventy-fourth year.

Sergel's works are all marked by great vigour of conception, by simplicity, and grace of style, and by an entire freedom from the mannerism which tainted the most graceful productions of the chisels of his cotemporaries. His best statues are his "Karl III.," "Juno," "Cupid and Venus," "Diomedes carrying off the Palladium," "Othryades," "a Faun," "Gustavus III., "Oxenstierna," "Mars and Venus," and a "Venus Callipyge." He executed a number of excellent groups, and some fine busts and portrait medallions.

SERGIPE, or Sergipe del Rey, the smallest of the provinces of Brazil, bounded on the N. by that of Alagoas, E. by the Atlantic, S. and W. by the province of Bahia, lying between S. Lat. 9. 15. and 11. 27., W. Long. 36. 20. and 39. 15. Area, 11,079 square miles. It extends for 110 miles along the coast, and nearly 140 inland. The coast line is in general low and sandy, and the surface of the country is level, except where it is broken by a few hills. These occur chiefly in the western part of the province, and are generally covered with forests. The largest river is the São Francisco, which flows eastwards into the Atlantic, forming the northern boundary of the province. The Itapicuru forms the southern boundary, flowing in the same direction; and the country is also watered by the Vazabarris and Sergipe, which also fall into the Atlantic. Rock-crystal, limestone, and saltpetre are the principal minerals found here. The soil on the whole is not remarkable for its fertility; for although the eastern portion produces rice, cotton, sugar-canes, tobacco, flax, and other crops in abundance, the western part of the province is of a very sterile and unproductive nature, being in many places stony, and throughout ill supplied with water. The rivers and lakes, of which there are several in the N.W., abound in fish, and the latter also in wild-fowl. Cattle, mules, and horses are reared in considerable numbers. The forests furnish valuable timber and dyeworks. Among the exports of the province the most important are cotton, sugar, brandy, tobacco, and cattle. The mouths of the rivers form many harbours along the coast, but they are in general small and shallow. Sergipe is divided into five comarcas and seventeen districts. It returns two senators and four deputies to the Brazilian legislature. The capital is Sargipe or São Christovão, a town of 3000 inhabitants, on the Atlantic coast. Pop. (1856) 183,600.

SERICA, the name given by the ancients to a tract of Eastern Asia, lying, according to Ptolemy, east of Scythia extra Imaum, north of India, and west of the land of the Sinae. It probably occupied the country now called Mongolia, and the western part of China. The people were called Seres, and were chiefly known to the Greek and Roman nations on account of the silk which they produced, and in which they carried on a lucrative trade. Indeed, so closely were they connected with this branch of trade that the classical name for a silkworm was *ser*, and for silk-cloth *serica vestis*. Some have supposed that the name of the insect was transferred to the people; but this is not so probable as the converse, for there are many instances of articles of commerce deriving their names from the places whence they come. According to the ancient accounts, the Seres were a mild and gentle people, avoiding as much as possible (like the Chinese of the present day), all intercourse with other nations. They were probably of the Mongolian race.

SERIES. See Algebra and Fluxions.

SERINAGUR. See Sireenuggur.

SERINGAPATAM (*Shri Ranga Patanam*, the city of Shri Ranga or Vishnu), a town of India, in the Rajah of

Mysore's dominions, 9 miles N.E. of Mysore, and 248 west of Madras, on the west end of an island in the Cauvery, N. Lat. 12. 25., E. Long. 76. 45. It is now a dull, deserted town, the mere ghost of its former magnificence, when it was the capital of Mysore and residence of Tippoo Sultan, with a population, it is said, of no less that 300,000. The fortifications, which are very strong, though not skilfully constructed, form an irregular pentagon, protected on two sides, the N. and S.W., by the river, and extending a mile and a half in length, from N.W. to S.E., by half that breadth. The strongest parts of the defences were towards the east and south, the safety of the other sides having been too much trusted to the Cauvery, though that river is fordable in the dry season. It was from this side that the town was stormed by the British in 1799, in preference to making a breach in the massive walls on the land side. The grass and trees now grow luxuriantly about the place where the deadly conflict took place, and where Tippoo himself fell. The principal buildings within the fortifications are the large, straggling, mean-looking palace, now in a state of decay; the Hindoo temple of Vishnu, and the sultan's mosque, containing the tombs of the nobles who fell in his cause, and commanding a fine view from its minarets. Seringapatam is said to have been founded in 1454 by a devotee of Vishnu. Its early history is involved in obscurity; but in 1610 it was possessed by Raj Wadegar, a Mysore chief. In 1697 it was besieged, but ineffectually, by the Mahrattas; and again, in 1772, after it had been for seven years occupied by Hyder Ali as his capital, these formidable assailants were bought off by a sum of L.150,000. Tippoo Sultan, the son and successor of Hyder Ali, also resided in Seringapatam, and erected the formidable defences of the town. On the 5th of April 1799 it was invested by the British, and on the 4th of May taken by storm. The town and fort were retained for some time as a military station, but afterwards abandoned on account of their insalubrity. The population in 1800 was 31,895; at present it is only 12,744.

SERINO, a town of the kingdom of Naples, province of Principato Uttra, on the Sabbato, 6 miles S.S.E. of Avellino. It consists of several adjacent villages, containing churches, convents, an hospital, and manufactures of hardware. Pop. 8000.

SERMIDE, a town of Austrian Italy, in the province and 27 miles S.E. of Mantua, on the right bank of the Po. It contains churches, public offices, and a court of law. Weaving and dyeing are carried on here. Pop. 5594.

SEROHEE, a town of India, capital of a state of the same name, in Rajpootana, 67 miles N.E. of Nusseerabad. It covers a large extent of ground, and contains many good brick-houses; but much of the town is uninhabited. The chief building is the palace of the rao or chief, which stands on a small hill, but is of no great beauty. Serohee has become, since it was taken under the British protection, a place of much commerce and wealth; and it is especially celebrated for the manufacture of sword-blades. The state of Serohee is bounded on the W. and N. by that of Joudpore, E. by Godwar and Oodeypore, and S. by the Guicowar's dominions. It has an area of 3024 square miles. The eastern and south-eastern parts are mountainous; the country has a general slope towards the N.W., and is watered chiefly by affluents of the Loni, which flows in that direction into the Gulf of Cutch. Mount Aboo, in this country, reaches the elevation of 5000 feet above the sea. There are many ruins, and other traces of the former civilization and prosperity of the country. Serohee was formerly joined to Joudpore; but is now independent, and since 1823 has been protected by the British.

SERON, a town of Spain, Andalusia, in the province and 28 miles N. of Almenia, on the right bank of the Almanzor. The principal buildings are a church, several hermitages, a court-house, and prison; and the manufactures of the town comprise linen, blankets, and earthenware. There are also oil and flour mills. The surrounding region is rich in iron, lead, and copper; and there were formerly many smelting places for these metals, but only two are now used. Nitre and white marble are also obtained in the vicinity. Pop. 5619.

SERPA, a town of Portugal, in the province of Alemtejo, on a height near the Guadiana, 17 miles E.S.E. of Beja. It is pretty well built, walled, and entered by five gates. There are here two churches, a castle, schools, and hospitals. Some contraband trade is carried on with Spain. Pop. 5600.

SERPENT, a powerful bass musical instrument of the wind kind, invented by a French priest at Auxerre in 1590. See the article MUSIC.

SERPENTINE VERSES begin and end with the same word; as, "Ambo florentes ætatibus, Arcades ambo."

SERPENTS. See REPTILIA.

SERPUCHOV, a town of European Russia, in the government and 56 miles S.S.W. of Moscow, at the point where the Nara and Serpeika fall into the Oka. It has a citadel, which stands on an eminence, and is surrounded by high walls now falling into decay. There are in the town a cathedral and numerous other churches, various public edifices, schools, and charitable institutions. Sailcloth, leather, paper, and tiles are made here; weaving is also carried on; and there is a considerable trade in corn, timber, cattle, tallow, hemp, &c. The town is very ancient, having been in existence as early as 1328. Pop. (1850) 12,196.

SERRA CAPRIOLA, a town of the kingdom of Naples, province of Capitanata, on a hill looking down upon the Fortore, 13 miles N.W. of San Severo. It is a small place, with several churches, convents, an hospital, &c. Near it are ruins, supposed to be those of the ancient Teate. Pop. 4000.

SERRANUS, JOANNES, or *Jean de Serres*, a learned French Protestant, was born about 1540 at Villeneuve-de-Berg. He acquired the Greek and Latin languages at Lausanne, and devoted himself to the study of the philosophy of Aristotle and of Plato. On his return to France he studied divinity, and in 1574 he began to distinguish himself by his writings, but was obliged to forsake his country after the dreadful massacre of St Bartholomew. He became minister of Nismes in 1582, but was never regarded as a very zealous Calvinist. He has even been suspected, though without reason, of having actually abjured the Protestant religion. He was one of the four clergymen whom Henry IV. consulted about the Catholic religion, and who returned for answer, "that Catholics might be saved." He wrote afterwards a treatise in order to reconcile the two communions, entitled *De Fide Catholioo, sive de Principiis Religionis Christianæ, communi omnium Christianorum consensu, semper et ubique ratis*, 1607. This work was disliked by the Catholics, and received with such indignation by the Calvinists of Geneva that many writers have affirmed that they poisoned the author. It is certain at least that he died at Geneva in 1598. His principal works are—A Latin translation of Plato, published by Henry Stephens; *A treatise on the Immortality of the Soul; De Statu Religionis et Republicæ in Francia; Mémoire de la Troisième Guerre Civile et derniers Troubles de France sous Charles IX.*, &c.; *Inventaire Général de l'Histoire de France, illustré par le Conférence de l'Eglise et de l'Empire; Recueil des Choses Memorables avenues en France sous Henry II., François II., Charles IX., Henri III.* These three historical treatises have been justly accused of partiality and passion; faults which it is next to impossible for a contemporary writer to avoid, especially if he bore any part in the transactions which he describes.

His style is incorrect and inelegant; and he has been accused by his enemies of making numerous mistakes and mis-statements of facts.

SERRAVALLE, a town of Austrian Italy, Venice, in a mountain valley on the Maschio, 24 miles N. of Treviso. It has a large market-place, a cathedral, and other churches, convents, schools, and an hospital. Woollen and silk stuffs, as well as paper, are made here; and there is a considerable trade in corn, wine, and honey. Pop. 5131.

SERTORIUS, QUINTUS, a clever Roman adventurer, was born of respectable parents at the Sabine village of Nursia, late in the second century before Christ. He gave early marks of being a ready speaker and skilful manœuverer, who, to great personal strength, added a stubborn endurance of fatigue. He commenced his military career in Gaul, where, in the bloody battle fought on the Rhone, B.C. 105, he was wounded, and saved his life by swimming across the river, clad in complete armour. Sertorius continued to distinguish himself, now by entering the Teuton camp at Aix as a spy, again by massacring the inhabitants of the town of Castulo in Spain, and anon, after repeated provocation, by spearing 4000 of those slaves whom Marius kept about him as a body guard. In 83 B.C. he was raised from the office of quæstor to that of prætor. After trying, ineffectually, to check the progress of Sulla on his return from the conquest of Mithridates, Sertorius was advised to betake himself to Further Spain, where he could administer the affairs of that province in comparative peace. With a handful of men, and very little means, he made his way to Spain, where he set about raising an army of Roman settlers and Spaniards, and equipping a fleet. While thus engaged, Luscus was despatched by Sulla to oppose the progress of Sertorius. The agile adventurer immediately put to sea, but was attacked by an overwhelming number of Mauritanians, and compelled to scud for the Pityussæ Islands, where he was joined by some Cilician rovers, who aided him in extinguishing the Roman garrison. Attacked by the fleet of Luscus, and his light ships being harassed by stormy weather, he was forced to land at the mouth of the Guadalquiver, after a wild passage through the Straits of Gibraltar. Having met some seamen who had just arrived, it was said, from the *Insulæ Fortunatæ*, Sertorius is reported to have contemplated setting out for those "Happy Isles," where he might spend the rest of his days far away from the strife of men. Ambition, as it generally does, urged him on to his end. He now turned on his former opponents, the Mauritanians, and took their king, in the city of Tingis, or Tangier. He afterwards went to aid the Libyans against the Romans. While in Africa he was presented with a fawn, which in time became so tame as to accompany its master wherever he went. The influence of this creature on the superstitious inhabitants of his camp is reported to have been very great. This "fawn of Sertorius" has become famous in literary as well as in political history. Corneille made it the subject of a tragedy, and R. H. E. Landor, in modern times, has chosen it as the subject of a tale. Sertorius had now to face the Roman forces under Metellus and Pompeius. To recount the endless manœuvres and skirmishes of his guerilla warfare, how suddenly he swept down upon the foe, like a beast of prey, at dusk; how nimbly he withdrew his handful of men as the sleepy foe roused themselves to the full danger of their situation; how quickly he would cross the sierras of Spain with his little band, as if their course was aided by the upper denizens of the air, would be much more than we here have space for, and it must accordingly be sought out in Plutarch's life of Sertorius. In these raids there was often much bloodshed, and Sertorius generally came off with the victory. Some say this active adventurer in time became lazy, and indulged himself with women and wine. It is very certain that his cruelty and suspicion became greater, and not altogether without cause. He had taken Spaniards for his guard, in distrust of his own countrymen. These Iberians were by no means satisfied with the humble rank assigned to them. Yet they were Romans who conspired against him. Invited to a banquet by his own generals, he was suddenly stabbed by Marius Antonius, B.C. 72. Thus ended the war of Sertorius, and Spain now passed into the peaceful possession of Rome. The curious will find considerable resemblance between the exploits of this ill-fated Roman adventurer and an English nobleman, Mordaunt, Earl of Peterborough, who achieved such astonishing deeds of arms in the Spanish peninsula during the reign of Queen Anne.

SERVAN, ST, a town of France, in the department of Ille-et-Vilaine, on the south side of the harbour of St Malo, at the mouth of the Rance, in the English Channel. It is a suburb of St Malo, and a favourite watering-place. The most remarkable building is an isolated tower, now used as a prison. This edifice stands on a rock, between the two harbours, and is approached by a drawbridge. One of the harbours is suitable for large, the other for small vessels. Shipbuilding is carried on here; many of the inhabitants are employed in cod-fishing; and there is a considerable trade in beer, wine, brandy, ship-biscuits, cordage, &c. Pop. 10,257.

SERVANDONI, GIOVANNI GERONIMO, a celebrated architect, was born at Florence in 1695. He rendered himself famous by his exquisite taste in architecture, and by his genius for decorations, fêtes, and embellishments. He was employed and rewarded by most of the princes in Europe. In Portugal he was honoured with the order of Christ. In France he was architect and painter to the king, and member of the different academies established for the advancement of these arts. He received the same titles from the kings of Britain, Spain, Poland, and from the Duke of Wirtemberg. Notwithstanding these advantages, his want of economy was so great that he left nothing behind him. He died at Paris in 1766. Paris is indebted to him for many of its ornaments. He made decorations for the theatres of London and Dresden. He was permitted to exhibit shows, consisting of ornamental decorations. Some of these were exceedingly grand; his "Descent of Æneas into Hell" in particular, and his "Enchanted Forest," are well known. He built and embellished a theatre at Chambor for Marshal Saxe, and furnished the plan and model of the theatre-royal at Dresden. He was employed frequently by the king of Portugal, to whom he presented several elegant plans and models. The Prince of Wales, too, the father of George III., engaged him in his service; but the death of that prince prevented the execution of the designs which had been projected. He presided at the magnificent fête given at Vienna on account of the marriage of the Archduke Joseph and the Infanta of Parma.

SERVANT. See MASTER AND SERVANT.

SERVETUS, or SERVETO, *alias* REVES, MICHAEL, a learned Spanish physician, and a renowned heretic, was born at Villanova, in Aragon, in 1509. His father, who exercised the profession of a notary, early designed him for the church, but subsequently perceiving in him a decided taste for theological speculation, and an open hostility to scholasticism, he deemed it more prudent to educate him for the law. In 1528 he went to the University of Toulouse, where he formed a connection with some inquiring youths who had become interested in the Lutheran innovations. On his leaving Toulouse in 1530, he found himself an ardent reformer, and set out for Italy and Germany to publish his new doctrines. Taking up his residence at Bâle, near Œcolampadius, he was at first well received by that reformer. Servetus, however, in his youthful zeal, had driven his speculations much too far for the

purposes of the Reformation, and Œcolampadius, on becoming aware of his views regarding the doctrine of the Trinity, is said at once to have withdrawn his friendship from him. A like reception awaited him at Strasbourg from Bucer and Capito. Hope was high, and intellectual strength was unquestionable in Servetus; he accordingly resolved to publish a book regarding the Trinity, which appeared at Haguenau in 1531, under the title of *De Trinitatis Erroribus, Libri vii.* This was followed up by another publication next year, entitled, *Dialogorum de Trinitate, Libri duo,* and with an appendix, consisting of *De Justicia Regni Christi, capitula quatuor, Per Michaelem Serveto, alias Reves, ab Aragonia Hispanum,* 1532, in which he came forward with those theories which were subsequently more fully developed in succeeding publications. These feelers which Servetus had cast out brought in rather alarming intelligence, which prompted him at once to change his place of residence, his profession, and his name. He accordingly packed up for France in 1533, under the title of Villanovanus, and settled in Paris, where he studied medicine with brilliant success. Having graduated in medicine, he wrote a learned book, entitled, *Ratio Syruporum,* which he gave to the world under the authorship of Michael Villanovanus. Servetus could not be at peace. His ever active intellect, and his restless desire for controversy, got him into endless difficulties. Having quarrelled with the physicians of Paris, he wrote an *Apologia,* which was suppressed by order of parliament, and Servetus, judging discretion to be the better part of valour betook himself to Lyons in 1535. Here he engaged with an eminent printing firm of the day to correct the press, and during his residence here he published, with characteristic notes, a good edition of Ptolemy's *Geography.* The medical hostility which his presence had engendered in the capital having now died out, he set out for Paris in 1537, where he taught geography, mathematics, and even astrology, with success. The last branch of knowledge not being quite to the taste of the doctors of the Sorbonne, drew down upon the head of Servetus another sentence of the parliament. The ubiquitous Spaniard forsook the capital for ever, and took up his residence at Charlieu, near Lyons, where he began practice as a physician. In 1540, solicited by the invitations of the Roman Catholic Archbishop, Pierre Paumier, whom he had formerly met in Paris, he was induced to exchange his residence for Vienne, in Dauphiné. Here he was diligent in the pursuit of his profession of a physician, and filled up his leisure hours with literary work for the booksellers of Lyons. It was during this time he published his edition of the Bible in Latin, with a preface and notes.

Theology, which he had ostensibly exchanged for medicine, was nevertheless his darling study. He allowed few days of his life to pass by without seeing a new theological speculation raised or completed. His mind had now become mature, and his circumstances were prosperous; why should not he endeavour to urge on the Reformation of Christianity which had already been begun, but which had not, in his estimation, gone anything like so far as truth would warrant? Why should not he make himself a name that would be remembered as well as Luther and Calvin, when he should no longer be known? Why, in short, should not he give publicity to those opinions which he knew only too well how to maintain, and which few men could surpass him in ingeniously, and even sophistically, defending? Some, or all of these motives, doubtless actuated the subtle and ambitious heretic, and he resolved now to put himself in communication with the great Genevan divine, and see what would come out of it. Some say he had known Calvin in Paris, but it is most probable his knowledge of him was merely epistolary. After the exchange of some preliminary courtesies, Servetus asked Calvin's judgment of a portion of his future volume *Christianismi Restitutio.* The Reformer combated very sharply this portion of his lucubrations, and Servetus replied with all the cool bitterness of a thorough-paced controversialist This was what Calvin was not prepared for, and possibly his temper had become more than ruffled by the rude manner of the Spanish doctor. In Calvin's letter to Farel, of 13th February 1546, he thus writes of Servetus:—"He offers to come hither, if I please. But I do not wish to pledge my word for his safety; for if he come, I shall not suffer him to depart alive, if my influence be of any avail." (Calvin's *Letters,* vol. ii., 1857.) This is very definite. Servetus now had recourse successively to Abel Popin, a pastor at Geneva, and to Pierre Viret, pastor at Lausanne, without any better result. He had now completed his *Christianismi Restitutio,* and Marinus, a German publisher at Bâle, got the first offer of it. The German was too wary to engage in any such enterprise, and Servetus had accordingly to prevail upon a bookseller in Vienne secretly to engage in the printing of it. The work was gone about with due caution, and on its publication in 1553, it was forwarded to Frellon, publisher in Lyons, who had formerly employed Servetus, and through whom the Spaniard had corresponded with Calvin. It was through this man, it is reported, that Calvin came by his copy of the work of Servetus; others say it reached him through the ordinary channels of the trade. At all events, De Trie, then residing at Geneva, and a friend of the Reformer, sent to a Lyonese the first sheet of this work, and pronounced Servetus the author. More letters came to Lyons, in which were some of those sent to Calvin by Servetus himself. The upshot was that the engines of the Inquisition were set in motion, and had not the Spaniard escaped from the prison in which he was confined in Vienne, he would, without doubt, have suffered the extreme penalty of the law. The ordinary tribunal of the Bailiwick of Vienne sat in judgment on the outlaw, and condemned him to the flames on the 17th of June 1553. So far as it is possible to ascertain anything with regard to the opinions promulgated in the *Christianismi Restitutio,* they seem to have been decidedly anti-Trinitarian. The author sought to bring men back to the simple faith of primitive Christianity, which, in his opinion, both the Reformed and Roman Catholic churches had forsaken. What galled Calvin perhaps nearly as much as the doctrines the book contained was the spirit in which he, the Reformer of Geneva, was spoken of in that publication. It is difficult on any other assumption to account for his singular animosity against Servetus. All the accustomed respect paid to Calvin was here treated with derision, and he was plied at once with the most ingenious arguments and handled with the most scurrilous abuse.

For a time Servetus lay concealed in the French territory, but subsequently taking courage, he set out for Geneva, and arrived there towards the end of the month of July, on his way to Italy. It is not certain by whom he was recognised; some would have it by Calvin himself. But this seems doubtful. The words of the *Procès* are, "M. Servetus was recognised by some brethren." Calvin instructed his servant, Nicolas de la Fontaine, to have him imprisoned, and to stand security according to the *lex talionis,* then a judicial usage in Geneva. Calvin writes, in his letter to Farel of the 20th August 1553, "Nicolas was released from prison on the third day, having given up my brother as his surety; on the fourth day he was set free." (Calvin's *Letters,* vol. ii., 399.) The forty charges brought against Servetus had been found proven by the Senate. Calvin says in the same letter, "I hope that sentence of death will at least be passed upon him; but I desire that the severity of the punishment may be mitigated." The Senate of Geneva, despite the remonstrances of Calvin to the contrary, resolved to lay the case before

the Swiss Churches of Berne, Zurich, Schaffhausen, and Basle. Calvin now busied himself in writing to the leading brethren of the several churches regarding the criminality of Servetus. He urged upon them, with more than ordinary warmth, the necessity for giving a judgment which should at once rid the church and the world of this man and his "detestable mockeries." The churches were unanimous in their verdict of the theological culpability of Servetus, and mildly exhorted their Genevan brethren to rid the church of this noisome pest. (See Calvin's *Letters*, vol. ii., p. 417.) After such replies the decision could not be long doubtful. Yet the sentence which was pending has been denominated by Lord Brougham, the greatest lawyer of the present generation, as "a mockery of a trial." On the 27th of October 1553, Servetus was led forth to hear his doom pronounced. He had escaped the terrors of the Inquisition at Vienne, only to meet death at Geneva. From the site where the fatal pile was erected beyond the walls of the city, he bequeathed with his breath a mournful souvenir to the Reformation, and an eternal subject of accusation to the enemies of Calvin. Persecution was the sad legacy left by the middle ages to Christian communities. The error of Calvin in the death of Servetus was the error likewise of Bucer, of Œcolampadius, of Melanchthon, and of Bullinger, for they all agreed in the sentence of condemnation pronounced upon the unfortunate Spaniard. Hence, while one cannot but deplore the error into which they were led, and feel a just pity for a great victim, respect for the memory of the Reformers whom an unhappy time made the accusers and judges of Servetus cannot but commingle with that righteous indignation which every one must feel at such an enormous departure from the principles of enlightened justice.

Many copies of the *Christianismi Restitutio* had been conveyed to Frankfurt for the Easter fairs; and Calvin lost no time in sounding the alarm to the pastors of that church to have them instantly and entirely destroyed. So successfully was the work done, that only *three* copies of the book are now in existence, one in the Imperial Library of Paris, another in that of Vienna, and a third in a private collection. (See Rilliet, *Relation du Procès de Servet*, p. 9, 1844.) Among other curious things contained in this very rare book, there is an important theory regarding the circulation of the blood. Servetus held, in opposition to all physicians of his day, that the whole mass of the blood passes through the lungs by the pulmonary artery and vein. From this suggestion Harvey had only to advance a single step to render himself immortal. (The chief authorities for the life of Servetus are De la Roche, 1712; Mosheim (in German), 1748; Treschel (in German), 1839; and Rilliet (in French), 1844, translated by Tweedie, 1846; besides the latest published authority, in Calvin's *Letters*, 1857.)

SERVIA (Turkish *Syrp*, Slavonic *Serbia*), one of the Danubian principalities, nominally included in the Ottoman empire, but in reality only tributary to that power; lying between N. Lat. 43. 2. and 44. 58., E. Long. 19. 10. and 22. 20.; bounded on the N. by the Austrian dominions, E. by Wallachia and Bulgaria, S. by Rumilia and Albania, and W. by Bosnia. Length from E. to W., 160 miles; greatest breadth, 200; area, 21,152 square miles. The country is very mountainous, having a general inclination towards the north, where the Danube flows along the frontier, and receives all the running water of the country. The mountains consist of northern branches of the Balkan chain, and are the most considerable offshoots of that range, being higher and more numerous than those either in Bulgaria to the east or Bosnia to the west. The extreme S.W. of the principality is also occupied by an offshoot of the Dinaric Alps, which divides the waters of the Drina from those of the Morava. The whole country is traversed by ridges extending from south to north, forming between them numerous narrow valleys, which seldom expand into plains. The passes over the mountains towards the south are very difficult, even for foot-passengers and beasts of burden. Indeed, in this direction, there extends an almost unbroken mass of ridges and plateaus, as far as the borders of Macedonia, Albania, and the Herzegovina. At the north-eastern corner of the land a branch of the Carpathian Mountains extends down to the Danube, forming the division between Wallachia and the Austrian empire. On the north and east Servia is bounded by the Danube and its affluent the Save. The former river touches the boundary at Belgrade, where it is joined by the Save from the west. It then flows eastward as far as Orsova, where it turns to the south, and separates Wallachia from Servia. It receives from the south the Morava, which is formed by the confluence of the Bulgarian and Servian Morava; and the Timok, which, for a short distance, separates Bulgaria from Servia. The chief affluents of the Save are the Drina, forming the frontier of Servia towards Bosnia and the Kolubara. The scenery of Servia is exceedingly beautiful; for the mountains are almost all covered with dense forests of oaks and other trees; the valleys and rivers form an endless and agreeable diversity; and the lower ground is exceedingly fertile, covered in many places with rich meadows, and in others with fields of Turkish wheat, which grows most luxuriantly. The mountains of Servia are very rich in minerals, such as gold, silver, copper, iron, loadstone, lead, and coal; and the forests abound in valuable timber. The country is, however, little cultivated, and scantily peopled; and its great resources want the hand of industry to develop them. Wolves, bears, foxes, deer, and hares, are the most numerous wild animals of the land. Fish abound in the rivers; and silk-worms and bees are reared in large numbers. Corn is grown chiefly in the valleys of the Morava, Save, and lower Drina; and notwithstanding the defective system of cultivation, the quantity raised is more than sufficient for the wants of the country. Vines are cultivated along the banks of the Danube. On an average there is more red than white wine produced; but the white grapes of Semendria, from vineyards said to have been originally planted by the emperor Probus, are highly esteemed. Tobacco, hemp, and various kinds of fruit, especially plums, are also grown in different parts of Servia. Various measures have been adopted by the government for the improvement of the cultivation of the country, by the establishment of agricultural schools, and of a model farm; but the effect of these has not yet been apparent. The rearing of cattle is one of the most important sources of wealth to the country; and live stock form one of the most considerable exports of the country. The horses are of good breed, but more remarkable for strength and endurance than for beauty. Horned cattle are chiefly used here in the labour of the farm; and the sheep, which are numerous, supply the people with milk, butter, cheese, and wool. The rearing of swine is very profitable, and is spread over all the country. Manufacturing industry is in Servia still in its infancy, and is somewhat discouraged by the little demand that there is for manufactured goods. But the Servians have a great aptitude for mechanical employments, and produce many articles of excellent construction. The women weave, during the winter, linen, woollen, and silk cloth, to supply the wants of the whole family; and many of the men are employed as masons, carpenters, tilers, smiths, millers, tailors, &c. There is a government printing-office at Belgrade, a cloth factory at Topdschider, a glass-work at Jagodina, a foundry at Kragujewaz, and an extensive powder-mill at Stragari. The trade with foreign countries is very active, and daily increasing in importance. Owing to the very limited demand for articles of foreign produc-

tion, the exports greatly exceed the imports. The principal articles of export are cattle, pigs, leeches, hides, wool, tallow, wax, and honey. The chief places of trade are Belgrade, Jagodina, Schabaz, Negotin, and Aleksinaz. For year ending 31st October 1857 the total imports were, L.548,000; exports, L.740,000; goods in transit, L.206,600. Of the imports, L.412,000 were from Turkey, and L.133,000 from Austria; of the exports, L.173,800 were to Turkey, and L.552,000 to Austria.

The country suffers from the want of good means of communication. Of the navigable rivers in the land, only the Danube and the Save are used for purposes of traffic; but the full freedom of navigation on these rivers is secured as a fundamental privilege of the nation. Freedom of trade is also secured as a national right to all Servians, not only in their own country, but in the whole Ottoman empire. Servia has no coinage of its own; but Austrian, Turkish, and Russian moneys are in circulation. Public education is one of the chief objects of attention to the government; but it is still in a very backward condition. The parish schools are supported by each separate parish, and the higher institutions by the government. Of the former there ought by law to be at least one in each parish, but in many places this is not the case. The higher schools comprise four gymnasia, two schools of art, and one of agriculture; a lyceum, with faculties of law, natural science, and philosophy; a theological seminary; and a military academy. The number of scholars attending these various institutions in 1855 was 11,281, of whom by far the greatest number belonged to the parish schools. There is one learned society, the Society for Servian Literature in Belgrade. In 1856 there were published in the country 3 journals, which had 1450 subscribers; and there were introduced from other countries 6 Slavonian, 84 German, 7 English, 21 French, 4 Italian, 2 Hungarian, and 1 Turkish newspaper. The religion of the great majority of the people is that of the Greek Church; and the national Church of Servia acknowledges its canonical dependence on the Constantinopolitan patriarchate by an annual remittance of 9000 piasters (about L.90). The archbishop of Belgrade enjoys the title of Metropolitan of Servia, and the supremacy over the three bishops who form with himself the National Synod, the highest ecclesiastical court in the country. Each bishop presides in a diocesan consistory; and all the prelates are appointed from the monastic order by the synod, with the concurrence of the prince. The number of the inferior clergy is 651, and that of the convents 38. Roman Catholics and Protestants are allowed to establish congregations, and to manage independently their church and school funds; but any secession from the national church is rigorously forbidden. Jews and Mohammedans are permitted the free exercise of their religion. Servia forms an integral part of the Turkish empire, but stands to it in a peculiar relation of dependence, according to which the nation and its prince are bound to loyalty and obedience to the sultan, and to the payment of an annual tribute of 2,300,000 piasters (about L.23,000); while, on the other hand, the Porte guarantees to the principality full internal sovereignty, the free election of their princes, an independent national government, full freedom of religion, legislation, trade, and navigation, and the right to maintain a national defensive force. The dignity of prince is hereditary in the male line, and was settled in 1842 on the family of Alexander Georgewitch. The Turks in the country are immediate subjects of the Porte; and there are 7 Turkish fortresses, 5 under the governor of Belgrade, and 2 under the Pasha of Widdin. The power of the prince is limited by a senate of 17 members, which possesses the chief legislative powers; and there is also a general assembly of the people which meets from time to time; but the extent of its powers is not accurately defined. There is no distinction of ranks, except what is derived from occupation. Most of the people are Servians, but the country also contains about 106,000 Wallachians, a few thousand Bulgarians, 16,000 Turks, about 1800 Jews, 18,000 gypsies, and about 6000 European foreigners. The country is divided into 17 circles, exclusive of the city of Belgrade; and it contained, in 1854, 39 towns, 2306 villages, and 160,294 houses. The total population in the same year was 1,029,082; the number of births, 34,167; of marriages, 11,863; and of deaths, 26,894. The annual average for 1837–53 was 1 birth to every 28·3 persons; 1 marriage to every 97; and 1 death to every 43·5; and the average annual increase of the population was 1·23 per cent.

The territory of Servia formed part of the Roman empire, and was included in the province of Upper Mœsia. From their conquerors, the original inhabitants received by degrees the benefits of civilization and Christianity; but both of these were exposed to many dangers from the inroads of the barbarians. Attila, and after him Theodoric, severely afflicted the country; but it gradually recovered from these misfortunes, and was again united to the Roman empire of the east. Afterwards it was ravaged by the Avars; and, finally, about the middle of the seventh century, the Serbs or Servians entered and occupied the land which they still possess. They spread themselves, however, over a much wider region, extending from the Euxine to the Adriatic, and from the Danube far into the valleys of the Balkan. Nominally under the protection of the Byzantine empire, they derived little advantage from that circumstance, in their constant wars with the Bulgarians and neighbouring Slavonic nations; and they made many attempts to attain an independent position. These efforts were at last successful in 1217, when Pope Honorius erected Servia into a kingdom, independent alike of Hungary and the Eastern Empire. The greatest of the monarchs of Servia was Stephan Duschan. At his coronation in 1333, he was acknowledged as the feudal lord of Ragusa, and his authority extended over Ætolia and Macedonia. He assumed the title of king and emperor, and bore on his banners the imperial double eagle. Before his death in 1356, the Servian sway extended over Bulgaria, Bosnia, Dalmatia, and a part of Albania; and he had even hoped, at the head of 80,000 men, to put a final end to the Byzantine empire. But he was cut off by death, and the monarchy began thereafter to decline, and was unable to stand before the advancing arms of the Turks. In the very year of Stephan's death, these formidable opponents first gained a firm footing in Europe; and in 1389, Lazarus, the last king of Servia, was beheaded in the tent of Amurad I., after the bloody battle of Amselfeld. Another victory gained by the Turks on the same field, sixty years later, brought the country completely under their power. Servia was, however, afterwards the scene of many contests between the Christian and the Turks, and contains the battle-fields of Batucsina (1689), Nissa (1689), Belgrade (1717), Groczka (1739), and others. The country remained under the Turkish yoke till the beginning of the present century; but at last the oppression which they suffered drove the people to rebellion. The first leader who raised the standard of independence, in 1801, was George Petrowitch, surnamed Czerny, or the Black. The Servians flocked to his standard, speedily drove the Turks to take refuge in the fortresses, and proceeded to besiege these. In 1806 they totally defeated a large Turkish army at Schabaz, soon after took Belgrade, and before the end of 1807 were in possession of the whole country. In 1811 George Czerny was appointed Prince of Servia; but not recognised by the Porte, and the conditions offered by that power in 1812 not being accepted, a fresh war ensued, which terminated unfavourably for the Servians. George Czerny had to flee, and the country was again re-

duced under the Turkish sway. Another leader rose up in the person of Melosch Olrenowitch, who restored, in some measure, the independence of his country, and concluded a treaty with the Porte in 1815. Two years later, George Czerny, returning to the country, was put to death by order of Melosch, who was determined to avoid any precipitate measures of hostility to the Turks. In 1827 Melosch was appointed Prince; but in 1839 he was forced to abdicate this dignity. Upon this, various contending factions strove for the supreme power in Servia; but, finally, a general assembly of the people, in 1842, elected Alexander Georgewitch, son of George Czerny, to be hereditary prince, and this choice was subsequently ratified by the Porte. The principality of Servia, which had previously been under the protection of Russia, was by the treaty of Paris, in 1856, placed under the collective guarantee of the contracting powers in that treaty.

SERVICE, Choral, in the Romish Church, &c., consists of a certain order of antiphonies and psalms sung to what is called *canto fermo* in Italian, *canto llano* in Spanish, and *plain-chant* in French. This kind of chant, in its simplest form, consists of slow sounds of equal duration, and without any embellishment, sung in unisons and octaves. In other cases the *canto fermo* is accompanied by parts in harmony, but always with due regard to a certain *antique* and very simple style of melody and of harmony, which is founded upon the peculiar *tonality* and *cadences* of the *canto fermo*, and without which it loses its characteristic effects. The *canto corale*, or choral chant, is often particularly named *canto Gregoriano*, or Gregorian chant, from the great pains taken by St Gregory, in the sixth century, to improve and to teach to his pupils the oriental church chants derived from the Greeks. St Ambrose before him had introduced the oriental choral chants into the western church of Italy. (See Music.) With regard to the tunes introduced into the early reformed church in the time of Luther and Calvin, some curious particulars are to be found in Bayle's *Dictionnaire Historique et Critique*, article Marot. The Puritans in England suppressed the church choral service, and permitted psalm-singing only. Charles II. revived the choral service in England. For minute accounts of the origin, progress, and revolutions of this species of music in various Christian churches, the reader may consult Gerbert, *De Cantu et Musica Sacra*, Padre Martini's *Storia*, Hawkins' and Burney's *Histories of Music*. For technicalities, &c., consult, among other works, A. E. Choron's *Méthode de Plain-Chant*, &c., Paris, 1818; and his *Principes pour apprendre le Plain-Chant*, Paris, 1818. (G. F. G.)

SERVITUDE, Penal. See Prison Discipline.

SERVIUS TULLIUS. See Roman History, § 4.

SESOSTRIS, or Rameses II. See Egypt.

SESSA, a town of the kingdom of Naples, province of Terra di Lavoro, on the western slope of the Massic Hills, on a small affluent of the Garigliano, 17 miles E. of Gaeta. It occupies the site of the ancient Suessa Aurunca, and is indeed built on the volcanic tufa which has covered the remains of that town; for an amphitheatre and some other buildings have been discovered beneath the town. The modern town is meanly built, but is the see of a bishop, and contains a cathedral, several other churches, convents, and charitable institutions. Some of the churches contain good pictures and monuments. Pop. 4000.

SESSION, Court of. See Scotland.

SESTERTIUS. See Coin.

SESTINI, Domenico, an eminent numismatist, naturalist, and traveller, was born at Florence about 1750. Having gained a solid grounding in classical learning, he entered upon the ecclesiastical profession, and in 1774 he became keeper of the cabinet of antiquities of Prince Biscari in Sicily. After holding this office for four years, he was appointed tutor to the Neapolitan ambassador at Constantinople, and was subsequently employed by Sir Robert Ainslie, the English ambassador, to collect medals for him. After various journeys taken from Constantinople, Sestini returned to Italy, where he published some six or seven works, mostly on his travels, and which were, for the most part, done into French. He subsequently visited the Levant, Salonichi, Tuscany, Germany, Paris, Florence, and Pisa. He resided, sometimes years, and sometimes only a few months, at those places. He was appointed honorary professor in the University of Pisa in 1814, and afterwards repaired to Hungary, where he was employed to arrange and catalogue the rich collection of coins and medals in the possession of Count Wiczay at Herderwar. Leopold II. subsequently chose Sestini to the office of royal antiquarian, and after his death, which occurred at Florence in 1832, he purchased his library and manuscripts, and among others, the work of his life in 14 vols. folio, the *Sistéma Numismatico*. Sestini wrote a great many works on his favourite branch of archæology, which will be found, with a biography of the author, in the *Antologia* of Florence for July 1832.

SETTLE, a market town of England, in the West Riding of Yorkshire, near the left bank of the Ribble, at the foot of a lofty limestone rock called Castleberg, rising in the midst of a fertile valley 54 miles W.N.W. of York. It is substantially built, and has one principal, and several smaller streets, and a market-place, in which stands a fine Elizabethan edifice for public purposes. The parish church stands on the other side of the river; but there is another established place of worship in the town, besides those belonging to the Wesleyan and Primitive Methodists, Independents, and Quakers. Settle contains cotton factories, worked by water-power, ropeworks, and paper-mills. Weekly markets and annual fairs are held here. Pop. 1976.

SETTLE, Elkanah, an English poet, who owes his reputation entirely to the ridicule which Dryden and Pope have heaped upon him, was born at Dunstable in 1648. He entered Trinity College, Cambridge, as a commoner, in 1666, where, although passing the university without a degree, he seems to have gained some sort of notoriety as a versifier. Dennis, Welstead, and Milbourn combine in placing Settle above Dryden during his college days; but the notoriety gained by youth is not always an earnest of after fame. Settle came up to London as a literary adventurer, and what with his university repute and the patronage of the profligate Rochester, he succeeded for a time in lording it over Dryden, who had then just entered upon his literary career. *Cambyses*, a tragedy, did not lower his reputation in the eyes of his professed admirers. His *Empress of Morocco*, printed in a style of unparalleled splendour, was acted by the lords and ladies of Whitehall, was applauded for a month at the theatre, and was sold at double its published price. The foolish author, quite intoxicated by his success, triumphantly ran a-muck of Dryden in a vaunting preface. Dryden, who could ill brook the taunts of an upstart adventurer, combined with Shadwell and Crowe in writing scurrilous notes to the *Empress*. The indignant author answered them after his fashion; but his fame had unfortunately now reached its culmination. He published a lame burlesque of Dryden's *Absalom and Achitophel*, entitled *Absalom Senior, or Absalom and Achitophel Transposed*, which had the effect of rousing the fierce wrath of the great poet, who, in the second part of his *Absalom and Achitophel*, impaled Settle and Shadwell under the names of Doeg and Og, and has rendered them quite an unenviable immortality.

> "Who by my muse to all succeeding times,
> Shall live, in spite of their own doggrel rhymes."

He satirizes, as only Dryden could, Settle's blundering

melody, his rude bombast, and his poverty of thought, and has left what, after all allowance has been made for the essential spirit of unfairness in which the poem is conceived, will be regarded by all readers as one of the most amusing pieces of poetical criticism on record. Pope has likewise once and again stumbled on poor unfortunate Settle in his *Dunciad* (Books i., 90, 146; iii., 37, 283), where he alludes in the most caustic terms to his glory as city poet and as Whig pamphleteer to Shaftesbury. Settle had the gratification of burning the Pope in effigy, to the no small delight of the London mob, in November 17, 1680; but afterwards he suddenly changed his party, and recanted his political heresies in 1683. The revolution extinguished him for ever, and he was compelled, as Dryden mockingly prophesied of him, to aspire to become "the master of a puppet-show." He kept a booth at Bartholomew fair, where in his old age he is said to have played the part of the dragon in green leather, in *St George for England*, with great effect! He was subsequently taken into the Charterhouse, where he died in 1723.

SETUBAL, erroneously called by the English St Elbes, a town of Portugal, in the province of Estremadura, on the north shore of a bay of the same name, 20 miles S.E. of Lisbon. It is encircled by old ruinous walls, and the whole valley in which it stands is commanded by several heights, which are crowned with forts. The town extends along the shore for about three-quarters of a mile, and consists for the most part of narrow crooked streets, extending parallel to the shore, or at right angles to it. There are several squares adorned with fountains. The houses are in general substantially built; and the most conspicuous edifices are four churches, some of which contain good paintings. There are two upper schools, and two hospitals, one of which occupies a handsome building. The harbour is large, deep, and furnished with commodious quays; but its entrance is obstructed by sand-banks. Large quantities of salt are made in the vicinity of Setubal, and exported to England, Sweden, and other countries. Corn, wine, and fruits are the chief other articles of trade. Setubal is an ancient town; and indeed, if we believe the Portuguese sages, was founded by Tubal, the grandson of Noah. There are many ancient remains in the vicinity, belonging probably to the ancient Cetobriga. After the expulsion of the Moors, Setubal was deserted for a long time; and it was only in the seventeenth century that it was fortified. The town suffered severely, along with Lisbon, from the earthquake of 1755. The people are extensively engaged in fishing. Pop. 15,201.

SEVAJEE. See HINDUSTAN.

SEVASTOPOL. See SEBASTOPOL.

SEVENOAKS, a market-town of England, in the county of Kent, on a hill 17 miles W. of Maidstone, and 23 S.S.E. of London. It is well built, and has two principal streets, which are wide, and contain many large houses. The parish church is a large edifice, chiefly in the perpendicular style, with a lofty tower. The other places of worship belong to Wesleyans and Baptists. There is a free grammar school, founded in 1418 by Sir William Sennocke, with two exhibitions to Cambridge, an endowed school, a range of almshouses, and a market-house. Near the town is Knole Park, a fine old mansion, in the midst of a magnificent park. Markets are held weekly at Sevenoaks, chiefly for corn. Pop. 1850.

SEVER, ST, a town of France, capital of an arrondissement in the department of Landes, in a fertile tract on the left bank of the Adour, 49 miles E.N.E. of Bayonne. This well-built place contains several fine edifices, among which are a magnificent church, a court-house, hospital, and barracks. It has a college, a court of law, tanneries, potteries, and oil mills. The chief articles of trade are corn, wine, brandy, and lithographic stones. Pop. (1856) 4679.

SEVERN, in point of length and importance, second to the Thames among British rivers; in the beauty and majesty of its aspect, surpassed by none. It rises at a place called Maes Hafren, in the moors, high up the eastern side of Plinlimmon, on the south-western border of Montgomeryshire. From that point its course is nearly semicircular to the sea, first towards the north-east, then southwards, and finally in a south-westerly direction to the Bristol Channel, which it enters at a point only 80 miles in a straight line S.E. of its source, though its length is about 200 miles. The counties it traverses are, in their order, Montgomeryshire, Shropshire, Worcestershire, and Gloucestershire. For the first 15 miles of its course the Severn flows over a rough precipitous bed, through a narrow valley, and is interrupted by many falls, some of which are of considerable size. At Llanidloes, the valley expands to the width of 1 or 2 miles, and assumes a more fertile and beautiful appearance. It is bounded on the S.E. by the range of the Plinlimmon Hills, and on the N.W. by the Berwyn Mountains. Its chief affluents here are the Clywedog and the Vyrnwy. From this gradually widening vale it emerges on the borders of Shropshire, and, turning to the S.E., enters the broad rich plain of Shrewsbury. With enlarged but gentle stream it flows beneath the dark castle and more modern towers of Shrewsbury; and skirted now by woods, now by meadows, it passes the western base of the Wrekin, and pursues its course through the county, receiving from the right the Meole, Cound, Mar Brook, and Bore Brook; and from the left the Perry Tern, Bell Brook, and Worf. Before leaving Shropshire, the river acquires a southerly direction, in which it continues to flow through Worcestershire. In this county it passes the towns of Stourport and Worcester, and, after entering Gloucestershire, those of Tewkesbury and Gloucester. From Buildwas under the Wrekin, to Gloucester, a distance of 72 miles, the fall of the river is only 104 feet; and from Stourport to Gloucester the breadth is very nearly the same, about 150 feet. Below the latter town, the breadth of the Severn, and the bold picturesque character of its banks, continually increase. Its course for some distance below Gloucester is very tortuous; but at Sharpness Point it expands very much, and, after a further course of 18 miles, the estuary of the Severn widens out into the Bristol Channel, just at the point where it receives from the left the Lower Avon or Bristol River; and from the right the Wye, which rises in Plinlimmon, close to its own source. From Gloucester downwards, the general course of the river is S.W. Besides the rivers already mentioned, the most important affluents of the Severn are the Teme from the right, the Upper Avon and the Frome from the left. In the lower part of its course, the Severn flows through a valley about 12 miles broad, bounded on the east by the Coteswold, and on the west by the Malvern Hills, neither of which rise to any great height. The whole extent of land drained by the Severn is 4500 square miles; and to this must be added 1400 drained by the Wye, making a total of 5900 square miles. Owing to the extent of this area, and the marly character of the greater part of it, the quantity of mud deposited in the estuary is greater than in that of any other river in Europe. The tide enters the estuary with great force; and the tidal wave or bore is here about 9 feet high. Inundations have frequently been caused by the sudden rise of the tide. At the mouth of the Severn it rises 48 feet, and at Chepstow, on the Wye, as high as 60 feet. The navigation of the Severn is of very great importance. It extends to 160 miles above its mouth, and affords to North Wales and the adjacent country the means of conveying their produce to the sea. Several canals connect it with the more important places in the adjacent parts of England. The Stroudwater Canal, and the Severn and Thames Canal, connect the waters of these two rivers; the Gloucester and Berkeley

Canal avoids the tedious windings of the Severn below the former town; and various other canals connect different parts of the river with Birmingham, Liverpool, and other towns. The Severn abounds in fish of many different kinds. The ancient name of the river was Hafren, by which it is still known above Llanidloes. It was called by the Romans Sabrina, a name it is said to have derived from a British princess who was drowned in it; and Milton has employed this name in his *Comus* to designate the goddess of the river.

SEVERUS. See Roman History, § 5.

SEVIGNÉ, Marie de Rabutin Chantal, Marquise de, was born in 1627. When only a year old she lost her father, who was killed in the descent of the English on the isle of Rhé, where he commanded a company of volunteers. In 1644 she married the Marquis of Sevigné, who was slain in a duel by the Chevalier d'Albret, in 1651. She had by him a son and a daughter, to the education of whom she afterwards religiously devoted herself. Her daughter was married in 1669 to the Count de Grignan, who conducted her to Provence. Madame de Sevigné consoled herself by writing frequent letters to her daughter, but she fell at last the victim to her maternal tenderness. In one of her visits to Grignan, she fatigued herself so much during the sickness of her daughter, that she was seized with a fever, which carried her off on the 14th of January 1696. We have two portraits of Madame de Sevigné; the one by the Comte de Bussi, and the other by Madame de la Fayette. Bussi describes her as a lively gay coquette, a lover of flattery, fond of titles, honour, and distinction; M. de la Fayette, as a woman of wit and good sense, as possessed of a noble spirit, formed for dispensing benefits, incapable of debasing herself by avarice, and blessed with a generous, obliging, and faithful heart. Both these portraits are in some measure just.

Madame de Sevigné was acquainted with all the wits of her age. It is said that she decided the famous dispute between Perrault and Boileau concerning the preference of the ancients to the moderns. She left behind her a most valuable collection of letters, a good edition of which is that of 1775, in eight volumes 12mo. "These letters," says Voltaire, "are filled with anecdotes, written with freedom, and in a natural and animated style; are an excellent criticism on studied letters of wit, and still more on those fictitious letters which aim at the epistolary style, by a recital of false sentiments and feigned adventures to an imaginary correspondent." It were to be wished that a proper selection had been made of these letters. They may be looked on as a relation of the manners, the tone, the genius, the fashions, and the etiquette, of the court of Louis XIV. They also contain many curious anecdotes nowhere else to be found. The most complete edition of these epistles is that of De Montmerqué, 13 vols., 1818, which contains many letters never before published. J. Ad. Aubenas has written the *Histoire de Madame de Sevigné de sa famille et de ses amis*, Paris, 1842; and Alphonse de Lamartine has written an elaborate account of her in his *Memoirs of Celebrated Characters*, Vol. III., 1856. A volume of *Sevigniana* was published at Paris in 1756.

SEVILLE (Sp. *Sevilla*), a province of Spain, Andalusia, bounded on the N. by the province of Badajoz, N.E. by that of Cordova, S.E. and S. by those of Malaga and Cadiz, and W. by that of Haelva. Area, 8011 square miles. It is in general a flat country, lying in the valley of the Guadalquiver, which traverses the province in a very irregular course from N.E. to S.W.; but near its northern and southern frontiers there are elevations of considerable height. In the north, Seville includes some of the highest summits of the Sierra Morena; and in the south, part of the Sierra of Ronda. Next to the Guadalquiver, the largest river in the province is its affluent the Jenil, which forms the boundary between Seville and Cordova. The Guadalquiver also receives from the right the Biar and the Cola; from the left the Corbones and the Guadaira, besides other streams of less importance. The mineral resources of the country are considerable. Coal is obtained in the Sierra Morena, marble and limestone in the Sierra of Ronda. Iron, silver, lead, and copper also exist in the province. The soil is extremely fertile, and produces in abundance all sorts of corn, wine, oil, vegetables, oranges, and other fruits. Tobacco, hemp, and flax are also grown. The climate is very warm and genial; the temperature in summer ranges from 90° to 100°, and in winter seldom descends lower than 48°; so that frost and snow are entirely unknown here. These rich and genial regions, which were made by the ancients the seat of the Elysian fields, have always offered a strong temptation to warlike tribes, and have been but feebly defended against their attacks by the indolent and peaceful natives of the soil. Manufactures are not carried on to any great extent here; the rich produce of the land sufficing to supply most of the necessaries and some of the luxuries of life. Silk fabrics are made in the capital; and in addition to this, coarse woollen cloth, linen, earthenware, cast-iron, soap, and brandy are manufactured in the province. Corn, oil, wool, fruits, and other articles are exported. The roads in this province, as in the whole of Andalusia, are very bad, being for the most part mere mule tracks. A railway has, however, been constructed from Cadiz to Cordova, which traverses the province; and the Guadalquiver is navigated by steamers as far as Seville. Pop. (1857) 501,050.

Seville, the capital of the above province, on the left bank of the Guadalquiver, 62 miles N.N.E. of Cadiz, and 242 S.W. of Madrid. It is circular in shape, about 5 miles in circumference, and surrounded with Moorish walls, which have 15 gates and 66 towers. The portion of the walls near the Cordova gate is one of the most perfect specimens of *ta pia*, a sort of hard concrete, formed of mortar, rubble, and stones. These walls, as well as what is called the golden tower, from having been the place of deposit for the treasures of America, are said to be of Roman origin; but their structure is undoubtedly Moorish. The only real Roman remains in the town are two pillars in the Alameda Vieja, some well-preserved *suggrundaria*, or underground tombs for infants, a subterranean aqueduct, and some fragmentary remains. Of Moorish antiquities there is no lack, for the town is indeed more than half Moorish. The streets are narrow and crooked, forming a labyrinth very difficult for the stranger to find his way through; and the houses have open courtyards, surrounded by corridors, and covered in summer with awnings. These narrow streets and spacious houses are very suitable to the hot weather in summer, as they afford some shelter and relief from the rays of the sun, which are very oppressive in the wide streets and small houses that have been erected in the more modern parts of the town. The Alameda Vieja was formerly the chief public walk of Seville; it is planted with elm-trees, and adorned with fountains and statues; but now the Paseo de Christina, and Las Delicias, a beautiful walk along the river-side, are more frequented. The streets of Sierpe and Francos are also very fashionable promenades; and the Plaza del Dugue is used for the same purpose in the summer moonlight nights. The chief other public squares are the Plaza de Toros, or bull-arena, which accommodates 14,000 spectators, and the Plaza de la Constitucion, which has a very picturesque appearance, with its Moorish arcades and balconies. The cathedral of Seville is one of the largest and grandest in Spain. It occupies the site of a former mosque, which was pulled down in 1480. The only portions that remain of the Moorish edifice are a horse-shoe gate, and the beautiful giralda or belfry, which was built in 1196. It was originally 250 feet high, and was the tower

 from which the Muezzin summoned the people to prayers; but in 1568 a very elegant belfry was added, raising the total height to 350 feet. A magnificent view is obtained from the summit, which is crowned by a vane, consisting of a bronze image of The Faith. The cathedral is of the same oblong form that the ancient mosque had; and its dimensions are—length, 431 feet; breadth, 315; height of the nave, 145 feet; of the *cimborio*, or transept dome, 171 feet. There are seven aisles, the two nearest the walls at each side being divided into chapels. At the west end of the central aisle is the tomb of Fernando, the son of Christopher Columbus; above which is erected, during Easter week, a large wooden chapel for the reception of the host. The painted windows of this cathedral are among the finest in Spain, mostly done by foreign artists in the 16th century. A rich Doric frontage, adorned with precious marbles, leads to the choir, and above it are two organs, one of which has 5300 pipes and 110 stops, being 50 more of the latter than that of Haarlem, and 20 more than that of Rotterdam. In the choir, the stalls, the archiepiscopal throne, and the carvings of the high altar are very fine. Behind the high altar is the Royal Chapel, which almost forms a church by itself. It is large and gloomy, and contains the tomb of Ferdinand III., who took the city from the Moors. Much superior to this chapel is the chapter-house, 50 feet long by 34 broad. Notwithstanding the repeated spoliations it has suffered, this cathedral is a magazine of the fine arts, and contains many of the masterpieces of Murillo and other great painters of the Seville school. Its general appearance is a gorgeous gloom, quiet and solemn; and when the rays of the sun fall on the cross above the high altar, it has a very fine effect. Besides the cathedral, Seville contained at one time about 140 churches; but many of these were destroyed or turned to other uses during the French invasion. There are now about 30 parish churches, some of which are very fine. Among those destroyed by the French were the Magdalena, in which Murillo was baptized; and Santa Cruz, where he was buried. His house is still preserved, containing the room in which he used to paint. Many also of the numerous convents that Seville possessed have been suppressed. Next to the cathedral, however, the most splendid building is the Alcasar, or royal palace, which has some Roman columns from the old prætorian palace on the same site. The principal hall, that of the ambassadors', in this palace is not inferior to that in the Alhambra; and the small chapel of Isabella is covered with some of the finest Moorish tiling in Spain. The University of Seville was founded in 1504, and transferred in 1767 to the Jesuits' convent, after their expulsion. It has one of the best collections of paintings in the town, and is usually attended by upwards of 1000 students. There are many other fine buildings in the town, such as the Lonja, or Exchange, in the classical style, the town-hall, court-house, the former mint, the archiepiscopal palace, the corporation house, and the Casa de Pilatos, a palace now belonging to the Duke de Medina Celi, built in the 15th century, it is said, after the model of Pilate's house in Jerusalem. There is a very good museum of paintings, an academy of the fine arts, two theatres, several colleges, a normal seminary, and numerous elementary schools. The number of benevolent institutions was at one time very great, there having been in 1558 no fewer than 76 hospitals; but many of these have since been suppressed. There are still, however, a considerable number, and some of them are very large and magnificent establishments. Seville contains two prisons and a house of correction, which are large and well managed. The largest manufactory in Seville is an enormous one of tobacco, outside the walls, occupying an area of 662 feet by 524. It has 28 interior courts, and employs no fewer than 4000 persons in the manufacture of cigars. Earthenware, crystal, machinery, soap, leather, cotton, linen, and silk fabrics, hats, &c., are also manufactured here. The manufactured articles are, however, of very inferior quality. Seville is said to have been formerly much more important as a manufacturing town than it is at present; and although many of the statements about its former prosperity are evidently and egregiously exaggerated, there is no reason to doubt that at one time it was an important seat of the silk manufacture. From about the middle of the seventeenth to the beginning of the present century, this branch of industry, with many fluctuations, continued to maintain a high position; but subsequently it has very much fallen off. The trade of the place, too, has declined from the period when it enjoyed a monopoly of the commerce with America, as the difficulty of navigating the river with large vessels caused Seville to be supplanted by the more convenient port of Cadiz. The chief articles exported are wool, leather, silk, oil, oranges, quicksilver, lead and copper; while the imports consist principally of iron, steel, hardware, timber, cloth, cheese, butter, &c. The total value of the imports in 1856 was, L.558,893; and of the exports, L.606,614. In the same year there entered the port 262 vessels; tonnage, 30,164: and there cleared 281; tonnage, 31,688. The first settlement that took place on the site of Seville was a Phœnician colony, under the name of Hispal, which has passed through the Hispalis of the Romans, and the Ishbiliah of the Moors, into the Sevilla of the modern Spaniards. Little is known of its history previous to the Roman conquest of the Peninsula. Julius Cæsar conquered it in 45 B.C., and patronized the town in opposition to Cordova, which had adhered to the cause of Pompey. It was, however, inferior in importance both to that town and to Gades, until the invasion of the Goths, who made it their capital; but in the sixth century the court was removed to the more central situation of Toledo. Seville opened its gates to the Moors in 711; and remained in their possession till 1247, when it was besieged by the Christians under Ferdinand III. of Castile and Leon. This siege, which issued in the capture of the city in the following year, is the most remarkable event by which the city has been distinguished. It was the capital of Spain from that period till the time of Charles V., who transferred that honour to Valladolid. In 1729 a treaty was concluded at Seville between England, France, and Spain. In 1810 it surrendered to the French under Soult, but was evacuated by them in 1812, after the battle of Salamanca. Many eminent men have been born in Seville or its vicinity. Among these are—the emperor Trajan; the philanthropic Las Casas; Rueda, the founder of Spanish comedy; Ulloa, the traveller; Murillo and Velasquez, the painters. Seville is, for size, the third city in Spain. Pop. (1857) 152,000.

SÈVRES, DEUX, a department of France, bounded on the N. by that of Maine-et-Loire, E. by that of Vienne, S. by those of Charente and Charente-Inférieure, and W. by that of Vendée. Its length, from N. to S., is about 79 miles; greatest breadth, 41; area, 2341 square miles. It is traversed by a chain of low hills, called the Hills of Gâtine, which extends from the mountains of Auvergne N.W. to the mouth of the Loire, entering the department from Vienne at the S.E., and leaving it at the N.W., on the borders of Vendée. Their mean height is not more than 450 feet; and they separate the valley of the Loire on the N.E. from those of the Charente, Sèvre Niortaise, and Lay, on the S.W. Neither the Loire nor the Charente traverse any part of the department, but they receive some considerable tributaries from it; the Loire receiving the Sèvre Nantaise flowing towards the N.W., and the Thouet with its tributaries the Cebron, Argenton, and Dive; and the Charente receiving the Boulonne. The Sèvre Niortaise receives the Mignon, which flows along the south-western boundary of the department. Of these rivers, three are

navigable for some distance, the Dive, the Sèvre Niortaise, and the Mignon. There are no considerable lakes in the country, but some ponds and marshes among the hills. The hills themselves are rugged and granitic, covered with wood, and traversed by numerous valleys. From these hills the ground descends on either side to extensive plains; those on the north having, like the hills generally, a granitic formation, while towards the south the prevailing structure of the country is calcareous. Thus, though the soil of the department is, on the whole, rich and fertile, it varies considerably in productiveness in different parts; the southern plain being in general superior to the northern. Agriculture is the chief employment of the people; but it is in a very backward state, few efforts being made to improve the soil. Corn and wine are the principal productions of the country; a considerable extent of ground is occupied by meadows and forests, chiefly on the slopes of the hills; hemp and flax grow in the more moist tracts; and hops are raised with success especially in the neighbourhood of Niort. Of the entire area of the department, there are calculated to be 1.010,000 acres of arable land; 185,000 of meadows; 50,000 of vineyards; 90,000 of wood; and 55,000 of heaths and waste land. The vineyards, which exist only in the south-west portion of the department, produce very good white wines, and excellent brandy. The extensive natural meadows of the country support cattle of good breeds, and sheep of a large size, which by a cross with the Spanish breed have been much improved in the quality of their wool; pigs, mules, and asses are also reared. It is estimated that the department contains 33,000 horses, 114,000 horned cattle, 426.000 sheep, 42,000 pigs, 20,000 goats, 13,000 mules, and 4000 asses. The mineral productions of the country are not of very great importance. Small quantities of iron, marble, mill-stones, chalk, potter's clay, and saltpetre, are the only minerals that are worked. Among the manufactories are those of woollen and cotton stuffs; of leather at Niort; besides distilleries, potteries, oil-mills, &c. The principal articles of trade are live stock; especially mules, which are sent in large numbers to Spain, and cattle which are sent either to Normandy to be fattened, or to Paris. Corn, wine, and brandy are also among the articles of commerce. Internal communication is facilitated by the navigable rivers, by numerous roads, and by a railway which traverses the southern part of the country. Deux Sèvres forms, along with Vienne, the diocese of the Bishop of Poitiers, and contains 5 Calvinist churches. It has 5 courts of law, subordinate to the appeal court at Poitiers, a tribunal of commerce, 4 colleges, a normal seminary, 2 superior and 527 elementary schools. The department has for its capital Niort, and is divided into four arrondissements, as follows:—

	Cantons.	Communes.	Pop. 1856.
Niort	10	93	108,160
Bressuire	6	91	71,192
Melle	7	91	77,384
Parthenay	8	79	71,110
Total	31	354	327,846

Sèvres, a town of France, department of Seine-et-Oise, on the left bank of the Seine, between the hills of Mendon and St Cloud, 6 miles N.W. of Paris. It is chiefly remarkable for the manufacture of the fine porcelain that takes its name from the town. The manufactory was removed from Vincennes to the present large building, in 1755, when it was purchased by Louis XV. It is now the property of the nation. There is here a large museum of porcelain, containing specimens of all ages and countries. Sèvres is also remarkable for the colouring of the china; and has manufactures of colour, enamel, and painted glass. Pop. 4891.

SEWESTAN, a tract of land in Afghanistan, forming the south-eastern corner of that country, lying between N. lat. 29° 30′ and 30° 30′; about E. long. 69° 30′. It forms part of the Khanat of Candahar. On the east it is separated by the Suliman Mountains from the Punjab; on the south from Beloochistan by the mountains about Kohun; on the west it is inclosed by the Toba and Hala ranges; and towards the north it has no definite limit. It consists of a flat dry clayey plain, whose excessive heat is only alleviated by the streams that flow in some places from the hills. The chief town is Sewee, or Sebee, near the southern frontier, in a tract of land which is one of the best cultivated parts of the country.

SEXAGESIMA, the second Sunday before Lent, or the next to Shrove Sunday; so called as being about the sixtieth day before Easter.

SEXAGESIMALS, or Sexagesimal Fractions, are such as have 60, or some multiple of 60, for their denominator. The denominator being usually omitted, 4°, 59′, 32″, 50‴, 16⁗, is to be read, 4 degrees, 59 minutes, 32 seconds, 50 thirds, and 16 fourths.

SEXTANT, denotes the sixth part of a circle, or an arch comprehending sixty degrees. The word sextant is more particularly used for an astronomical instrument made like a quadrant, excepting that its limb only comprehends sixty degrees. (See Quadrant and Mural Circle.)

SEXTUS EMPIRICUS, the celebrated author of the *Pyrrhonian Hypotyposes*, was a physician who attached himself to the school of the Empirici, and hence the name by which he is usually known. He was a pupil of Herodotus of Tarsus (Diog. Laërt. ix. *Timon*), who was himself a physician, and most probably a contemporary of Galen. This serves to settle, with some degree of accuracy, the era of Sextus, who must have flourished about the first half of the third century after Christ. Nothing whatever is known of his life. He has given full proof to all succeeding thinkers in the two books which he has left behind him, of the precise complexion of his creed, and the amount of ingenuity with which he was capable of defending it. The first work, Πυῤῥώνιαι Ὑποτύπωσεις ἢ σκεπτικὰ ὑπομνήματα, contains a complete repository of the doctrines of the sceptics. His second work, Πρὸς τοὺς μαθηματικοὺς ἀντιῤῥητικοί, in eleven books, is against the mathematicians, or dogmatists, and attempts to refute every vestige of positive knowledge which man has ever elaborated. The works combined form the most correct account extant of the ancient sceptical thinkers, and their mode of assailing all manner of dogmatism. It is a perfect store-house of doubts regarding every imaginable phasis of human knowledge. It is set forth with eminent clearness, and contains an exposition of the doctrines maintained by the sceptical school. Sextus now and then degenerates into pure logomachy, a thing to be expected, but with this exception, it is really wonderful the amount of acute pertinacious pursuit with which every idea, real or supposed, is hunted down and strained into the sceptical alembic. He enunciates at the outset what he understands by scepticism. It is, he says, a disposition to doubt of everything beyond mere phenomena. Sextus carries out this definition with the most rigid exactness. It is, without doubt, one of the most refreshing books that a man of reflection can meet with, and it is really surprising to find that the same everlasting problems, which, sixteen centuries ago, were perplexing the minds of thinking men, are still occupying the attention and exciting the passions of philosophers, and apparently will do so to the very end. For an account of the tenets of this author see Scepticism. The *Editio Princeps* of the Greek text of Sextus was that of Paris and Geneva, 1621. The second impression of the works of Sextus Empiricus was by J. A. Fabricius, Leipzig, 1718. A good edition of the Greek text is that of Bekker, Berlin, 1842. The first Latin translation of the *Hypo-*

typoses was published by H. Stephens, in 1562. The first Latin version of the work against the Dogmatists is by G. Hervet, Antwerp and Paris, 1569. Buhle translated the *Hypotyposes*, or outlines, in 1801; and there is an anonymous French version, or rather paraphrase, of them, supposed to be by one Huart, a teacher of mathematics, published in 1725. An English version of the works of Sextus is still a desideratum; but the text would require considerable purification before a respectable translation could be executed. None of the medical works of Sextus remain.

SEYCHELLES, a group of islands in the Indian Ocean, lying between S. Lat. 3. 33. and 5. 35., E. Long. 55. 15. and 56. 10.; 915 miles N. of Mauritius, 566 N.E. of Madagascar, and 1470 S.W. of the continent of India. They are 29 in number, but most of them are of very small size, being merely rocks rather than islands. They stand on a bank of coral and sand, rising from the depths of the ocean to a distance varying from 12 to 40 fathoms from its surface. This bank stretches from north to south for a distance of about 200 miles, and from east to west 30 or 40 miles. The islands themselves, with the exception of two of coralline structure, are granitic, and have a very rugged and irregular appearance, rising into peaks in the centre, which are not cultivated, but covered with perpetual verdure. The soil is good, and the climate warm and equable; hurricanes and violent gales are unknown. Sugar canes, tobacco of excellent quality, cloves, and many kinds of trees, among which is the *coco de mer*, or Seychelles cocoa-nut, peculiar to these islands, grow luxuriantly. Cotton is also raised, and an active trade is carried on in it; but though of excellent quality, it has not yet come into competition with that of the United States. Turtles abound in the islands, and the sperm whale is frequently met with at no great distance. The people are much given to seafaring pursuits, and there is a great want of agricultural labourers. Mahé, the the largest of the islands, is about 17 miles long by 4 broad, and rises to the height of 2000 feet. It is well wooded, and watered by many rivulets. The scenery is very picturesque, and the soil varied, but fertile. On its east coast is a fine bay called Port Victoria, 4 miles deep by 3½ wide, and capable of accommodating a large number of vessels. Next in size to the island of Mahé are those of Praslin, Silhouette, Digue, and Curieuse. The Seychelles are a dependency of Mauritius, and are under a civil commissioner, subject to the government of that island. The public expenditure for 1855 amounted to L.4090, while the revenue was little more than half that sum; the total revenue for the three years 1853–4–5 being L.6495. Education is in a backward state, and there were only forty-nine children attending school in 1855. Most of the inhabitants are Roman Catholics; and indeed there is no Protestant church in the islands, though a chaplain of that religion officiates in Mahé. The Seychelles were first discovered by Vasco di Gama in 1502; but it was not till 1742 that they were explored by Captain Picault, who took possession of them in the name of the King of France, and called them after the French marine minister at that time. They were captured by the British in 1794, and ceded to them along with Mauritius by the treaty of 1815. The population in 1856 of the Seychelles, including the other dependencies of Mauritius, was 8007.

SEYNE, a seaport of France, in the department of Var, on the Mediterranean, 3 miles S.W. of Toulon, at the west end of the inner roadstead of that town. It is regularly laid out and well built, and has spacious quays, a good harbour, and a shipbuilding-yard. Many of the inhabitants are employed in tunny and sardine fisheries, and there is a considerable coasting trade. Pop. 4582.

SÉZANNE, a town of France, in the department of Marne, on the slope of a hill, 25 miles S.W. of Epernay. It was formerly fortified, and the site of its defences is now occupied with fine boulevards. There is a curious old church, with painted glass in the windows. Flour, oil, vinegar, leather, coarse cloth, tiles, and earthenware are made here; and there is some trade in honey and wax. Pop. 4453.

SEZZA, or SEZZE (anc. *Setia*), a town of the Papal States, in the province and 18 miles S.W. of Frosinone. The place was anciently celebrated for its wine, but this is not now above mediocrity. Here are the remains of an old temple of Saturn, and of the Cyclopean fortifications of the town. Figs and other fruits are grown in the neighbourhood. Pop. 8650.

SFAX, or SFAKUS, a town of Tunis, on the west shore of the Gulf of Cabes, 70 miles N.N.E. of Cabes. N. Lat. 34. 44., E. Long. 10. 40. It stands in a very fertile region; and outside the walls by which it is surrounded, lie beautiful gardens. Most of the houses are well built, and there is one large mosque, besides others of smaller size. There are important manufactories of woollen cloth and mats in the town; and an active trade is carried on in fruits, soap, wax, and wool. Sfax is a place of resort for the caravans that come from Gadames in the Sahara. The harbour is very much choked up with mud. As none but natives are allowed to live in the town, there are many dwellings outside the walls. Pop. 6000.

SFORZA. See ITALY.

'SGRAVESANDE. See GRAVESANDE.

SHADWELL, THOMAS, a dramatic writer, well known as the hero of Dryden's satire of *MacFlecknoe*, was born in Norfolk in 1640 of an ancient Staffordshire family. He was educated at Caius College, Cambridge, and subsequently went to study law at the Inner Temple. Disgusted with the drudgery attendant upon legal pursuits, he quitted law and London together, and spent some time in foreign travel. Returning to England, he betook himself to writing for the stage, and gained considerable reputation among the reigning wits of the time, of whom the chief were Dryden, Otway, and Rochester, as a smart, witty talker, but he was pronounced much too hasty a writer. Shadwell, who was a large, round, unwieldy man, set up as a second Ben Jonson, and in eating and drinking he must be confessed to have rivalled his master, but came very far short of him in genius. He rose to be poet-laureate and historiographer to the king on the retirement of Dryden in 1688, and was one of the most important writers of the Whig party. Dryden, who had formerly been his friend, has immortalized him in perhaps the keenest personal satire in the English language. Conceived, as the *MacFlecknoe* is, in a thoroughly satirical spirit, of course all hope of fairness is at once banished from the mind on reading the first line of it. Yet with such immense gusto does the poet bring all the resources of his wonderful art to crush his opponent, and with such singular relish does he heap upon him the most unmeasured contempt, that one cannot help excusing the satirist while one laughs hugely at *MacFlecknoe*. Dryden has been often blamed for the untruthfulness of his representation; he should have been blamed rather for being a satirist. Not satisfied with the bruising which Shadwell had received in the *MacFlecknoe*, Dryden has drawn another immortal portrait of him on his way home from a treason-tavern—

> "Round as a globe, and liquored every chink,
> Goodly and great, he sails behind his link;"

in the second part of his *Absalom and Achitophel*. Shadwell did not escape the bitter mockery of Pope in his *Dunciad*. The great defect of Shadwell in dramatic composition seems to have been his precipitation. Rochester, who, with all his faults, must be allowed the character of great penetration, has left a much more flattering delineation of this much maligned poet than any that has yet been given of him. His Lordship says he had unquestionable genius, but his artistic

skill was below mediocrity. This nobleman further adds:—"If Shadwell had burnt all he wrote, and printed all he spoke, he would have had more wit and humour than any other poet." Shadwell died in 1692 in consequence of too large a dose of opium, which he is reported to have been in the habit of taking.

A complete edition of Shadwell's works was published in 1720, in 4 vols. 12mo. His dramatic works are:—*The Sullen Lovers*, 1668; *The Royal Shepherdess*, 1669; *The Humorist*, 1671; *The Miser*, 1672; *Epsom Wells*, 1673; *Psyche*, 1675; *The Libertine*, 1676; *The Virtuoso*, 1676; *Timon of Athens*, 1678; *A True Widow*, 1679; *The Woman Captain*, 1680; *The Lancashire Witches*, 1682; *The Squire of Alsatia*, 1688; *Bury Fair*, 1689; *The Amorous Bigot*, 1690; *The Scowerers*, 1691; and *The Volunteers*, 1693.

SHAFTESBURY, Earl of. See Cooper.

SHAFTESBURY, a market-town, municipal, and parliamentary borough of England, in Dorsetshire, on the summit of a high, narrow hill, commanding a fine view over the fertile country which stretches at its foot, 22 miles N.E. of Dorchester, and 95 S.W. of London. On account of its lofty and exposed situation, it has a cold, bleak, but healthy atmosphere. Irregularly laid out, the houses are for the most part well built of the freestone quarried in the vicinity. Of the places of worship in the town, four belong to the Established Church: St Peter's, near the centre of the town, an ancient edifice, but modernized for the worse; Trinity Church, in the midst of the lime-trees of its spacious churchyard; St James'; and Rombald's. The Independents, Wesleyans, and Quakers have also places of worship here. The town-hall is a handsome building, recently erected by the Marquis of Westminster. There is an endowed blue coat school in the town, national and other schools, a reading-room, savings' bank, and some charitable institutions. The manufacture of buttons was formerly carried on at Shaftesbury, but has entirely fallen off. Some trade is carried on in butter and cheese, as well as in the agricultural produce of the fine land round about. Weekly markets and three annual fairs are held. The borough is governed by a mayor, three other aldermen and eighteen councillors; and it returns one member to Parliament. The modern town is supposed to occupy the site of the place called Caersepton by the ancient Britons. It was a Roman station, but attained to no great importance till the foundation of the celebrated abbey here by Alfred about 888. Both before and after this time it was destroyed by the Danes, but each time it was afterwards restored. It is said to have contained at the time of the Norman conquest 166 houses and 12 churches. In the abbey of Shaftesbury, Canute died in 1035, and Elizabeth, the wife of King Robert the Bruce of Scotland, was confined for some time in 1313. The family of Ashley Cooper take the title of earl from the town of Shaftesbury. It was first conferred by Charles II. in 1672 on his favourite statesman. Pop. (1851) of the municipal borough, 2503; of the parliamentary borough, 9404.

SHAHABAD, a district of British India, Bengal, lying between N. Lat. 24. 30. and 25. 46.; E. Long. 83. 20. and 84. 56.; bounded on the N. by the districts of Ghazeepoor and Sarun, E. by that of Patna, S.E. and S. by that of Behar, and W. by those of Mirzapore and Benares. Length from N.E. to S.W. 106 miles; breadth 56; area, 4403 square miles. It is almost entirely inclosed by natural boundaries, formed by the Ganges on the N., the Carumnassa on the W., and the Sone on the S.E. and E. The last two rivers both fall into the Ganges, which, as well as the Sone, is navigable here. The south-western part of the district is occupied by a hilly country, rising to the height of about 700 feet above the sea, and about 500 above the low lands on the banks of the Ganges. This latter portion consists of an extensive plain, liable to annual inundations of the Ganges. Most of the land is arable; and the soil is either sandy or clayey, producing, without irrigation, wheat, barley, and some other crops; while the northern portions of the country are rendered exceedingly rich by the overflowing of the river, and are planted chiefly with rice, which produces two crops a year. Maize, millet, lentils, beans, and various other plants are also grown. The chief commercial crops are sugar, cotton, opium, indigo, and tobacco. A large portion of the country is covered with wood and jungle; but the trees are generally stunted, and yield little good timber. Cotton cloth, silk, paper, spirits, oil, and sugar are manufactured. The chief exports are silk, paper, cotton, wheat, and other grains, pulse, bamboos, and opium; the imports include tobacco, sugar, iron, copper, lead, tin, zinc, salt, &c. Shahabad is traversed by the route from Calcutta to Allahabad, and also by that from Dinapoor to Ghazeepoor. The country at one time formed part of the great Magadha empire; but came into the power of the sultans of Lahore towards the close of the twelfth century. The southern part of the district was ceded to the British by the Emperor of Delhi in 1765, and the northern part by the Vizier of Oude in 1775. Pop. 1,600.000.

SHAH ADDULAZIM, a village of Persia, in the province of Irak Ajemi, 5 miles S.E. of Teheran. It is famous as the birth-place of the Caliph Harunur-rashid, and also for a noble mosque which it contains; and still more renowned as occupying the site of the ancient Rhagae, now Rhe, the capital of Arsaces, and the birth-place of Hasan Sabah, the prince of the Assassins, called the "Old Man of the Mountain," who founded the sect of the Ismaelians. The sepulchre of Togral Beg, the Seljuk prince, who conquered Persia in the eleventh century, stands beside the village near the hills. It is a large polygonal brick tower.

SHAHJEHANPORE, a district of British India, N.W. provinces, lying between N. Lat. 27. 15. and 28. 45.; E. Long. 79. 23., and 80. 30.; having Oude on the E., and the districts of Budaon and Bareilly on the W., that of Pilleebheet on the N., and Furruckabad on the S. Its shape is irregular, somewhat like a crescent concave to the west; and its area is 2483 square miles. The country has a general slope downwards from N.W. to S.E.; and in this direction the principal rivers flow. The Gogra washes its north-eastern, and the Ganges its south-western frontier for a short distance. Between these flow the Goomtee, Gurrah, Ramgunga, and others of smaller size. All these rivers ultimately flow into the Ganges. The most elevated portion of the district is in the extreme north, and attains a height of 798 feet above the sea, the bed of the Ganges is about 500 feet above the sea. In the north a large part of the land is occupied by the marshy forests and jungles that lie at the base of the sub-Himalaya range. Gigantic trees, interspersed with thick underwood or tall herbage, cover the land, and a deadly malaria has emptied these forests of men and domestic animals; the elephant, rhinoceros, tiger, panther, and other wild animals roam undisturbed. This country is only useful for a short season for pasturage, and for the production of timber. The southern part of Shahjehanpore enjoys a healthy climate, and a soil rich, well wooded, and highly cultivated. Wheat, rice, maize, cotton, sugar, tobacco, pulse, and many kinds of fruit are grown. The people are generally employed in agriculture, in which they are skilful and industrious. About three-fourths of them are Hindoos, and the rest Mohammedans. Shahjehanpore formed part of the dominions of the Rohilla Patans until their total defeat and overthrow by the British in 1774. It was then transferred to the vizier of Oude, and finally ceded to the East India Company in 1801. Pop. (1848) 812,588. The chief town is Shahjehanpore, on the left bank of the Garrah. It is large and generally well built, and contains a castle, and several stately old mosques, all in a ruinous condition. The bazaars are well stocked and frequented. Pop. 62,785.

SHAKSPEARE.[1]

Shakspeare.

Shakspeare.

William Shakspeare, the protagonist on the great arena of modern poetry, and the glory of the human intellect, was born at Stratford-upon-Avon, in the county of Warwick, in the year 1564, and upon some day, not precisely ascertained, in the month of April. It is certain that he was baptized on the 26th; and from that fact, combined with some shadow of a tradition, Malone has inferred that he was born on the 23d. There is doubtless, on the one hand, no absolute necessity deducible from law or custom, as either operated in those times, which obliges us to adopt such a conclusion; for children might be baptized, and were baptized. at various distances from their birth: yet, on the other hand, the 23d is as likely to have been the day as any other; and more likely than any earlier day, upon two arguments. First, because there was probably a tradition floating in the seventeenth century, that Shakspeare died upon his birth-day: now it is beyond a doubt that he died upon the 23d of April. Secondly, because it is a reasonable presumption, that no parents, living in a simple community, tenderly alive to the pieties of household duty, and in an age still clinging reverentially to the ceremonial ordinances of religion, would much delay the adoption of their child into the great family of Christ. Considering the extreme frailty of an infant's life during its two earliest years, to delay would often be to disinherit the child of its Christian privileges; privileges not the less eloquent to the feelings from being profoundly mysterious, and, in the English church, forced not only upon the attention, but even upon the eye, of the most thoughtless. According to the discipline of the English church, the unbaptized are buried with "maimed rites," shorn of their obsequies, and sternly denied that "sweet and solemn farewell" by which otherwise the church expresses her final charity with all men; and not only so, but they are even *locally* separated and sequestrated. Ground the most hallowed, and populous with Christian burials of households,

> That died in peace with one another,
> Father, sister, son, and brother.

opens to receive the vilest malefactor; by which the church symbolically expresses her maternal willingness to gather back into her fold those even of her flock who have strayed from her by the most memorable aberrations; and yet, with all this indulgence, she banishes to unhallowed ground the innocent bodies of the unbaptized. To them and to suicides she turns a face of wrath. With this gloomy fact offered to the very external senses, it is difficult to suppose that any parents would risk their own reproaches by putting the fulfilment of so grave a duty on the hazard of a convulsion fit. The case of royal children is different; their baptisms, it is true, were often delayed for weeks; but the household chaplains of the palace were always at hand, night and day, to baptize them in the very agonies of death.[2] We must presume, therefore, that William Shakspeare was born on some day very little anterior to that of his baptism; and the more so because the season of the year was lovely and genial, the 23d of April in 1564 corresponding in fact with what we now call the 3d of May, so that, whether the child was to be carried abroad, or the clergyman to be summoned, no hindrance would arise from the weather. One only argument has sometimes struck us for supposing that the 22d might be the day, and not the 23d; which is, that Shakspeare's sole grand-daughter, Lady Barnard, was married on the 22d of April 1626, ten years exactly from the poet's death; and the reason for choosing this day *might* have had a reference to her illustrious grandfather's birthday; which, there is good reason for thinking, would be celebrated as a festival in the family for generations. Still this choice *may* have been an accident, or governed merely by reason of convenience. And, on the whole, it is as well perhaps to acquiesce in the old belief, that Shakspeare was born and died on the 23d of April. We cannot do wrong if we drink to his memory on both 22d and 23d.

On a first review of the circumstances, we have reason to feel no little perplexity in finding the materials for a life of this transcendent writer so meagre and so few; and amongst them the larger part of doubtful authority. All the energy of curiosity directed upon this subject, through a period of one hundred and fifty years (for so long it is since Betterton the actor began to make researches) has availed us little or nothing. Neither the local traditions of his provincial birth-place, though sharing with London through half

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[1] Mr Campbell, in his edition of Shakspeare's dramatic works, observes that "the poet's name has been variously written Shaxpeare, Shackspeare. Shakspeare, and Shakspere;" to which varieties might be added Shagspere, from the Worcester Marriage License, published in 1836. But the fact is, that by combining with all the differences in spelling the first syllable, all those in spelling the second, more than twenty-five distinct varieties of the name may be expanded (like an algebraic series), for the choice of the curious in mis-spelling. Above all things, those varieties which arise from the intercalation of the middle *e* (that is, the *e* immediately before the final syllable *spear*), can never be overlooked by those who remember, at the opening of the Dunciad, the note upon this very question about the orthography of Shakspeare's name, as also upon the other great question about the title of the immortal Satire, Whether it ought not to have been the Dunceiade, seeing that Dunce, its great author and progenitor, cannot possibly dispense with the letter *e*. Meantime we must remark, that the first three of Mr Campbell's variations are mere caprices of the press; as is Shagspere; or, more probably, this last euphonious variety arose out of the gross clownish pronunciation of the two hiccuping "*marksmen*" who rode over to Worcester for the license; and one cannot forbear laughing at the bishop's secretary for having been so misled by two varlets, professedly incapable of signing their own names. The same drunken villains had cut down the bride's name *Hathaway* into *Hathwey*. Finally, to treat the matter with seriousness, Sir Frederick Madden has shown, in his recent letter to the Society of Antiquaries, that the poet himself in all probability wrote the name uniformly *Shakspere*. Orthography, both of proper names, of appellatives, and of words universally, was very unsettled up to a period long subsequent to that of Shakspeare. Still it must usually have happened that names written variously and laxly by others, would be written uniformly by the owners; especially by those owners who had occasion to sign their names frequently, and by literary people, whose attention was often, as well as consciously, directed to the proprieties of spelling. *Shakspeare* is now too familiar to the eye for any alteration to be attempted; but it is pretty certain that Sir Frederick Madden is right in stating the poet's own signature to have been uniformly *Shakspere*. It is so written twice in the course of his will, and it is so written on a blank leaf of Florio's English translation of Montaigne's Essays; a book recently discovered, and sold, on account of its autograph, for a hundred guineas.

[2] But, as a proof that, even in the case of royal christenings, it was not thought pious to "tempt God," as it were, by delay, Edward VI. the only son of Henry VIII. was born on the 12th day of October in the year 1537. And there was a delay on account of the sponsors, since the birth was not in London. Yet how little that delay was made, may be seen by this fact: The birth took place in the dead of the night, the day was Friday; and yet, in spite of all delay, the christening was most pompously celebrated on the succeeding Monday. And Prince Arthur, the elder brother of Henry VIII. was christened on the very next Sunday succeeding to his birth, notwithstanding an inevitable delay, occasioned by the distance of Lord Oxford, his godfather, and the excessive rains, which prevented the earl being reached by couriers, or himself reaching Winchester, without extraordinary exertions.

a century the honour of his familiar presence, nor the recollections of that brilliant literary circle with whom he lived in the metropolis, have yielded much more than such an outline of his history as is oftentimes to be gathered from the penurious records of a grave-stone. That he lived, and that he died, and that he was " a little lower than the angels ;"—these make up pretty nearly the amount of our undisputed report. It may be doubted indeed whether at this day we are as accurately acquainted with the life of Shakspeare as with that of Chaucer, though divided from each other by an interval of two centuries, and (what should have been more effectual towards oblivion) by the wars of the two roses. And yet the traditional memory of a rural and a sylvan region, such as Warwickshire at that time was, is usually exact as well as tenacious ; and, with respect to Shakspeare in particular, we may presume it to have been full and circumstantial through the generation succeeding to his own, not only from the curiosity, and perhaps something of a scandalous interest, which would pursue the motions of one living so large a part of his life at a distance from his wife, but also from the final reverence and honour which would settle upon the memory of a poet so pre-eminently successful; of one who, in a space of five-and-twenty years, after running a bright career in the capital city of his native land, and challenging notice from the throne, had retired with an ample fortune, created by his personal efforts, and by labours purely intellectual.

How are we to account, then, for that deluge, as if from Lethe, which has swept away so entirely the traditional memorials of one so illustrious? Such is the fatality of error which overclouds every question connected with Shakspeare, that two of his principal critics, Steevens and Malone, have endeavoured to solve the difficulty by cutting it with a falsehood. They deny in effect that he *was* illustrious in the century succeeding to his own, however much he has since become so. We shall first produce their statements in their own words, and we shall then briefly review them.

Steevens delivers *his* opinion in the following terms :—" How little Shakspeare was once read, may be understood from Tate, who, in his dedication to the altered play of King Lear, speaks of the original as an obscure piece, recommended to his notice by a friend ; and the author of the Tatler, having occasion to quote a few lines out of Macbeth, was content to receive them from Davenant's alteration of that celebrated drama, in which almost every original beauty is either awkwardly disguised or arbitrarily omitted." Another critic, who cites this passage from Steevens, pursues the hypothesis as follows :—" In fifty years after his death, Dryden mentions that he was then become *a little obsolete*. In the beginning of the last century, Lord Shaftesbury complains of his *rude unpolished style, and his antiquated phrase and wit*. It is certain that, for nearly a hundred years after his death, partly owing to the immediate revolution and rebellion, and partly to the licentious taste encouraged in Charles II.'s time, and perhaps partly to the incorrect state of his works, he was ALMOST ENTIRELY NEGLECTED." This critic then goes on to quote with approbation the opinion of Malone,—" that if he had been read, admired, studied, and imitated, in the same degree as he is now, the enthusiasm of some one or other of his admirers in the last age would have induced him to make some inquiries concerning the history of his theatrical career, and the anecdotes of his private life." After which this enlightened writer re-affirms and clenches the judgment he has quoted by saying,—" His admirers, however, *if he had admirers in that age*, possessed no portion of such enthusiasm."

It may perhaps be an instructive lesson to young readers, if we now show them, by a short sifting of these confident dogmatists, how easy it is for a careless or a half-read man to circulate the most absolute falsehoods under the semblance of truth ; falsehoods which impose upon himself as much as they do upon others. We believe that not one word or illustration is uttered in the sentences cited from these three critics, which is not *virtually* in the very teeth of the truth.

To begin with Mr Nahum Tate:—This poor grub of literature, if he did really speak of Lear as " an *obscure* piece, recommended to his notice by a friend," of which we must be allowed to doubt, was then uttering a conscious falsehood. It happens that Lear was one of the few Shakspearian dramas which had kept the stage unaltered. But it is easy to see a mercenary motive in such an artifice as this. Mr Nahum Tate is not of a class of whom it can be safe to say that they are " well known :" they and their desperate tricks are essentially obscure, and good reason he has to exult in the felicity of such obscurity ; for else this same vilest of travesties, Mr Nahum's Lear, would consecrate his name to everlasting scorn. For himself, he belonged to the age of Dryden rather than of Pope : he " flourished," if we can use such a phrase of one who was always withering, about the era of the Revolution ; and his Lear, we believe, was arranged in the year 1682. But the family to which he belongs is abundantly recorded in the Dunciad ; and his own name will be found amongst its catalogues of heroes.

With respect to *the author of the Tatler*, a very different explanation is requisite. Steevens means the reader to understand Addison ; but it does not follow that the particular paper in question was from his pen. Nothing, however, could be more natural than to quote from the common form of the play as then in possession of the stage. It was *there*, beyond a doubt, that a fine gentleman living upon town, and not professing any deep scholastic knowledge of literature (a light in which we are always to regard the writers of the Spectator, Guardian, &c.), would be likely to have learned anything he quoted from Macbeth. This we say generally of the writers in those periodical papers ; but, with reference to Addison in particular, it is time to correct the popular notion of his literary character, or at least to mark it by severer lines of distinction. It is already pretty well known, that Addison had no very intimate acquaintance with the literature of his own country. It is known also, that he did not think such an acquaintance any ways essential to the character of an elegant scholar and *littérateur*. Quite enough he found it, and more than enough for the time he had to spare, if he could maintain a tolerable familiarity with the foremost Latin poets, and a very slender one indeed with the Grecian. *How* slender, we can see in his " Travels." Of modern authors, none as yet had been published with notes, commentaries, or critical collations of the text ; and, accordingly, Addison looked upon all of them, except those few who professed themselves followers in the retinue and equipage of the ancients, as creatures of a lower race. Boileau, as a mere imitator and propagator of Horace, he read, and probably little else, amongst the French classics. Hence it arose that he took upon himself to speak sneeringly of Tasso. To this, which was a bold act for his timid mind, he was emboldened by the countenance of Boileau. Of the elder Italian authors, such as Ariosto, and, *a fortiori*, Dante, he knew absolutely nothing. Passing to our own literature, it is certain that Addison was profoundly ignorant of Chaucer and of Spenser. Milton only,—and why? simply because he was a brilliant scholar, and stands like a bridge between the Christian literature and the Pagan,—Addison had read and esteemed. There was also in the very constitution of Milton's mind, in the majestic regularity and planetary solemnity of its *epic* movements, something which he could understand and appreciate : as to the meteoric and incalculable eccentricities of the *dramatic* mind, as it dis-

played itself in the heroic age of our drama, amongst the Titans of 1590-1630, they confounded and overwhelmed him.

In particular, with regard to Shakspeare, we shall now proclaim a discovery which we made some twenty years ago. We, like others, from seeing frequent references to Shakspeare in the Spectator, had acquiesced in the common belief, that, although Addison was no doubt profoundly unlearned in Shakspeare's language, and thoroughly unable to do him justice (and this we might well assume, since his great rival Pope, who had expressly studied Shakspeare, was, after all, so memorably deficient in the appropriate knowledge),—yet, that of course he had a vague popular knowledge of the mighty poet's cardinal dramas. Accident only led us into a discovery of our mistake. Twice or thrice we had observed, that if Shakspeare were quoted, that paper turned out not to be Addison's; and at length, by express examination, we ascertained the curious fact, that Addison has never in one instance quoted or made any reference to Shakspeare.[1] But was this, as Steevens most disingenuously pretends, to be taken as an exponent of the public feeling towards Shakspeare? Was Addison's neglect representative of a general neglect? If so, whence came Rowe's edition, Pope's, Theobald's, Sir Thomas Hanmer's, Bishop Warburton's, all upon the heels of one another? With such facts staring him in the face, how shameless must be that critic who could, in support of such a thesis, refer to "*the author of the Tatler*," contemporary with all these editors. The truth is, Addison was well aware of Shakspeare's hold on the popular mind; too well aware of it. The feeble constitution of the poetic faculty, as existing in himself, forbade his sympathising with Shakspeare; the proportions were too colossal for his delicate vision; and yet, as one who sought popularity himself, he durst not shock what perhaps he viewed as a national prejudice. Those who have happened, like ourselves, to see the effect of passionate music and "deep-inwoven harmonics" upon the feeling of an idiot, may conceive what we mean. Such music does not utterly revolt the idiot; on the contrary, it has a strange but a horrid fascination for him: it alarms, irritates, disturbs, makes him profoundly unhappy; and chiefly by unlocking imperfect glimpses of thoughts and slumbering instincts, which it is for his peace to have entirely obscured, because for him they can be revealed only partially, and with the sad effect of throwing a baleful gleam upon his blighted condition. Do we mean, then, to compare Addison with an idiot? Not generally, by any means. Nobody can more sincerely admire him where he was a man of real genius, viz. in his delineations of character and manners, or in the exquisite delicacies of his humour. But assuredly Addison, as a poet, was amongst the sons of the feeble; and between the authors of Cato and of King Lear there was a gulf never to be bridged over.[2]

But Dryden, we are told, pronounced Shakspeare already in *his* day "*a little obsoletè*." Here now we have wilful, deliberate falsehood. *Obsolete*, in Dryden's meaning, does not imply that he was so with regard to his popularity (the question then at issue), but with regard to his diction and choice of words. To cite Dryden as a witness for any purpose against Shakspeare,—Dryden, who of all men had the most ransacked wit and exhausted language in celebrating the supremacy of Shakspeare's genius, does indeed require as much shamelessness in feeling as mendacity in principle.

But then Lord Shaftesbury, who may be taken as half way between Dryden and Pope (Dryden died in 1700, Pope was then twelve years old, and Lord S. wrote chiefly, we believe, between 1700 and 1710), "complains," it seems, "of his rude unpolished style, and his antiquated phrase and wit." What if he does? Let the whole truth be told, and then we shall see how much stress is to be laid upon such a judgment. The second Lord Shaftesbury, the author of the Characteristics, was the grandson of that famous political agitator, the Chancellor Shaftesbury, who passed his whole life in storms of his own creation. The second Lord Shaftesbury was a man of crazy constitution, querulous from ill health, and had received an eccentric education from his eccentric grandfather. He was practised daily in *talking* Latin, to which afterwards he added a competent study of the Greek; and finally he became unusually learned for his rank, but the most absolute and undistinguishing pedant that perhaps literature has to show. He sneers continually at the regular-built academic pedant; but he himself, though no academic, was essentially the very impersonation of pedantry. No thought however beautiful, no image however magnificent, could conciliate his praise as long as it was clothed in English; but present him with the most trivial common-places in Greek, and he unaffectedly fancied them divine; mistaking the pleasurable sense of his own power in a difficult and rare accomplishment for some peculiar force or beauty in the passage. Such was the outline of his literary taste. And was it upon Shakspeare only, or upon him chiefly, that he lavished his pedantry? Far from it. He attacked Milton with no less fervour; he attacked Dryden with a thousand times more. Jeremy Taylor he quoted only to ridicule; and even Locke, the confidential friend of his grandfather, he never alludes to without a sneer. As to Shakspeare, so far from Lord Shaftesbury's censures arguing his deficient reputation, the very fact of his noticing him at all proves his enormous popularity; for upon system he noticed those only who ruled the public taste. The insipidity of his objections to Shakspeare may be judged from this, that he comments in a spirit of absolute puerility upon the name *Desdemona*, as though intentionally formed from the Greek word for *superstition*. In fact, he had evidently read little beyond the list of names in Shakspeare; yet there is proof enough that the irresistible beauty of what little he *had* read was too much for all his pedantry, and startled him exceedingly; for ever afterwards he speaks of Shakspeare as one who, with a little aid from Grecian sources, really had something great and promising about him. As to modern authors, neither this Lord Shaftesbury nor Addison read anything for the latter years of their life but Bayle's Dictionary. And most of the little scintillations of erudition which may be found in the notes to the Characteristics, and in the Essays of Addison, are derived, almost without exception, and uniformly without acknowledgment, from Bayle.[3]

Finally, with regard to the sweeping assertion, that "for nearly a hundred years after his death Shakspeare was almost entirely neglected," we shall meet this scandalous falsehood by a rapid view of his fortunes during the century in question. The tradition has always been, that Shakspeare was honoured by the especial notice of Queen Elizabeth, as well as by that of James I. At one time we were disposed to question the truth of this tradition; but that was for want of

[1 "Mr De Quincey is certainly mistaken when he says that Addison has never in one instance quoted or made any reference to Shakspeare. No. 160 (of the *Spectator*) bears the signature of C., and immediately follows the *Vision of Mirza*, bearing the same signature."—*Charles Knight*. In No. 160 Shakspeare is placed amongst the first class of great geniuses.]

2 Probably Addison's fear of the national feeling was a good deal strengthened by his awe of Milton and of Dryden, both of whom had expressed a homage towards Shakspeare which language cannot transcend. Amongst his political friends, also, were many intense admirers of Shakspeare.

3 He who is weak enough to kick and spurn his own native literature, even if it were done with more knowledge than is shown by Lord Shaftesbury, will usually be kicked and spurned in his turn; and accordingly it has been often remarked, that the *Characteristics* are unjustly neglected in our days. For Lord Shaftesbury, with all his pedantry, was a man of great talents. Leibnitz had the sagacity to see this through the mists of a translation.

having read attentively the lines of Ben Jonson to the memory of Shakspeare, those generous lines which have so absurdly been taxed with faint praise. Jonson could make no mistake on this point: he, as one of Shakspeare's familiar companions, must have witnessed at the very time, and accompanied with friendly sympathy, every motion of royal favour towards Shakspeare. Now he, in words which leave no room for doubt, exclaims

> Sweet swan of Avon, what a sight it were
> To see thee in our waters yet appear;
> And make those flights upon the banks of Thames
> *That so did take Eliza and our James.*

These princes, then, *were* taken, were fascinated, with some of Shakspeare's dramas. In Elizabeth the approbation would probably be sincere. In James we can readily suppose it to have been assumed; for he was a pedant in a different sense from Lord Shaftesbury; not from undervaluing modern poetry, but from caring little or nothing for any poetry, although he wrote about its mechanic rules. Still the royal *imprimatur* would be influential and serviceable no less when offered hypocritically than in full sincerity. Next let us consider, at the very moment of Shakspeare's death, who were the leaders of the British youth, the *principes juventutis*, in the two fields, equally important to a great poet's fame, of rank and of genius? The Prince of Wales and John Milton; the first being then about sixteen years old, the other about eight. Now these two great powers, as we may call them, these presiding stars over all that was English in thought and action, were both impassioned admirers of Shakspeare. Each of them counts for many thousands. The Prince of Wales[1] had learned to appreciate Shakspeare, not originally from reading him, but from witnessing the court representations of his plays at Whitehall. Afterwards we know that he made Shakspeare his closet companion, for he was reproached with doing so by Milton. And we know also, from the just criticism pronounced upon the character and diction of Caliban by one of Charles's confidential counsellors, Lord Falkland, that the king's admiration of Shakspeare had impressed a determination upon the court reading. As to Milton, by double prejudices, puritanical and classical, his mind had been preoccupied against the full impressions of Shakspeare. And we know that there is such a thing as keeping the sympathies of love and admiration in a dormant state, or state of abeyance; an effort of self-conquest realized in more cases than one by the ancient fathers, both Greek and Latin, with regard to the profane classics. Intellectually they admired, and would not belie their admiration; but they did not give their hearts cordially, they did not abandon themselves to their natural impulses. They averted their eyes and weaned their attention from the dazzling object. Such, probably, was Milton's state of feeling towards Shakspeare after 1642, when the theatres were suppressed, and the fanatical fervour in its noontide heat. Yet even then he did not belie his reverence intellectually for Shakspeare; and in his younger days we know that he had spoken more enthusiastically of Shakspeare than he ever did again of any uninspired author. Not only did he address a sonnet to his memory, in which he declares that kings would wish to die, if by dying they could obtain such a monument in the hearts of men; but he also speaks of him in his *Il Penseroso* as the tutelary genius of the English stage. In this transmission of the torch (λαμπαδοφορια) Dryden succeeds to Milton; he was born nearly thirty years later; about thirty years they were contemporaries; and by thirty years, or nearly, Dryden survived his great leader. Dryden, in fact, lived out the seventeenth century. And we have now arrived within nine years of the era when the critical editions started in hot succession to one another. The names we have mentioned were the great influential names of the century. But of inferior homage there was no end. How came Betterton the actor, how came Davenant, how came Rowe, or Pope, by their intense (if not always sound) admiration for Shakspeare, unless they had found it fuming upwards like incense to the Pagan deities in ancient times from altars erected at every turning upon all the paths of men?

But it is objected that inferior dramatists were sometimes preferred to Shakspeare; and again, that vile travesties of Shakspeare were preferred to the authentic dramas. As to the first argument, let it be remembered, that if the saints of the chapel are always in the same honour, because *there* men are simply discharging a duty, which once due will be due for ever; the saints of the theatre, on the other hand, must bend to the local genius, and to the very reasons for having a theatre at all. Men go thither for amusement: this is the paramount purpose; and even acknowledged merit or absolute superiority must give way to it. Does a man at Paris expect to see Molière reproduced in proportion to his admitted precedency in the French drama? On the contrary, that very precedency argues such a familiarization with his works, that those who are in quest of relaxation will reasonably prefer any recent drama to that which, having lost all its novelty, has lost much of its excitement. We speak of ordinary minds; but in cases of *public* entertainments, deriving part of their power from scenery and stage pomp, novelty is for all minds an essential condition of attraction. Moreover, in some departments of the comic, Beaumont and Fletcher, when writing in combination, really had a freedom and breadth of manner which excels the comedy of Shakspeare. As to the altered Shakspeare as taking precedency of the genuine Shakspeare, no argument can be so frivolous. The public were never allowed a choice; the great majority of an audience even now cannot be expected to carry the real Shakspeare in their mind, so as to pursue a comparison between that and the alteration. Their comparisons must be exclusively amongst what they have opportunities of seeing; that is, between the various pieces presented to them by the managers of theatres. Further than this it is impossible for them to extend their office of judging and collating; and the degenerate taste which substituted the caprices of Davenant, the rants of Dryden, or the filth of Tate, for the jewellery of Shakspeare, cannot with any justice be charged upon the public, not one in a thousand of whom was furnished with any means of comparing, but exclusively upon those (viz. theatrical managers) who had the very amplest. Yet even in excuse for *them* much may be said. The very length of some plays compelled them to make alterations. The best of Shakspeare's dramas, King Lear, is the least fitted for representation; and, even for the vilest alteration, it ought in candour to be considered that possession is nine points of the law. He who would not have introduced, was often obliged to retain.

Finally, it is urged, that the small number of editions through which Shakspeare passed in the seventeenth century, furnishes a separate argument, and a conclusive one, against his popularity. We answer, that, considering the

[1] Perhaps the most bitter political enemy of Charles I. will have the candour to allow that, for a prince of those times, he was truly and eminently accomplished. His knowledge of the arts was considerable; and, as a patron of art, he stands foremost amongst all British sovereigns to this hour. He said truly of himself, and wisely as to the principle, that he understood English law as well as a gentleman ought to understand it; meaning that an attorney's minute knowledge of forms and technical niceties was illiberal. Speaking of him as an author, we must remember that the *Eikon Basilikè* is still unappropriated; that question is still open. But supposing the king's claim negatived, still, in his controversy with Henderson, in his negotiations at the Isle of Wight and elsewhere, he discovered a power of argument, a learning, and a strength of memory, which are truly admirable; whilst the whole of his accomplishments are recommended by a modesty and a humility as rare as they are unaffected.

bulk of his plays collectively, the editions were *not* few: compared with any known case, the copies sold of Shakspeare were quite as many as could be expected under the circumstances. Ten or fifteen times as much consideration went to the purchase of one great folio like Shakspeare, as would attend the purchase of a little volume like Waller or Donne. Without reviews, or newspapers, or advertisements to diffuse the knowledge of books, the progress of literature was necessarily slow, and its expansion narrow. But this is a topic which has always been treated unfairly, not with regard to Shakspeare only, but to Milton, as well as many others. The truth is, we have not facts enough to guide us; for the number of editions often tells nothing accurately as to the number of copies. With respect to Shakspeare it is certain, that, had his masterpieces been gathered into small volumes, Shakspeare would have had a most extensive sale. As it was, there can be no doubt, that from his own generation, throughout the seventeenth century, and until the eighteenth began to accommodate, not any greater popularity in *him*, but a greater taste for reading in the public, his fame never ceased to be viewed as a national trophy of honour; and the most illustrious men of the seventeenth century were no whit less fervent in their admiration than those of the eighteenth and the nineteenth, either as respected its strength and sincerity, or as respected its open profession.[1]

It is therefore a false notion, that the general sympathy with the merits of Shakspeare ever beat with a languid or intermitting pulse. Undoubtedly, in times when the functions of critical journals and of newspapers were not at hand to diffuse or to strengthen the impressions which emanated from the capital, all opinions must have travelled slowly into the provinces. But even then, whilst the perfect organs of communication were wanting, indirect substitutes were supplied by the necessities of the times, or by the instincts of political zeal. Two channels especially lay open between the great central organ of the national mind, and the remotest provinces. Parliaments were occasionally summoned (for the judges' circuits were too brief to produce much effect); and during their longest suspensions, the nobility, with large retinues, continually resorted to the court. But an intercourse more constant and more comprehensive was maintained through the agency of the two universities. Already, in the time of James I., the growing importance of the gentry, and the consequent birth of a new interest in political questions, had begun to express itself at Oxford, and still more so at Cambridge. Academic persons stationed themselves as sentinels at London, for the purpose of watching the court and the course of public affairs. These persons wrote letters, like those of the celebrated Joseph Mede, which we find in Ellis's Historical Collections, reporting to their fellow-collegians all the novelties of public life as they arose, or personally carried down such reports, and thus conducted the general feelings at the centre into lesser centres, from which again they were diffused into the ten thousand parishes of England; for (with a very few exceptions in favour of poor benefices, Welch or Cumbrian), every parish priest must unavoidably have spent his three years at one or other of the English universities. And by this mode of diffusion it is that we can explain the strength with which Shakspeare's thoughts and diction impressed themselves from a very early period upon the national literature, and even more generally upon the national thinking and conversation.[2]

The question therefore revolves upon us in threefold difficulty, How, having stepped thus prematurely into this inheritance of fame, leaping, as it were, thus abruptly into the favour alike of princes and the enemies of princes, had it become possible that in his native place (honoured still more in the final testimonies of his preference when founding a family mansion), such a man's history, and the personal recollections which cling so affectionately to the great

[1] The necessity of compression obliges us to omit many arguments and references by which we could demonstrate the fact, that Shakspeare's reputation was always in a progressive state; allowing only for the interruption of about seventeen years, which this poet, in common with all others, sustained, not so much from the state of war (which did not fully occupy four of those years), as from the triumph of a gloomy fanaticism. Deduct the twenty-three years of the seventeenth century which had elapsed before the first folio appeared, to this space add seventeen years of fanatical madness, during fourteen of which *all* dramatic entertainments were suppressed, the remainder is sixty years. And surely the sale of four editions of a vast folio in that space of time was an expression of an abiding interest. *No other poet, except Spenser, continued to sell throughout the century.* Besides, in arguing the case of a *dramatic* poet, we must bear in mind, that although readers of learned books might be diffused over the face of the land, the readers of poetry would be chiefly concentred in the metropolis; and such persons would have no need to buy what they heard at the theatres. But then comes the question, whether Shakspeare kept possession of the theatres. And we are really humiliated by the gross want of sense which has been shown, by Malone chiefly, but also by many others, in discussing this question. From the Restoration to 1682, says Malone, no more than four plays of Shakspeare's were performed by a principal company in London. "Such was the lamentable taste of those times, that the plays of Fletcher, Jonson, and Shirley, were much oftener exhibited than those of our author." What cant is this! If that taste were "lamentable," what are we to think of our own times, when plays a thousand times below those of Fletcher, or even of Shirley, continually displace Shakspeare? Shakspeare would himself have exulted in finding that he gave way only to dramatists so excellent. And, as we have before observed, both then and now, it is the very familiarity with Shakspeare which often banishes him from audiences honestly in quest of relaxation and amusement. Novelty is the very soul of such relaxation; but in our closets, when we are *not* unbending, when our minds are in a state of tension from intellectual cravings, then it is that we resort to Shakspeare; and oftentimes those who honour him most, like ourselves, are the most impatient of seeing his divine scenes disfigured by unequal representation (good, perhaps, in a single personation, bad in all the rest); or to hear his divine thoughts mangled in the recitation; or (which is worst of all) to hear them dishonoured and defeated by imperfect apprehension in the audience, or by defective sympathy. Meantime, if one theatre played only four of Shakspeare's dramas, another played at least seven. But the grossest folly of Malone is, in fancying the numerous alterations so many insults to Shakspeare, whereas they expressed as much homage to his memory as if the unaltered dramas had been retained. The substance *was* retained. The changes were merely concessions to the changing views of scenical propriety; sometimes, no doubt, made with a simple view to the revolution effected by Davenant at the restoration, in bringing *scenes* (in the painter's sense) upon the stage; sometimes also with a view to the altered fashions of the audience during the suspensions of the action, or perhaps to the introduction of *after-pieces*, by which, of course, the time was abridged for the main performance. A volume might be written upon this subject. Meantime let us never be told, that a poet was losing, or had lost his ground, who found in his lowest depression, amongst his almost idolatrous supporters, a great king distracted by civil wars, a mighty republican poet distracted by puritanical fanaticism, the greatest successor by far of that great poet, a papist and a bigoted royalist, and finally, the leading actor of the century, who gave and reflected the ruling impulses of his age.

[2] One of the profoundest tests by which we can measure the congeniality of an author with the national genius and temper, is the degree in which his thoughts or his phrases interweave themselves with our daily conversation, and pass into the currency of the language. *Few French authors, if any, have imparted one phrase to the colloquial idiom;* with respect to Shakspeare, a large dictionary might be made of such phrases as "win golden opinions," "in my mind's eye," "patience on a monument," "o'erstep the modesty of nature," "more honour'd in the breach than in the observance," "palmy state," "my poverty and not my will consents," and so forth, without end. This reinforcement of the general language, by aids from the mintage of Shakspeare, had already commenced in the seventeenth century.

intellectual potentates who have recommended themselves by gracious manners, could so soon and so utterly have been obliterated?

Malone, with childish irreflection, ascribes the loss of such memorials to the want of enthusiasm in his admirers. Local researches into private history had not then commenced. Such a taste, often petty enough in its management, was the growth of after-ages. Else how came Spenser's life and fortunes to be so utterly overwhelmed in oblivion? No poet of a high order could be more popular.

The answer we believe to be this: Twenty-six years after Shakspeare's death commenced the great parliamentary war: this it was, and the local feuds arising to divide family from family, brother from brother, upon which we must charge the extinction of traditions and memorials, doubtless abundant up to that era. The parliamentary contest, it will be said, did not last above three years; the king's standard having been first raised at Nottingham in August 1642, and the battle of Naseby (which terminated the open warfare) having been fought in June 1645. Or even if we extend its duration to the surrender of the last garrison, that war terminated in the spring of 1646. And the brief explosions of insurrection or of Scottish invasion which occurred on subsequent occasions were all locally confined; and none came near to Warwickshire, except the battle of Worcester, more than five years after. This is true; but a short war will do much to efface recent and merely personal memorials. And the following circumstances of the war were even more important than the general fact.

First of all, the very mansion founded by Shakspeare became the military head-quarters for the queen in 1644, when marching from the eastern coast of England to join the king in Oxford; and one such special visitation would be likely to do more serious mischief in the way of extinction, than many years of general warfare. Secondly, as a fact, perhaps, equally important, Birmingham, the chief town of Warwickshire, and the adjacent district, the seat of our hardware manufactures, was the very focus of disaffection towards the royal cause. Not only, therefore, would this whole region suffer more from internal and spontaneous agitation, but it would be the more frequently traversed vindictively from without, and harassed by flying parties from Oxford, or others of the king's garrisons. Thirdly, even apart from the political aspects of Warwickshire, this county happens to be the central one of England, as regards the roads between the north and south; and Birmingham has long been the great central axis,[1] in which all the radii from the four angles of England proper meet and intersect. Mere accident, therefore, of local position, much more when united with that avowed inveteracy of malignant feeling, which was bitter enough to rouse a re-action of bitterness in the mind of Lord Clarendon, would go far to account for the wreck of many memorials relating to Shakspeare, as well as for the subversion of that quiet and security for humble life, in which the traditional memory finds its best *nidus*. Thus we obtain one solution, and perhaps the main one, of the otherwise mysterious oblivion which had swept away all traces of the mighty poet, by the time when those quiet days revolved upon England, in which again the solitary agent of learned research might roam in security from house to house, gleaning those personal remembrances which, even in the fury of civil strife, might long have lingered by the chimney corner. But the fierce furnace of war had probably, by its *local* ravages, scorched this field of natural tradition, and thinned the gleaner's inheritance by three parts out of four. This, we repeat, may be one part of the solution to this difficult problem.

And if another is still demanded, possibly it may be found in the fact, hostile to the perfect consecration of Shakspeare's memory, that after all he was a player. Many a coarse-minded country gentleman, or village pastor, who would have held his town glorified by the distinction of having sent forth a great judge or an eminent bishop, might disdain to cherish the personal recollections which surrounded one whom custom regarded as little above a mountebank, and the illiberal law as a vagabond. The same degrading appreciation attached both to the actor in plays and to their author. The contemptuous appellation of "play book," served as readily to degrade the mighty volume which contained Lear and Hamlet, as that of "play-actor," or "player-man," has always served with the illiberal or the fanatical to dishonour the persons of Roscius or of Garrick, of Talma or of Siddons. Nobody, indeed, was better aware of this than the noble-minded Shakspeare; and feelingly he has breathed forth in his sonnets this conscious oppression under which he lay of public opinion, unfavourable by a double title to his own pretensions; for, being both dramatic author and dramatic performer, he found himself heir to a two-fold opprobrium, and at an era of English society when the weight of that opprobrium was heaviest. In reality, there was at this period a collision of forces acting in opposite directions upon the estimation of the stage and scenical art, and therefore of all the ministers in its equipage. Puritanism frowned upon these pursuits, as ruinous to public morals; on the other hand, loyalty could not but tolerate what was patronized by the sovereign; and it happened that Elizabeth, James, and Charles I., were all alike lovers and promoters of theatrical amusements, which were indeed more indispensable to the relief of court ceremony, and the monotony of aulic pomp, than in any other region of life. This royal support, and the consciousness that any brilliant success in these arts implied an unusual share of natural endowments, did something in mitigation of a scorn which must else have been intolerable to all generous natures.

But whatever prejudice might thus operate against the perfect sanctity of Shakspeare's posthumous reputation, it is certain that the splendour of his worldly success must have done much to obliterate that effect; his admirable colloquial talents a good deal, and his gracious affability still more. The wonder therefore will still remain, that Betterton, in less than a century from his death, should have been able to glean so little. And for the solution of this wonder we must throw ourselves chiefly upon the explanations we have made as to the parliamentary war, and the local ravages of its progress in the very district, of the very town, and the very house.

If further arguments are still wanted to explain this mysterious abolition, we may refer the reader to the following succession of disastrous events, by which it should seem that a perfect malice of misfortune pursued the vestiges of the mighty poet's steps. In 1613, the Globe theatre, with which he had been so long connected, was burned to the ground. Soon afterwards a great fire occurred in Stratford; and next (without counting upon the fire of London, just fifty years after his death, which, however, would consume many an important record from periods far more remote), the house of Ben Jonson, in which probably, as Mr Campbell suggests, might be parts of his correspondence, was also burned. Finally, there was an old tradition that Lady Barnard, the sole grand-daughter of Shakspeare, had carried off many of his papers from Stratford; and these papers have never since been traced.

In many of the elder lives it has been asserted, that John Shakspeare, the father of the poet, was a butcher,

[1] In fact, by way of representing to himself the system or scheme of the English roads, the reader has only to imagine one great letter X, or a St Andrew's cross, laid down from north to south, and decussating at Birmingham. Even Coventry, which makes a slight variation for one or two roads, and so far disturbs this decussation, by shifting it eastwards, is still in Warwickshire.

and in others that he was a woolstapler. It is now settled beyond dispute that he was a glover. This was his professed occupation in Stratford, though it is certain that, with this leading trade, from which he took his denomination, he combined some collateral pursuits; and it is possible enough that, as openings offered, he may have meddled with many. In that age, and in a provincial town, nothing like the exquisite subdivision of labour was attempted which we now see realized in the great cities of Christendom. And one trade is often found to play into another with so much reciprocal advantage, that even in our own days we do not much wonder at an enterprising man, in country places, who combines several in his own person. Accordingly John Shakspeare is known to have united with his town calling the rural and miscellaneous occupations of a farmer.

Meantime his avowed business stood upon a very different footing from the same trade as it is exercised in modern times. Gloves were in that age an article of dress more costly by much, and more elaborately decorated, than in our own. They were a customary present from some cities to the judges of assize, and to other official persons; a custom of ancient standing, and in some places, we believe, still subsisting; and in such cases it is reasonable to suppose that the gloves must originally have been more valuable than the trivial modern article of the same name. So also, perhaps, in their origin, of the gloves given at funerals. In reality, whenever the simplicity of an age makes it difficult to renew the parts of a wardrobe except in capital towns of difficult access, prudence suggests that such wares should be manufactured of more durable materials; and, being so, they become obviously susceptible of more lavish ornament. But it will not follow, from this essential difference in the gloves of Shakspeare's age, that the glover's occupation was more lucrative. Doubtless he sold more costly gloves, and upon each pair had a larger profit; but for that very reason he sold fewer. Two or three gentlemen "of worship" in the neighbourhood might occasionally require a pair of gloves, but it is very doubtful whether any inhabitant of Stratford would ever call for so mere a luxury.

The practical result, at all events, of John Shakspeare's various pursuits does not appear permanently to have met the demands of his establishment; and in his maturer years there are indications still surviving that he was under a cloud of embarrassment. He certainly lost at one time his social position in the town of Stratford; but there is a strong presumption, in *our* construction of the case, that he finally retrieved it; and for this retrieval of a station which he had forfeited by personal misfortunes or neglect, he was altogether indebted to the filial piety of his immortal son.

Meantime the earlier years of the elder Shakspeare wore the aspect of rising prosperity, however unsound might be the basis on which it rested. There can be little doubt that William Shakspeare, from his birth up to his tenth or perhaps his eleventh year, lived in careless plenty, and saw nothing in his father's house but that style of liberal housekeeping which has ever distinguished the upper yeomanry and the rural gentry of England. Probable enough it is that the resources for meeting this liberality were not strictly commensurate with the family income, but were sometimes allowed to entrench, by means of loans or mortgages, upon capital funds. The stress upon the family finances was perhaps at times severe; and that it was borne at all, must be imputed to the large and even splendid portion which John Shakspeare received with his wife.

This lady, for such she really was in an eminent sense, by birth as well as by connections, bore the beautiful name of Mary Arden, a name derived from the ancient forest district[1] of the county; and doubtless she merits a more elaborate notice than our slender materials will furnish. To have been *the mother of Shakspeare*,—how august a title to the reverence of infinite generations, and of centuries beyond the vision of prophecy. A plausible hypothesis has been started in modern times, that the facial structure, and that the intellectual conformation, may be deduced more frequently from the corresponding characteristics in the mother than in the father. It is certain that no very great man has ever existed, but that his greatness has been rehearsed and predicted in one or other of his parents. And it cannot be denied, that in the most eminent men, where we have had the means of pursuing the investigation, the mother has more frequently been repeated and reproduced than the father. We have known cases where the mother has furnished all the intellect, and the father all the moral sensibility; upon which assumption, the wonder ceases that Cicero, Lord Chesterfield, and other brilliant men, who took the utmost pains with their sons, should have failed so conspicuously; for possibly the mothers had been women of excessive and even exemplary stupidity. In the case of Shakspeare, each parent, if we had any means of recovering their characteristics, could not fail to furnish a study of the most profound interest; and with regard to his mother in particular, if the modern hypothesis be true, and if we are indeed to deduce from *her* the stupendous intellect of her son, in that case she must have been a benefactress to her husband's family beyond the promises of fairyland or the dreams of romance; for it is certain that to her chiefly this family was also indebted for their worldly comfort.

Mary Arden was the youngest daughter and the heiress of Robert Arden of Wilmecote, Esq. in the county of Warwick. The family of Arden was even then of great antiquity. About one century and a quarter before the birth of William Shakspeare, a person bearing the same name as his maternal grandfather had been returned by the commissioners in their list of the Warwickshire gentry; he was there styled Robert Arden, Esq. of Bromich. This was in 1433, or the 12th year of Henry VI. In Henry VII.'s reign, the Ardens received a grant of lands from the crown; and in 1568, four years after the birth of William Shakspeare, Edward Arden, of the same family, was sheriff of the county. Mary Arden was therefore a young lady of excellent descent and connections, and an heiress of considerable wealth. She brought to her husband, as her marriage portion, the landed estate of Asbies, which, upon any just valuation, must be considered as a handsome dowry for a woman of her station. As this point has been contested, and as it goes a great way towards determining the exact social position of the poet's parents, let us be excused for sifting it a little more narrowly than might else seem warranted by the proportions of our present life. Every question which it can be reasonable to raise at all, it must be reasonable to treat with at least so much of minute research as may justify the conclusions which it is made to support.

The estate of Asbies contained fifty acres of arable land, six of meadow, and a right of commonage. What may we assume to have been the value of its fee-simple? Malone, who allows the total fortune of Mary Arden to have been L.110. 13s. 4d., is sure that the value of Asbies could not have been more than one hundred pounds. But why? Because, says he, the "average" rent of land at that time was no more than three shillings per acre. This we deny; but

[1] And probably so called by some remote ancestor who had emigrated from the forest of Ardennes, in the Netherlands, and *now* for ever memorable to English ears from its proximity to Waterloo.

Shakspeare.

upon that assumption, the total yearly rent of fifty-six acres would be exactly eight guineas.[1] And therefore, in assigning the value of Asbies at one hundred pounds, it appears that Malone must have estimated the land at no more than twelve years' purchase, which would carry the value to L.100. 16s. "Even at this estimate," as the latest annotator[2] on this subject *justly* observes, "Mary Arden's portion was a larger one than was usually given to a landed gentleman's daughter." But this writer objects to Malone's principle of valuation. "We find," says he, "that John Shakspeare also farmed the meadow of Tugton, containing sixteen acres, at the rate of eleven shillings per acre. Now what proof has Mr Malone adduced that the acres of Asbies were not as valuable as those of Tugton? And if they were so, the former estate must have been worth between three and four hundred pounds." In the main drift of his objections we concur with Mr Campbell. But as they are liable to some criticism, let us clear the ground of all plausible cavils, and then see what will be the result. Malone, had he been alive, would probably have answered, that Tugton was a farm specially privileged by nature; and that if any man contended for so unusual a rent as eleven shillings an acre for land not known to him, the *onus probandi* would lie upon *him*. Be it so; eleven shillings is certainly above the ordinary level of rent, but three shillings is below it. We contend, that for tolerably good land, situated advantageously, that is, with a ready access to good markets and good fairs, such as those of Coventry, Birmingham, Gloucester, Worcester, Shrewsbury, &c., one noble might be assumed as the annual rent; and that in such situations twenty years' purchase was not a valuation, even in Elizabeth's reign, very unusual. Let us, however, assume the rent at only five shillings, and land at sixteen years' purchase: upon this basis, the rent would be L.14, and the value of the fee-simple L.224. Now, if it were required to equate that sum with its present value, a very operose[3] calculation might be requisite. But contenting ourselves with the gross method of making such equations between 1560 and the current century, that is, multiplying by five, we shall find the capital value of the estate to be eleven hundred and twenty pounds, whilst the annual rent would be exactly seventy. But if the estate had been sold, and the purchase-money lent upon mortgage (the only safe mode of investing money at that time), the annual interest would have reached L.28, equal to L.140 of modern money; for mortgages in Elizabeth's age readily produced ten per cent.

A woman who should bring at this day an annual income of L.140 to a provincial tradesman, living in a sort of *rus in urbe*, according to the simple fashions of rustic life, would assuredly be considered as an excellent match. And there can be little doubt that Mary Arden's dowry it was which, for some ten or a dozen years succeeding to his marriage, raised her husband to so much social consideration in Stratford. In 1550 John Shakspeare is supposed to have first settled in Stratford, having migrated from some other part of Warwickshire. In 1557 he married Mary Arden; in 1565, the year subsequent to the birth of his son William his third child, he was elected one of the aldermen; and in the year 1568 he became first magistrate of the town, by the title of high bailiff. This year we may assume to have been that in which the prosperity of this family reached its zenith; for in this year it was, over and above the presumptions furnished by his civic honours, that he obtained a grant of arms from Clarencieux of the Heralds' College. On this occasion he declared himself worth five hundred pounds derived from his ancestors. And we really cannot understand the right by which critics, living nearly three centuries from his time, undertake to know his affairs better than himself, and to tax him with either inaccuracy or falsehood. No man would be at leisure to court heraldic honours when he knew himself to be embarrassed, or apprehended that he soon might be so. A man whose anxieties had been fixed at all upon his daily livelihood would, by this chase after the aërial honours of heraldry, have made himself a butt for ridicule such as no fortitude could enable him to sustain.

In 1568, therefore, when his son William would be moving through his fifth year, John Shakspeare (now honoured by the designation of *Master*) would be found at times in the society of the neighbouring gentry. Ten years in advance of this period he was already in difficulties. But there is no proof that these difficulties had then reached a point of degradation, or of memorable distress. The sole positive indications of his decaying condition are, that in 1578 he received an exemption from the small weekly assessment levied upon the aldermen of Stratford for the relief of the poor; and that in the following year, 1579, he is found enrolled amongst the defaulters in the payment of taxes. The latter fact undoubtedly goes to prove that, like every man who is falling back in the world, he was occasionally in arrears. Paying taxes is not like the honours awarded or the processions regulated by Clarencieux; no man is ambitious of precedency there; and if a laggard pace in that duty is to be received as evidence of pauperism, nine tenths of the English people might occasionally be classed as paupers. With respect to his liberation from the weekly assessment, that may bear a construction different from the one which it has received. This payment, which could never have been regarded as a burthen, not amounting to five pounds annually of our present money, may have been held up as an exponent of wealth and consideration; and John Shakspeare may have been required to resign it as an honourable distinction, not suitable to the circumstances of an embarrassed man. Finally, the fact of his being indebted to Robert Sadler, a baker, in the sum of five pounds, and his being under the necessity of bringing a friend as security for the payment, proves nothing at

[1] Let not the reader impute to us the gross anachronism of making an estimate for Shakspeare's days in a coin which did not exist until a century, within a couple of years, after Shakspeare's birth, and did not settle to the value of twenty-one shillings until a century after his death. The nerve of such an anachronism would lie in putting the estimate into a mouth of that age. And this is precisely the blunder into which the foolish forger of Vortigern, &c. has fallen. He does not indeed directly mention guineas; but indirectly and virtually he does, by repeatedly giving us accounts imputed to Shakspearian contemporaries, in which the sum-total amounts to L.5. 5s.; or to L.26. 5s.; or, again, to L.17. 17s. 6d. A man is careful to subscribe L.14. 14s. and so forth. But how could such amounts have arisen unless under a secret reference to guineas, which were not in existence until Charles II.'s reign; and, moreover, to guineas at their final settlement by law into twenty-one shillings each, which did not take place until George I.'s reign.

[2] Thomas Campbell the poet, in his eloquent Remarks on the Life and Writings of William Shakspeare, prefixed to a popular edition of the poet's dramatic works. London, 1838.

[3] After all the assistance given to such equations between different times or different places by Sir George Shuckborough's tables, and other similar investigations, it is still a very difficult problem, complex, and, after all, merely tentative in the results, to assign the true value in such cases; not only for the obvious reason, that the powers of money have varied in different directions with regard to different objects, and in different degrees where the direction has on the whole continued the same, but because the very objects to be taken into computation are so indeterminate, and vary so much, not only as regards century and century, kingdom and kingdom, but also, even in the same century and the same kingdom, as regards rank and rank. That which is a mere necessary to one, is a luxurious superfluity to another. And, in order to ascertain these differences, it is an indispensable qualification to have studied the habits and customs of the several classes concerned, together with the variations of those habits and customs.

all. There is not a town in Europe in which opulent men cannot be found that are backward in the payment of their debts. And the probability is, that Master Sadler acted like most people who, when they suppose a man to be going down in the world, feel their respect for him sensibly decaying, and think it wise to trample him under foot, provided only in that act of trampling they can squeeze out of him their own individual debt. Like that terrific chorus in Spohr's oratorio of St Paul, "*stone him to death*" is the cry of the selfish and the illiberal amongst creditors, alike towards the just and the unjust amongst debtors.

It was the wise and beautiful prayer of Agar, "Give me neither poverty nor riches;" and, doubtless, for quiet, for peace, and the *latentis semita vitæ*, that is the happiest dispensation. But, perhaps, with a view to a school of discipline and of moral fortitude, it might be a more salutary prayer, "Give me riches *and* poverty, and afterwards neither." For the transitional state between riches and poverty will teach a lesson both as to the baseness and the goodness of human nature, and will impress that lesson with a searching force, such as no borrowed experience ever can approach. Most probable it is that Shakspeare drew some of his powerful scenes in the Timon of Athens, those which exhibit the vileness of ingratitude and the impassioned frenzy of misanthropy, from his personal recollections connected with the case of his own father. Possibly, though a cloud of 270 years now veils it, this very Master Sadler, who was so urgent for his five pounds, and who so little apprehended that he should be called over the coals for it in the Encyclopædia Britannica, may have sate for the portrait of that Lucullus who says of Timon—

> Alas, good lord! a noble gentleman 'tis, if he would not keep so good a house. Many a time and often I have dined with him, and told him on't; and come again to supper to him, of purpose to have him spend less: and yet he would embrace no counsel, take no warning by my coming. Every man has his fault, and honesty is his; I have told him on't, but I could never get him from it.

For certain years, perhaps, John Shakspeare moved on in darkness and sorrow:

> His familiars from his buried fortunes
> Slunk all away; left their false vows with him,
> Like empty purses pick'd: and his poor self,
> A dedicated beggar to the air,
> With his disease of all-shunn'd poverty,
> Walk'd, like contempt, alone.

We, however, at this day are chiefly interested in the case as it bears upon the education and youthful happiness of the poet. Now if we suppose that from 1568, the high noon of the family prosperity, to 1578, the first year of their mature embarrassments, one half the interval was passed in stationary sunshine, and the latter half in the gradual twilight of declension, it will follow that the young William had completed his tenth year before he heard the first signals of distress; and for so long a period his education would probably be conducted on as liberal a scale as the resources of Stratford would allow. Through this earliest section of his life he would undoubtedly rank as a gentleman's son, possibly as the leader of his class, in Stratford. But what rank he held through the next ten years, or, more generally, what was the standing in society of Shakspeare until he had created a new station for himself by his own exertions in the metropolis, is a question yet unsettled, but which has been debated as keenly as if it had some great dependencies. Upon this we shall observe, that could we by possibility be called to settle beforehand what rank were best for favouring the development of intellectual powers, the question might wear a face of deep practical importance; but when the question is simply as to a matter of fact, what *was* the rank held by a man whose intellectual development has long ago been completed, this becomes a mere question of curiosity. The tree has fallen; it is confessedly the noblest of all the forest; and we must therefore conclude that the soil in which it flourished was either the best possible, or, if not so, that any thing bad in its properties had been disarmed and neutralized by the vital forces of the plant, or by the benignity of nature. If any future Shakspeare were likely to arise, it might be a problem of great interest to agitate, whether the condition of a poor man or of a gentleman were best fitted to nurse and stimulate his faculties. But for the actual Shakspeare, since what he was he was, and since nothing greater can be imagined, it is now become a matter of little moment whether his course lay for fifteen or twenty years through the humilities of absolute poverty, or through the chequered paths of gentry lying in the shade. Whatever *was*, must, in this case at least, have been the best, since it terminated in producing Shakspeare; and thus far we must all be optimists.

Yet still, it will be urged, the curiosity is not illiberal which would seek to ascertain the precise career through which Shakspeare ran. This we readily concede; and we are anxious ourselves to contribute any thing in our power to the settlement of a point so obscure. What we have wished to protest against is the spirit of partisanship in which this question has too generally been discussed. For, whilst some with a foolish affectation of plebeian sympathies overwhelm us with the insipid commonplaces about birth and ancient descent, as honours containing nothing meritorious, and rush eagerly into an ostentatious exhibition of all the circumstances which favour the notion of a humble station and humble connections; others, with equal forgetfulness of true dignity, plead with the intemperance and partiality of a legal advocate for the pretensions of Shakspeare to the hereditary rank of gentleman. Both parties violate the majesty of the subject. When we are seeking for the sources of the Euphrates or the St Lawrence, we look for no proportions to the mighty volume of waters in that particular summit amongst the chain of mountains which embosoms its earliest fountains, nor are we shocked at the obscurity of these fountains. Pursuing the career of Mahommed, or of any man who has memorably impressed his own mind or agency upon the revolutions of mankind, we feel solicitude about the circumstances which might surround his cradle to be altogether unseasonable and impertinent. Whether he were born in a hovel or a palace, whether he passed his infancy in squalid poverty, or hedged around by the glittering spears of body-guards, as mere questions of fact may be interesting; but, in the light of either accessories or counteragencies to the native majesty of the subject, are trivial and below all philosophic valuation. So with regard to the creator of Lear and Hamlet, of Othello and Macbeth; to him from whose golden urns the nations beyond the far Atlantic, the multitude of the isles, and the generations unborn in Australian climes, even to the realms ot the rising sun (the ἀνατολαι ἠελιοιο), must in every age draw perennial streams of intellectual life, we feel that the little accidents of birth and social condition are so unspeakably below the grandeur of the theme, are so irrelevant and disproportioned to the real interest at issue, so incommensurable with any of its relations, that a biographer of Shakspeare at once denounces himself as below his subject if he can entertain such a question as seriously affecting the glory of the poet. In some legends of saints, we find that they were born with a lambent circle or golden aureola about their heads. This angelic coronet shed light alike upon the chambers of a cottage or a palace, upon the gloomy limits of a dungeon or the vast expansion of a cathedral; but the cottage, the palace, the dungeon, the cathedral, were all equally incapable of adding one ray of colour or one pencil of light to the supernatural halo.

Having therefore thus pointedly guarded ourselves from misconstruction, and consenting to entertain the question

as one in which we, the worshippers of Shakspeare, have an interest of curiosity, but in which he, the object of our worship, has no interest of glory, we proceed to state what appears to us the result of the scanty facts surviving when collated with each other.

By his mother's side, Shakspeare was an authentic gentleman. By his father's he would have stood in a more dubious position; but the effect of municipal honours to raise and illustrate an equivocal rank has always been acknowledged under the popular tendencies of our English political system. From the sort of lead, therefore, which John Shakspeare took at one time amongst his fellow-townsmen, and from his rank of first magistrate, we may presume that, about the year 1568, he had placed himself at the head of the Stratford community. Afterwards he continued for some years to descend from this altitude; and the question is, at what point this gradual degradation may be supposed to have settled. Now we shall avow it as our opinion, that the composition of society in Stratford was such that, even had the Shakspeare family maintained their superiority, the main body of their daily associates must still have been found amongst persons below the rank of gentry. The poet must inevitably have mixed chiefly with mechanics and humble tradesmen, for such people composed perhaps the total community. But had there even been a gentry in Stratford, since they would have marked the distinctions of their rank chiefly by greater reserve of manners, it is probable that, after all, Shakspeare, with his enormity of delight in exhibitions of human nature, would have mostly cultivated that class of society in which the feelings are more elementary and simple, in which the thoughts speak a plainer language, and in which the restraints of factitious or conventional decorum are exchanged for the restraints of mere sexual decency. It is a noticeable fact to all who have looked upon human life with an eye of strict attention, that the abstract image of womanhood, in its loveliness, its delicacy, and its modesty, nowhere makes itself more impressive or more advantageously felt than in the humblest cottages, because it is there brought into immediate juxtaposition with the grossness of manners and the careless license of language incident to the fathers and brothers of the house. And this is more especially true in a nation of unaffected sexual gallantry,[1] such as the English and the Gothic races in general; since, under the immunity which their women enjoy from all servile labours of a coarse or out-of-doors order, by as much lower as they descend in the scale of rank, by so much more do they benefit under the force of contrast with the men of their own level. A young man of that class, however noble in appearance, is somewhat degraded in the eyes of women, by the necessity which his indigence imposes of working under a master; but a beautiful young woman, in the very poorest family, unless she enters upon a life of domestic servitude (in which case her labours are light, suited to her sex, and withdrawn from the public eye), so long in fact as she stays under her father's roof, is as perfectly her own mistress and *sui juris* as the daughter of an earl. This personal dignity, brought into stronger relief by the mercenary employments of her male connections, and the feminine gentleness of her voice and manners, exhibited under the same advantages of contrast, oftentimes combine to make a young cottage beauty as fascinating an object as any woman of any station.

Hence we may in part account for the great event of Shakspeare's early manhood, his premature marriage. It has always been known, or at least traditionally received for a fact, that Shakspeare had married whilst yet a boy; and that his wife was unaccountably older than himself. In the very earliest biographical sketch of the poet, compiled by Rowe, from materials collected by Betterton the actor, it was stated (and that statement is now ascertained to have been correct), that he had married Anne Hathaway, "the daughter of a substantial yeoman." Further than this nothing was known. But in September 1836 was published a very remarkable document, which gives the assurance of law to the time and fact of this event, yet still, unless collated with another record, does nothing to lessen the mystery which had previously surrounded its circumstances. This document consists of two parts: the first, and principal, according to the logic of the case, though second according to the arrangement, being a *license* for the marriage of William Shakspeare with Anne Hathaway, under the condition "of *once* asking of the bannes of matrimony," that is, in effect, dispensing with two out of the three customary askings; the second or subordinate part of the document being a *bond* entered into by two sureties, viz. Fulke Sandells and John Rychardson, both described as *agricolæ* or yeomen, and both marksmen (that is, incapable of writing, and therefore subscribing by means of *marks*), for the payment of forty pounds sterling, in the event of Shakspeare, yet a minor, and incapable of binding himself, failing to fulfil the conditions of the license. In the bond, drawn up in Latin, there is no mention of Shakspeare's name; but in the license, which is altogether English, *his* name, of course, stands foremost; and as it may gratify the reader to see the very words and orthography of the original, we here extract the *operative* part of this document, prefacing only, that the license is attached by way of explanation to the bond. "The condition of this obligation is suche, that if herafter there shall not appere any lawfull lett or impediment, by reason of any precontract, &c., but that Willm. Shagspere, one thone ptie" [on the one party], "and Anne Hathwey of Stratford, in the diocess of Worcester, maiden, may lawfully solemnize matrimony together; and in the

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[1] Never was the *esse quam videri* in any point more strongly discriminated than in this very point of gallantry to the female sex, as between England and France. In France, the verbal homage to woman is so excessive as to betray its real purpose, viz. that it is a mask for secret contempt. In England, little is *said;* but, in the mean time, we allow our sovereign ruler to be a woman; which in France is impossible. Even that fact is of some importance, but less so than what follows. In every country whatsoever, if any principle has a deep root in the moral feelings of the people, we may rely upon its showing itself, by a thousand evidences, amongst the very lowest ranks, and in their daily intercourse, and their *undress* manners. Now in England there is, and always has been, a manly feeling, most widely diffused, of unwillingness to see labours of a coarse order, or requiring muscular exertions, thrown upon women. Pauperism, amongst other evil effects, has sometimes locally disturbed this predominating sentiment of Englishmen; but never at any time with such depth as to kill the root of the old hereditary manliness. Sometimes at this day a gentleman, either from carelessness, or from over-ruling force of convenience, or from real defect of gallantry, will allow a female servant to carry his portmanteau for him; though, after all, that spectacle is a rare one. And everywhere women of all ages engage in the pleasant, nay elegant, labours of the hay field; but in Great Britain women are never suffered to mow, which is a most athletic and exhausting labour, nor to load a cart, nor to drive a plough or hold it. In France, on the other hand, before the Revolution (at which period the pseudo-homage, the lip-honour, was far more ostentatiously professed towards the female sex than at present), a Frenchman of credit, and vouching for his statement by the whole weight of his name and personal responsibility (M. Simond, now an American citizen), records the following abominable scene as one of no uncommon occurrence: A woman was in some provinces yoked side by side with an ass to the plough or the harrow; and M. Simond protests that it excited no horror to see the driver distributing his lashes impartially between the woman and her brute yoke-fellow. So much for the wordy pomps of French gallantry. In England, we trust, and we believe, that any man, caught in such a situation, and in such an abuse of his power (supposing the case otherwise a possible one), would be killed on the spot.

same afterwards remaine and continew like man and wiffe. And, moreover, if the said Willm. Shagspere do not proceed to solemnization of mariadg with the said Anne Hathwey, without the consent of hir frinds;—then the said obligation" [viz. to pay forty pounds] "to be voyd and of none effect, or els to stand & abide in full force and vertue."

What are we to think of this document? Trepidation and anxiety are written upon its face. The parties are not to be married by a special license; not even by an ordinary license; in that case no proclamation of banns, no public asking at all, would have been requisite. Economical scruples are consulted; and yet the regular movement of the marriage "through the bell-ropes"[1] is disturbed. Economy, which retards the marriage, is here evidently in collision with some opposite principle which precipitates it. How is all this to be explained? Much light is afforded by the date when illustrated by another document. The bond bears date on the 28th day of November in the 25th year of our lady the queen, that is, in 1582. Now the baptism of Shakspeare's eldest child, Susanna, is registered on the 26th of May in the year following. Suppose, therefore, that his marriage was solemnized on the 1st day of December; it was barely possible that it could be earlier, considering that the sureties, drinking, perhaps, at Worcester throughout the 28th of November, would require the 29th, in so dreary a season, for their return to Stratford; after which some preparation might be requisite to the bride, since the marriage was *not* celebrated at Stratford. Next suppose the birth of Miss Susanna to have occurred, like her father's, two days before her baptism, viz. on the 24th of May. From December the 1st to May the 24th, both days inclusively, are 175 days; which, divided by seven, gives precisely twenty-five weeks, that is to say, six months short by one week. Oh, fie, Miss Susanna, you came rather before you were wanted.

Mr Campbell's comment upon the affair is, that "*if* this was the case," viz. if the baptism were really solemnized on the 26th of May, "the poet's first child would *appear* to have been born only six months and eleven days after the bond was entered into." And he then concludes that, on this assumption, "Miss Susanna Shakspeare came into the world a little prematurely." But this is to doubt where there never was any ground for doubting; the baptism was *certainly* on the 26th of May; and, in the next place, the calculation of six months and eleven days is sustained by substituting lunar months for calendar, and then only by supposing the marriage to have been celebrated on the very day of subscribing the bond in Worcester, and the baptism to have been coincident with the birth; of which suppositions the latter is improbable, and the former, considering the situation of Worcester, impossible.

Strange it is, that, whilst all biographers have worked with so much zeal upon the most barren dates or most baseless traditions in the great poet's life, realising in a manner the chimeras of Laputa, and endeavouring "to extract sunbeams from cucumbers," such a story with regard to such an event, no fiction of village scandal, but involved in legal documents, a story so significant and so eloquent to the intelligent, should formerly have been dismissed without notice of any kind, and even now, after the discovery of 1836, with nothing beyond a slight conjectural insinuation. For our parts, we should have been the last amongst the biographers to unearth any forgotten scandal, or, after so vast a lapse of time, and when the grave had shut out all but charitable thoughts, to point any moral censures at a simple case of natural frailty, youthful precipitancy of passion, of all trespasses the most venial, where the final intentions are honourable. But in this case there seems to have been something more in motion than passion or the ardour of youth. "I like not," says Parson Evans (alluding to Falstaff in masquerade), "I like not when a woman has a great peard; I spy a great peard under her muffler." Neither do we like the spectacle of a mature young woman, five years past her majority, wearing the semblance of having been led astray by a boy who had still two years and a half to run of his minority. Shakspeare himself, looking back on this part of his youthful history from his maturest years, breathes forth pathetic counsels against the errors into which his own inexperience had been ensnared. The disparity of years between himself and his wife he notices in a beautiful scene of the Twelfth Night. The Duke Orsino, observing the sensibility which the pretended Cesario had betrayed on hearing some touching old snatches of a love strain, swears that his beardless page must have felt the passion of love, which the other admits. Upon this the dialogue proceeds thus:

Duke. What kind of woman is't?
Viola. Of your complexion.
Duke. She is not worth thee then:—What years?
Viola. I' faith,
About your years, my lord.
Duke. Too old, by heaven. *Let still the woman take*
An elder than herself: so wears she to him,
So sways she level in her husband's heart.
For, boy, however we do praise ourselves,
Our fancies are more giddy and unfirm,
More longing, wavering, sooner lost and worn,
Than women's are.
Viola. I think it well, my lord.
Duke. Then *let thy love be younger than thyself,*
Or thy affection cannot hold the bent;
For women are as roses, whose fair flower,
Being once display'd, doth fall that very hour.

These counsels were uttered nearly twenty years after the event in his own life to which they probably look back; for this play is supposed to have been written in Shakspeare's thirty-eighth year. And we may read an earnestness in pressing the point as to the *inverted* disparity of years, which indicates pretty clearly an appeal to the lessons of his personal experience. But his other indiscretion, in having yielded so far to passion and opportunity as to crop by prelibation, and before they were hallowed, those flowers of paradise which belonged to his marriage-day; this he adverts to with even more solemnity of sorrow, and with more pointed energy of moral reproof, in the very last drama which is supposed to have proceeded from his pen, and therefore with the force and sanctity of testamentary counsel. The Tempest is all but ascertained to have been composed in 1611, that is, about five years before the poet's death; and indeed could not have been composed much earlier; for the very incident which suggested the basis of the plot, and of the local scene, viz. the shipwreck of Sir George Somers on the Bermudas (which were in consequence denominated the Somers' Islands), did not occur until the year 1609. In the opening of the fourth act, Prospero formally betrothes his daughter to Ferdinand; and in doing so he pays the prince a well-merited compliment of having "worthily purchas'd" this rich jewel, by the patience with which, for her sake, he had supported harsh usage, and other painful circumstances of his trial. But, he adds solemnly,

If thou dost break her virgin knot before
All sanctimonious ceremonies may
With full and holy rite be minister'd;

[1] Amongst people of humble rank in England, who only were ever asked in church, until the new-fangled systems of marriage came up within the last ten or fifteen years, during the currency of the three Sundays on which the banns were proclaimed by the clergyman from the reading desk, the young couple elect were said jocosely to be "hanging in the bell-ropes;" alluding perhaps to the joyous peal contingent on the final completion of the marriage.

in that case what would follow?

> No sweet aspersion shall the heavens let fall,
> To make this contract grow; *but barren hate,*
> *Sour-ey'd disdain and discord, shall bestrew*
> *The union of your bed with weeds so loathly*
> *That you shall hate it both.* Therefore take heed,
> As Hymen's lamps shall light you.

The young prince assures him in reply, that no strength of opportunity, concurring with the uttermost temptation, not

> the murkiest den,
> The most opportune place, the strong'st suggestion
> Our worser genius can———

should ever prevail to lay asleep his jealousy of self-control, so as to take any advantage of Miranda's innocence. And he adds an argument for this abstinence, by way of reminding Prospero, that not honour only, but even prudential care of his own happiness, is interested in the observance of his promise. Any unhallowed anticipation would, as he insinuates,

> take away
> The edge of that day's celebration,
> When I shall think, or Phœbus' steeds are founder'd,
> Or night kept chain'd below;

that is, when even the winged hours would seem to move too slowly. Even thus Prospero is not quite satisfied: during his subsequent dialogue with Ariel, we are to suppose that Ferdinand, in conversing apart with Miranda, betrays more impassioned ardour than the wise magician altogether approves. The prince's caresses have not been unobserved; and thus Prospero renews his warning:

> Look thou be true: do not give dalliance
> Too much the rein: the strongest oaths are straw
> To the fire i' the blood: be more abstemious,
> Or else—good night your vow.

The royal lover re-assures him of his loyalty to his engagements; and again the wise father, so honourably jealous for his daughter, professes himself satisfied with the prince's pledges.

Now in all these emphatic warnings, uttering the language "of that sad wisdom folly leaves behind," who can avoid reading, as in subtile hieroglyphics, the secret record of Shakspeare's own nuptial disappointments? We, indeed, that is, universal posterity through every age, have reason to rejoice in these disappointments; for to them, past all doubt, we are indebted for Shakspeare's subsequent migration to London, and his public occupation, which, giving him a deep pecuniary interest in the productions of his pen, such as no other literary application of his powers could have approached in that day, were eventually the means of drawing forth those divine works which have survived their author for our everlasting benefit.

Our own reading and deciphering of the whole case is as follows. The Shakspeares were a handsome family, both father and sons. This we assume upon the following grounds: First, on the presumption arising out of John Shakspeare's having won the favour of a young heiress higher in rank than himself; secondly, on the presumption involved in the fact of three amongst his four sons having gone upon the stage, to which the most obvious (and perhaps in those days a *sine qua non*) recommendation would be a good person and a pleasing countenance; thirdly, on the direct evidence of Aubrey, who assures us that William Shakspeare was a handsome and a well-shaped man; fourthly, on the implicit evidence of the Stratford monument, which exhibits a man of good figure and noble countenance; fifthly, on the confirmation of this evidence by the Chandos portrait, which exhibits noble features, illustrated by the utmost sweetness of expression; sixthly, on the selection of theatrical parts, which it is known that Shakspeare personated, most of them being such as required some dignity of form, viz. kings, the athletic (though aged) follower of an athletic young man, and supernatural beings. On these grounds, direct or circumstantial, we believe ourselves warranted in assuming that William Shakspeare was a handsome and even noble-looking boy. Miss Anne Hathaway had herself probably some personal attractions; and, if an indigent girl, who looked for no pecuniary advantages, would probably have been early sought in marriage. But as the daughter of "a substantial yeoman," who would expect some fortune in his daughter's suitors, she had, to speak coarsely, a little outlived her market. Time she had none to lose. William Shakspeare pleased her eye; and the gentleness of his nature made him an apt subject for female blandishments, possibly for female arts. Without imputing, however, to this Anne Hathaway any thing so hateful as a settled plot for ensnaring him, it was easy enough for a mature woman, armed with such inevitable advantages of experience and of self-possession, to draw onward a blushing novice; and, without directly creating opportunities, to place him in the way of turning to account such as naturally offered. Young boys are generally flattered by the condescending notice of grown-up women; and perhaps Shakspeare's own lines upon a similar situation, to a young boy adorned with the same natural gifts as himself, may give us the key to the result:

> Gentle thou art, and therefore to be won;
> Beauteous thou art, therefore to be assail'd;
> And, when a woman woos, what woman's son
> Will sourly leave her till he have prevail'd?

Once, indeed, entangled in such a pursuit, any person of manly feelings would be sensible that he had no retreat: *that* would be—to insult a woman, grievously to wound her sexual pride, and to insure her lasting scorn and hatred. These were consequences which the gentle-minded Shakspeare could not face: he pursued his good fortunes, half perhaps in heedlessness, half in desperation, until he was roused by the clamorous displeasure of her family upon first discovering the situation of their kinswoman. For such a situation there could be but one atonement, and that was hurried forward by both parties; whilst, out of delicacy towards the bride, the wedding was not celebrated in Stratford (where the register contains no notice of such an event); nor, as Malone imagined, in Weston-upon-Avon, that being in the diocese of Gloucester; but in some parish, as yet undiscovered, in the diocese of Worcester.

But now arose a serious question as to the future maintenance of the young people. John Shakspeare was depressed in his circumstances, and he had other children besides William, viz. three sons and a daughter. The elder lives have represented him as burdened with ten; but this was an error, arising out of the confusion between John Shakspeare the glover and John Shakspeare a shoemaker. This error has been thus far of use, that, by exposing the fact of two John Shakspeares (not kinsmen) residing in Stratford-upon-Avon, it has satisfactorily proved the name to be amongst those which are locally indigenous to Warwickshire. Meantime it is now ascertained that John Shakspeare the glover had only eight children, viz. four daughters and four sons. The order of their succession was this: Joan, Margaret, WILLIAM, Gilbert, a second Joan, Anne, Richard, and Edmund. Three of the daughters, viz. the two eldest of the family, Joan and Margaret, together with Anne, died in childhood: all the rest attained mature ages, and of these William was the eldest. This might give him some advantage in his father's regard; but in a question of pecuniary provision precedency amongst the children of an insolvent is nearly nominal. For the present John Shakspeare could do little for his son; and, under these circumstances, perhaps the father of Anne Hathaway would come forward to assist the new-married couple. This condition

of dependency would furnish matter for painful feelings and irritating words: the youthful husband, whose mind would be expanding as rapidly as the leaves and blossoms of spring-time in polar latitudes, would soon come to appreciate the sort of wiles by which he had been caught. The female mind is quick, and almost gifted with the power of witchcraft, to decipher what is passing in the thoughts of familiar companions. Silent and forbearing as William Shakspeare might be, Anne, his staid wife, would read his secret reproaches; ill would she dissemble her wrath, and the less so from the consciousness of having deserved them. It is no uncommon case for women to feel anger in connection with one subject, and to express it in connection with another; which other, perhaps (except as a serviceable mask), would have been a matter of indifference to their feelings. Anne would therefore reply to those inevitable reproaches which her own sense must presume to be lurking in her husband's heart, by others equally stinging, on his inability to support his family, and on his obligations to her father's purse. Shakspeare, we may be sure, would be ruminating every hour on the means of his deliverance from so painful a dependency; and at length, after four years' conjugal discord, he would resolve upon that plan of solitary emigration to the metropolis, which, at the same time that it released him from the humiliation of domestic feuds, succeeded so splendidly for his worldly prosperity, and with a train of consequences so vast for all future ages.

Such, we are persuaded, was the real course of Shakspeare's transition from school-boy pursuits to his public career: and upon the known temperament of Shakspeare, his genial disposition to enjoy life without disturbing his enjoyment by fretting anxieties, we build the conclusion, that had his friends furnished him with ampler funds, and had his marriage been well assorted or happy, we—the world of posterity—should have lost the whole benefit and delight which we have since reaped from his matchless faculties. The motives which drove him *from* Stratford are clear enough; but what motives determined his course *to* London, and especially to the stage, still remains to be explained. Stratford-upon-Avon, lying in the high road from London through Oxford to Birmingham (or more generally to the north), had been continually visited by some of the best comedians during Shakspeare's childhood. One or two of the most respectable metropolitan actors were natives of Stratford. These would be well known to the elder Shakspeare. But, apart from that accident, it is notorious that mere legal necessity and usage would compel all companies of actors, upon coming into any town, to seek, in the first place, from the chief magistrate, a license for opening a theatre, and next, over and above this public sanction, to seek his personal favour and patronage. As an alderman, therefore, but still more whilst clothed with the official powers of chief magistrate, the poet's father would have opportunities of doing essential services to many persons connected with the London stage. The conversation of comedians acquainted with books, fresh from the keen and sparkling circles of the metropolis, and filled with racy anecdotes of the court, as well as of public life generally, could not but have been fascinating by comparison with the stagnant society of Stratford. Hospitalities on a liberal scale would be offered to these men: not impossibly this fact might be one principal key to those dilapidations which the family estate had suffered. These actors, on *their* part, would retain a grateful sense of the kindness they had received, and would seek to repay it to John Shakspeare, now that he was depressed in his fortunes, as opportunities might offer. His eldest son, growing up a handsome young man, and beyond all doubt from his earliest days of most splendid colloquial powers (for assuredly of *him* it may be taken for granted,

Nec licuit populis parvum te, Nile, videre),

would be often reproached in a friendly way for burying himself in a country life. These overtures, prompted alike by gratitude to the father, and a real selfish interest in the talents of the son, would at length take a definite shape; and, upon some clear understanding as to the terms of such an arrangement, William Shakspeare would at length (about 1586, according to the received account, that is, in the fifth year of his married life, and the twenty-third or twenty-fourth of his age), unaccompanied by wife or children, translate himself to London. Later than 1586 it could not well be; for already in 1589 it has been recently ascertained that he held a share in the property of a leading theatre.

We must here stop to notice, and the reader will allow us to notice with summary indignation, the slanderous and idle tale which represents Shakspeare as having fled to London in the character of a criminal, from the persecutions of Sir Thomas Lucy of Charlecot. This tale has long been propagated under two separate impulses: chiefly, perhaps, under the vulgar love of pointed and glaring contrasts; the splendour of the man was in this instance brought into a sort of epigrammatic antithesis with the humility of his fortunes; secondly, under a baser impulse, the malicious pleasure of seeing a great man degraded. Accordingly, as in the case of Milton,[1] it has been affirmed that Shakspeare had suffered corporal chastisement, in fact (we abhor to utter such words), that he had been judicially whipped. Now, first of all, let us mark the inconsistency of this tale: the poet was whipped, that is, he was punished most disproportionately, and yet he fled to avoid punishment. Next, we are informed that his offence was deer-stealing, and from the park of Sir Thomas Lucy. And it has been well ascertained that Sir Thomas had no deer, and had no park. Moreover, deer-stealing was regarded by our ancestors exactly as poaching is regarded by us. Deer ran wild in all the great forests; and no offence was looked upon as so venial, none so compatible with a noble Robin-Hood style of character, as this very trespass upon what were regarded as *feræ naturæ*, and not at all as domestic property. But had it been otherwise, a trespass was not punishable with whipping; nor had Sir Thomas Lucy the power to irritate a whole community like Stratford-upon-Avon, by branding with permanent disgrace a young man so closely connected with three at least of the best families in the neighbourhood. Besides, had Shakspeare suffered any dishonour of that kind, the scandal would infallibly have pursued him at his very heels to Lon-

[1] In a little memoir of Milton, which the author of this article drew up some years ago for a public society, and which is printed in an abridged shape, he took occasion to remark, that Dr Johnson, who was meanly anxious to revive this slander against Milton, as well as some others, had supposed Milton himself to have this flagellation in his mind, and indirectly to confess it, in one of his Latin poems, where, speaking of Cambridge, and declaring that he has no longer any pleasure in the thoughts of revisiting that university, he says,

"Nec duri libet usque minas perferre magistri,
Cæteraque ingenio non subeunda meo."

This last line the malicious critic would translate—"And other things insufferable to a man of my temper." But, as we then observed, *ingenium* is properly expressive of the *intellectual* constitution, whilst it is the *moral* constitution that suffers degradation from personal chastisement—the sense of honour, of personal dignity, of justice, &c. *Indoles* is the proper term for this latter idea; and in using the word *ingenium*, there cannot be a doubt that Milton alluded to the dry scholastic disputations, which were shocking and odious to his fine poetical genius. If, therefore, the vile story is still to be kept up in order to dishonour a great man, at any rate let it not in future be pretended that any countenance to such a slander can be drawn from the confessions of the poet himself.

don; and in that case Greene, who has left on record, in a posthumous work of 1592, his malicious feelings towards Shakspeare, could not have failed to notice it. For, be it remembered, that a judicial flagellation contains a twofold ignominy: flagellation is ignominious in its own nature, even though unjustly inflicted, and by a ruffian; secondly, any judicial punishment is ignominious, even though not wearing a shade of personal degradation. Now a judicial flagellation includes both features of dishonour. And is it to be imagined that an enemy, searching with the diligence of malice for matter against Shakspeare, should have failed, six years after the event, to hear of that very memorable disgrace which had exiled him from Stratford, and was the very occasion of his first resorting to London; or that a leading company of players in the metropolis, *one of whom*, and a chief one, *was his own townsman*, should cheerfully adopt into their society, as an honoured partner, a young man yet flagrant from the lash of the executioner or the beadle?

This tale is fabulous, and rotten to its core; yet even this does less dishonour to Shakspeare's memory than the sequel attached to it. A sort of scurrilous rondeau, consisting of nine lines, so loathsome in its brutal stupidity, and so vulgar in its expression, that we shall not pollute our pages by transcribing it, has been imputed to Shakspeare ever since the days of the credulous Rowe. The total point of this idiot's drivel consists in calling Sir Thomas "an asse;" and well it justifies the poet's own remark, "Let there be gall enough in thy ink, no matter though thou write with a goose pen." Our own belief is, that these lines were a production of Charles II.'s reign, and applied to a Sir Thomas Lucy, not very far removed, if at all, from the age of him who first picked up the precious filth: the phrase "parliament *member*," we believe to be quite unknown in the colloquial use of Queen Elizabeth's reign.

But, that we may rid ourselves once and for ever of this outrageous calumny upon Shakspeare's memory, we shall pursue the story to its final stage. Even Malone has been thoughtless enough to accredit this closing chapter, which contains, in fact, such a superfetation of folly as the annals of human dulness do not exceed. Let us recapitulate the points of the story. A baronet, who has no deer and no park, is supposed to persecute a poet for stealing these aerial deer out of this aerial park, both lying in *nephelococcygia*. The poet sleeps upon this wrong for eighteen years; but at length, hearing that his persecutor is dead and buried, he conceives bloody thoughts of revenge. And this revenge he purposes to execute by picking a hole in his dead enemy's coat-of-arms. Is this coat-of-arms, then, Sir Thomas Lucy's? Why, no: Malone admits that it is not. For the poet, suddenly recollecting that this ridicule would settle upon the son of his enemy, selects another coat-of-arms, with which his dead enemy never had any connection, and he spends his thunder and lightning upon this irrelevant object; and, after all, the ridicule itself lies in a Welchman's mispronouncing one single heraldic term—a Welchman who mispronounces all words. The last act of the poet's malice recalls to us a sort of jest-book story of an Irishman, the vulgarity of which the reader will pardon in consideration of its relevancy. The Irishman having lost a pair of silk stockings, mentions to a friend that he has taken steps for recovering them by an advertisement, offering a reward to the finder. His friend objects that the costs of advertising, and the reward, would eat out the full value of the silk stockings. But to this the Irishman replies, with a knowing air, that he is not so green as to have overlooked *that;* and that, to keep down the reward, he had advertised the stockings as worsted. Not at all less flagrant is the bull ascribed to Shakspeare, when he is made to punish a dead man by personalities meant for his exclusive ear, through his coat-of-arms, but at the same time, with the express purpose of blunting and defeating the edge of his own scurrility, is made to substitute for the real arms some others which had no more relation to the dead enemy than they had to the poet himself. This is the very sublime of folly, beyond which human dotage cannot advance.

It is painful, indeed, and dishonourable to human nature, that whenever men of vulgar habits and of poor education wish to impress us with a feeling of respect for a man's talents, they are sure to cite, by way of evidence, some gross instance of malignity. Power, in their minds, is best illustrated by malice or by the infliction of pain. To this unwelcome fact we have some evidence in the wretched tale which we have just dismissed; and there is another of the same description to be found in all lives of Shakspeare, which we will expose to the contempt of the reader whilst we are in this field of discussion, that we may not afterwards have to resume so disgusting a subject.

This poet, who was a model of gracious benignity in his manners, and of whom, amidst our general ignorance, thus much is perfectly established, that the term *gentle* was almost as generally and by prescriptive right associated with his name as the affix of *venerable* with Bede, or *judicious* with Hooker, is alleged to have insulted a friend by an imaginary epitaph beginning "*Ten in the Hundred*," and supposing him to be damned, yet without wit enough (which surely the Stratford bellman could have furnished) for devising any, even fanciful, reason for such a supposition; upon which the comment of some foolish critic is, "The *sharpness of the satire* is said to have stung the man so much that he never forgave it." We have heard of the sting in the tail atoning for the brainless head; but in this doggerel the tail is surely as stingless as the head is brainless. For, 1*st*, *Ten in the Hundred* could be no reproach in Shakspeare's time, any more than to call a man *Three-and-a-half-per-cent.* in this present year 1838; except, indeed, amongst those foolish persons who built their morality upon the Jewish ceremonial law. Shakspeare himself took ten per cent. 2*dly*, It happens that John Combe, so far from being the object of the poet's scurrility, or viewing the poet as an object of implacable resentment, was a Stratford friend; that one of his family was affectionately remembered in Shakspeare's will by the bequest of his sword; and that John Combe himself recorded his perfect charity with Shakspeare by leaving him a legacy of L.5 sterling. And in this lies the key to the whole story. For, 3*dly*, the four lines were written and printed before Shakspeare was born. The name Combe is a common one; and some stupid fellow, who had seen the name in Shakspeare's will, and happened also to have seen the lines in a collection of epigrams, chose to connect the cases by attributing an identity to the two John Combes, though at war with chronology.

Finally, there is another specimen of doggerel attributed to Shakspeare, which is not equally unworthy of him, because not equally malignant, but otherwise equally below his intellect, no less than his scholarship; we mean the inscription on his grave-stone. This, as a sort of *siste viator* appeal to future sextons, is worthy of the grave-digger or the parish-clerk, who was probably its author. Or it may have been an antique formula, like the vulgar record of ownership in books—

Anthony Timothy Dolthead's book,
God give him grace therein to look.

Thus far the matter is of little importance; and it might have been supposed that malignity itself could hardly have imputed such trash to Shakspeare. But when we find, even in this short compass, scarcely wider than the posy of a ring, room found for traducing the poet's memory, it becomes important to say, that the leading sentiment, the

horror expressed at any disturbance offered to his bones, is not one to which Shakspeare could have attached the slightest weight; far less could have outraged the sanctities of place and subject, by affixing to any sentiment whatever (and, according to the fiction of the case, his farewell sentiment) the sanction of a curse.

Filial veneration and piety towards the memory of this great man have led us into a digression that might have been unseasonable in any cause less weighty than one having for its object to deliver his honoured name from a load of the most brutal malignity. Never more, we hope and venture to believe, will any thoughtless biographer impute to Shakspeare the asinine doggerel with which the uncritical blundering of his earliest biographer has caused his name to be dishonoured. We now resume the thread of our biography. The stream of history is centuries in working itself clear of any calumny with which it has once been polluted.

Most readers will be aware of an old story, according to which Shakspeare gained his livelihood for some time after coming to London by holding the horses of those who rode to the play. This legend is as idle as any one of those which we have just exposed. No custom ever existed of riding on horseback to the play. Gentlemen, who rode valuable horses, would assuredly not expose them systematically to the injury of standing exposed to cold for two or even four hours; and persons of inferior rank would not ride on horseback in the town. Besides, had such a custom ever existed, stables (or sheds at least) would soon have arisen to meet the public wants; and in some of the dramatic sketches of the day, which noticed every fashion as it arose, this would not have been overlooked. The story is traced originally to Sir William Davenant. Betterton the actor, who professed to have received it from him, passed it onwards to Rowe, he to Pope, Pope to Bishop Newton the editor of Milton, and Newton to Dr Johnson. This pedigree of the fable, however, adds nothing to its credit, and multiplies the chances of some mistake. Another fable, not much less absurd, represents Shakspeare as having from the very first been borne upon the establishment of the theatre, and so far contradicts the other fable, but originally in the very humble character of *call-boy* or deputy prompter, whose business it was to summon each performer according to his order of coming upon the stage. This story, however, quite as much as the other, is irreconcileable with the discovery recently made by Mr Collier, that in 1589 Shakspeare was a shareholder in the important property of a principal London theatre. It seems destined that all the undoubted facts of Shakspeare's life should come to us through the channel of legal documents, which are better evidence even than imperial medals; whilst, on the other hand, all the fabulous anecdotes, not having an attorney's seal to them, seem to have been the fictions of the wonder-maker. The plain presumption from the record of Shakspeare's situation in 1589, coupled with the fact that his first arrival in London was possibly not until 1587, but according to the earliest account not before 1586, a space of time which leaves but little room for any remarkable changes of situation, seems to be, that, either in requital of services done to the players by the poet's family, or in consideration of money advanced by his father-in-law, or on account of Shakspeare's personal accomplishments as an actor, and as an adapter of dramatic works to the stage; for one of these reasons, or for all of them united, William Shakspeare, about the 23d year of his age, was adopted into the partnership of a respectable histrionic company, possessing a first-rate theatre in the metropolis. If 1586 were the year in which he came up to London, it seems probable enough that his immediate motive to that step was the increasing distress of his father; for in that year John Shakspeare resigned the office of alderman. There is, however, a bare possibility that Shakspeare might have gone to London about the time when he completed his twenty-first year, that is, in the spring of 1585, but not earlier. Nearly two years after the birth of his eldest daughter Susanna, his wife lay in for a second and a *last* time; but she then brought her husband twins, a son and a daughter. These children were baptized in February of the year 1585; so that Shakspeare's whole family of three children were born and baptized two months before he completed his majority. The twins were baptized by the names of Hamnet and Judith, those being the names of two amongst their sponsors, viz. Mr Sadler and his wife. Hamnet, which is a remarkable name in itself, becomes still more so from its resemblance to the immortal name of Hamlet[1] the Dane; it was, however, the real baptismal name of Mr Sadler, a friend of Shakspeare's, about fourteen years older than himself. Shakspeare's son must then have been most interesting to his heart, both as a twin child and as his only boy. He died in 1596, when he was about eleven years old. Both daughters survived their father; both married; both left issue, and thus gave a chance for continuing the succession from the great poet. But all the four grandchildren died without offspring.

Of Shakspeare personally, at least of Shakspeare the man, as distinguished from the author, there remains little more to record. Already in 1592, Greene, in his posthumous Groat's-worth of Wit, had expressed the earliest vocation of Shakspeare in the following sentence:—"There is an upstart crow, beautified with our feathers; in his own conceit the only *Shakscene* in a country!" This alludes to Shakspeare's office of re-casting, and even re-composing, dramatic works, so as to fit them for representation; and Master Greene, it is probable, had suffered in his self-estimation, or in his purse, by the alterations in some piece of his own which the duty of Shakspeare to the general interests of the theatre had obliged him to make. In 1591 it has been supposed that Shakspeare wrote his first drama, the Two Gentlemen of Verona; the least characteristically marked of all his plays, and, with the exception of Love's Labour's Lost, the least interesting.

From this year, 1591 to that of 1611, are just twenty years, within which space lie the whole dramatic creations of Shakspeare, averaging nearly one for every six months. In 1611 was written the Tempest, which is supposed to have been the last of all Shakspeare's works. Even on that account, as Mr Campbell feelingly observes, it has "a sort of sacredness;" and it is a most remarkable fact, and one calculated to make a man superstitious, that in this play the great enchanter Prospero, in whom, "*as if conscious*," says Mr Campbell, "*that this would be his last work*, the poet has been *inspired to typify himself as* a wise, potent, and *benevolent magician*," of whom, indeed, as of Shakspeare himself, it may be said, that "within that circle" (the circle of his own art) "none durst tread but he," solemnly and for ever renounces his mysterious functions, symbolically breaks his enchanter's wand, and declares that he will bury his books, his science, and his secrets

Deeper than did ever plummet sound.

Nay, it is even ominous, that in this play, and from the

[1] And singular enough it is, as well as interesting, that Shakspeare had so entirely superseded to his own ear and memory the name Hamnet by the dramatic name of Hamlet, that in writing his will, he actually mis-spells the name of his friend Sadler, and calls him Hamlet. His son, however, who should have familiarized the true name to his ear, had then been dead for twenty years.

Shakspeare. voice of Prospero, issues that magnificent prophecy of the total destruction which should one day swallow up

> The solemn temples, the great globe itself,
> Yea all which it inherit.

And this prophecy is followed immediately by a most profound ejaculation, gathering into one pathetic abstraction the total philosophy of life:

> We are such stuff
> As dreams are made of; and our little life
> Is rounded by a sleep;

that is, in effect, our life is a little tract of feverish vigils, surrounded and islanded by a shoreless ocean of sleep—sleep before birth, sleep after death.

These remarkable passages were probably not undesigned; but if we suppose them to have been thrown off without conscious notice of their tendencies, then, according to the superstition of the ancient Grecians, they would have been regarded as prefiguring words, prompted by the secret genius that accompanies every man, such as insure along with them their own accomplishment. With or without intention, however, it is believed that Shakspeare wrote nothing more after this exquisite romantic drama. With respect to the remainder of his personal history, Dr Drake and others have supposed, that during the twenty years from 1591 to 1611, he visited Stratford often, and latterly once a year.

In 1589 he had possessed some share in a theatre; in 1596 he had a considerable share. Through Lord Southampton, as a surviving friend of Lord Essex, who was viewed as the martyr to his Scottish politics, there can be no doubt that Shakspeare had acquired the favour of James I.; and accordingly, on the 29th of May 1603, about two months after the king's accession to the throne of England, a patent was granted to the company of players who possessed the Globe theatre; in which patent Shakspeare's name stands second. This patent raised the company to the rank of his majesty's servants, whereas previously they are supposed to have been simply the servants of the Lord Chamberlain. Perhaps it was in grateful acknowledgment of this royal favour that Shakspeare afterwards, in 1606, paid that sublime compliment to the house of Stuart which is involved in the vision shown to Macbeth. This vision is managed with exquisite skill: it was impossible to display the whole series of princes from Macbeth to James I.; but he beholds the posterity of Banquo, one "gold-bound brow" succeeding to another, until he comes to an eighth apparition of a Scottish king,

> Who bears a glass
> Which shows him many more; and some he sees
> Who *twofold* balls and *treble* sceptres carry;

thus bringing down without tedium the long succession to the very person of James I. by the symbolic image of the two crowns united on one head.

About the beginning of the century Shakspeare had become rich enough to purchase the best house in Stratford, called *The Great House*, which name he altered to *New Place;* and in 1602 he bought 107 acres adjacent to this house for a sum (L.320) corresponding to about 1500 guineas of modern money. Malone thinks that he purchased the house as early as 1597; and it is certain that about that time he was able to assist his father in obtaining a renewed grant of arms from the Heralds' College, and therefore, of course, to re-establish his father's fortunes. Ten years of well-directed industry, viz. from 1591 to 1601, and the prosperity of the theatre in which he was a proprietor, had raised him to affluence; and after another ten years, improved with the same success, he was able to retire with an income of L.300, or (according to the customary computations) in modern money of L.1500, per annum. Shakspeare was in fact the first man of letters, Pope the second, and Sir Walter Scott the third, who, in Great Britain, has ever realized a large fortune by literature; or in Christendom, if we except Voltaire, and two dubious cases in Italy. The four or five latter years of his life Shakspeare passed in dignified ease, in profound meditation, we may be sure, and in universal respect, at his native town of Stratford; and there he died, on the 23d of April 1616.[1]

His daughter Susanna had been married on the 5th of June of the year 1607, to Dr John Hall,[2] a physician in Stratford. The doctor died in November 1635, aged sixty; his wife, at the age of sixty-six, on July 11, 1640. They had one child, a daughter, named Elizabeth, born in 1608, married April 22, 1626, to Thomas Nashe, Esq. left a widow in 1647, and subsequently remarried to Sir John Barnard; but this Lady Barnard, the sole grand-daughter of the poet, had no children by either marriage. The other daughter Judith, on February 10, 1616 (about ten weeks before her father's death) married Mr Thomas Quiney of Stratford, by whom she had three sons, Shakspeare, Richard, and Thomas. Judith was about thirty-one years old at the time of her marriage; and living just forty-six years afterwards, she died in February 1662, at the age of seventy-seven. Her three sons died without issue; and thus, in the direct lineal descent, it is certain that no representative has survived of this transcendent poet, the most august amongst created intellects.

After this review of Shakspeare's life, it becomes our duty to take a summary survey of his works, of his intellectual powers, and of his station in literature, a station which is now irrevocably settled, not so much (which happens in other cases) by a vast overbalance of favourable suffrages, as by acclamation; not so much by the *voices* of those who admire him up to the verge of idolatry, as by the *acts* of those who everywhere seek for his works among the primal necessities of life, demand them, and crave them as they do their daily bread; not so much by eulogy openly proclaiming itself, as by the silent homage recorded in the endless multiplication of what he has bequeathed us; not so much by his own compatriots, who, with regard to almost every other author,[3] compose the total amount of his

[1] "I have heard that Mr Shakspeare was a natural wit, without any art at all. Hee frequented the plays all his younger time, but in his elder days lived at Startford, and supplied the stage with two plays every year, and for itt had an allowance so large, that he spent at the rate of 1,000*l.* a-year, as I have heard. Shakespeare, Drayton, and Ben Jonson, had a merie meeting, and it seems drank too hard, for Shakespear died of a feavour there contracted." (Diary of the Rev. John Ward, A. M. Vicar of Stratford-upon-Avon, extending from 1648 to 1679, p. 183. Lond. 1839, 8vo.)

[2] It is naturally to be supposed that Dr Hall would attend the sick-bed of his father-in-law; and the discovery of this gentleman's medical diary promised some gratification to our curiosity as to the cause of Shakspeare's death. Unfortunately, it does not commence until the year 1617.

[3] An exception ought perhaps to be made for Sir Walter Scott and for Cervantes; but with regard to all other writers, Dante, suppose, or Ariosto amongst Italians, Camoens amongst those of Portugal, Schiller amongst Germans, however ably they may have been naturalized in foreign languages, as all of those here mentioned (excepting only Ariosto) have in one part of their works been most powerfully naturalized in English, it still remains true (and the very sale of the books is proof sufficient) that an alien author never does take root in the general sympathies out of his own country; he takes his station in libraries, he is read by the man of learned leisure, he is known and valued by the refined and the elegant, but he is not (what Shakspeare is for Germany and America in any proper sense a *popular* favourite.

effective audience, as by the unanimous "all hail!" of intellectual Christendom; finally, not by the hasty partisanship of his own generation, nor by the biassed judgment of an age trained in the same modes of feeling and of thinking with himself, but by the solemn award of generation succeeding to generation, of one age correcting the obliquities or peculiarities of another; by the verdict of two hundred and thirty years, which have now elapsed since the very *latest* of his creations, or of two hundred and forty-seven years if we date from the earliest; a verdict which has been continually revived and re-opened, probed, searched, vexed, by criticism in every spirit, from the most genial and intelligent, down to the most malignant and scurrilously hostile which feeble heads and great ignorance could suggest when co-operating with impure hearts and narrow sensibilities; a verdict, in short, sustained and countersigned by a longer series of writers, many of them eminent for wit or learning, than were ever before congregated upon any inquest relating to any author, be he who he might, ancient[1] or modern, Pagan or Christian. It was a most witty saying with respect to a piratical and knavish publisher, who made a trade of insulting the memories of deceased authors by forged writings, that he was "among the new terrors of death." But in the gravest sense it may be affirmed of Shakspeare, that he is among the modern luxuries of life; that life, in fact, is a new thing, and one more to be coveted, since Shakspeare has extended the domains of human consciousness, and pushed its dark frontiers into regions not so much as dimly descried or even suspected before his time, far less illuminated (as now they are) by beauty and tropical luxuriance of life. For instance,—a single instance, indeed one which in itself is a world of new revelation,—the possible beauty of the female character had not been seen as in a dream before Shakspeare called into perfect life the radiant shapes of Desdemona, of Imogene, of Hermione, of Perdita, of Ophelia, of Miranda, and many others. The Una of Spenser, earlier by ten or fifteen years than most of these, was an idealized portrait of female innocence and virgin purity, but too shadowy and unreal for a dramatic reality. And as to the Grecian classics, let not the reader imagine for an instant that any prototype in this field of Shakspearian power can be looked for there. The *Antigone* and the *Electra* of the tragic poets are the two leading female characters that classical antiquity offers to our respect, but assuredly not to our impassioned love, as disciplined and exalted in the school of Shakspeare. They challenge our admiration, severe, and even stern, as impersonations of filial duty, cleaving to the steps of a desolate and afflicted old man; or of sisterly affection, maintaining the rights of a brother under circumstances of peril, of desertion, and consequently of perfect self-reliance. Iphigenia, again, though not dramatically coming before us in her own person, but according to the beautiful report of a spectator, presents us with a fine statuesque model of heroic fortitude, and of one whose young heart, even in the very agonies of her cruel immolation, refused to forget, by a single indecorous gesture, or so much as a moment's neglect of her own princely descent, and that she herself was "a lady in the land." These are fine marble groups, but they are not the warm breathing realities of Shakspeare; there is "no speculation" in their cold marble eyes; the breath of life is not in their nostrils; the fine pulses of womanly sensibilities are not throbbing in their bosoms. And besides this immeasurable difference between the cold moony reflexes of life, as exhibited by the power of Grecian art, and the true sunny life of Shakspeare, it must be observed that the Antigones, &c. of the antique put forward but one single trait of character, like the aloe with its single blossom: this solitary feature is presented to us as an abstraction, and as an insulated quality; whereas in Shakspeare all is presented in the *concrete;* that is to say, not brought forward in relief, as by some effort of an anatomical artist; but embodied and imbedded, so to speak, as by the force of a creative nature, in the complex system of a human life; a life in which all the elements move and play simultaneously, and with something more than mere simultaneity or co-existence, acting and re-acting each upon the other, nay, even acting by each other and through each other. In Shakspeare's characters is felt for ever a real *organic* life, where each is for the whole and in the whole, and where the whole is for each and in each. They only are real incarnations.

The Greek poets could not exhibit any approximations to *female* character, without violating the truth of Grecian life, and shocking the feelings of the audience. The drama with the Greeks, as with us, though much less than with us, was a picture of human life; and that which could not occur in life could not wisely be exhibited on the stage. Now, in ancient Greece, women were secluded from the society of men. The conventual sequestration of the γυναικωνῖτις, or female apartment[2] of the house, and the Mahommedan consecration of its threshold against the ingress of males, had been transplanted from Asia into Greece thousands of years perhaps before either convents or Mahommed existed. Thus barred from all open social intercourse, women could not develope or express any character by word or action. Even to *have* a character, violated, to a Grecian mind, the ideal portrait of feminine excellence; whence, perhaps, partly the too generic, too little individualized, style of Grecian beauty. But prominently to *express* a character was impossible under the common tenor of Grecian life, unless when high tragical catastrophes transcended the decorums of that tenor, or for a brief interval raised the curtain which veiled it. Hence the subordinate part which women play upon the Greek stage in all but some half dozen cases. In the paramount tragedy on that stage, the model tragedy, the *Œdipus Tyrannus* of Sophocles, there is virtually no woman at all; for Jocasta is a party to the story merely as the dead Laius or the self-murdered Sphinx was a party, viz. by her contributions to the fatalities of the event, not by any thing she does or says spontaneously. In fact, the

[1] It will occur to many readers, that perhaps Homer may furnish the sole exception to this sweeping assertion: any *but* Homer is clearly and ludicrously below the level of the competition; but even Homer, "with his tail on" (as the Scottish Highlanders say of their chieftains when belted by their ceremonial retinues), musters nothing like the force which *already* follows Shakspeare; and be it remembered, that Homer sleeps and has long slept as a subject of criticism or commentary, while in Germany as well as England, and *now even in France*, the gathering of wits to the vast equipage of Shakspeare is advancing in an accelerated ratio. There is, in fact, a great delusion current upon this subject. Innumerable references to Homer, and brief critical remarks on this or that pretension of Homer, this or that scene, this or that passage, lie scattered over literature ancient and modern; but the express works dedicated to the separate service of Homer are, after all, not many. In Greek we have only the large Commentary of Eustathius, and the Scholia of Didymus, &c.; in French little or nothing before the prose translation of the seventeenth century, which Pope esteemed "elegant," and the skirmishings of Madame Dacier, La Motte, &c.; in English, besides the various translations and their prefaces (which, by the way, began as early as 1555), nothing of much importance until the elaborate preface of Pope to the Iliad, and his elaborate postscript to the Odyssey—nothing certainly before that, and very little indeed since that, except Wood's Essay on the Life and Genius of Homer. On the other hand, of the books written in illustration or investigation of Shakspeare, a very considerable library might be formed in England, and another in Germany.

[2] Apartment is here used, as the reader will observe, in its true and continental acceptation, as a division or *compartment* of a house including many rooms; a suite of chambers, but a suite which is partitioned off (as in palaces), not a single chamber; a sense so commonly and so erroneously given to this word in England.

Shakspeare.

Greek poet, if a wise poet, could not address himself genially to a task in which he must begin by shocking the sensibilities of his countrymen. And hence followed, not only the dearth of female characters in the Grecian drama, but also a second result still more favourable to the sense of a new power evolved by Shakspeare. Whenever the common law of Grecian life did give way, it was, as we have observed, to the suspending force of some great convulsion or tragical catastrophe. This for a moment (like an earthquake in a nunnery) would set at liberty even the timid, fluttering Grecian women, those doves of the dove-cot, and would call some of them into action. But which? Precisely those of energetic and masculine minds; the timid and feminine would but shrink the more from public gaze and from tumult. Thus it happened, that such female characters as *were* exhibited in Greece, could not but be the harsh and the severe. If a gentle Ismene appeared for a moment in contest with some energetic sister Antigone (and chiefly, perhaps, by way of drawing out the fiercer character of that sister), she was soon dismissed as unfit for scenical effect. So that not only were female characters few, but, moreover, of these few the majority were but repetitions of masculine qualities in female persons. Female agency being seldom summoned on the stage except when it had received a sort of special dispensation from its sexual character, by some terrific convulsions of the house or the city, naturally it assumed the style of action suited to these circumstances. And hence it arose, that not woman as she differed from man, but woman as she resembled man—woman, in short, seen under circumstances so dreadful as to abolish the effect of sexual distinction, was the woman of the Greek tragedy.[1] And hence generally arose for Shakspeare the wider field, and the more astonishing by its perfect novelty, when he first introduced female characters, not as mere varieties or echoes of masculine characters, a Medea or Clytemnestra, or a vindictive Hecuba, the mere tigress of the tragic tiger, but female characters that had the appropriate beauty of female nature; woman no longer grand, terrific, and repulsive, but woman "after her kind"—the other hemisphere of the dramatic world; woman running through the vast gamut of womanly loveliness; woman as emancipated, exalted, ennobled, under a new law of Christian morality; woman the sister and co-equal of man, no longer his slave, his prisoner, and sometimes his rebel. "It is a far cry to Loch Awe;" and from the Athenian stage to the stage of Shakspeare, it may be said, is a prodigious interval. True; but prodigious as it is, there is really nothing between them. The Roman stage, at least the tragic stage, as is well known, was put out, as by an extinguisher, by the cruel amphitheatre, just as a candle is made pale and ridiculous by daylight. Those who were fresh from the real murders of the bloody amphitheatre regarded with contempt the mimic murders of the stage. Stimulation too coarse and too intense had its usual effect in making the sensibilities callous. Christian emperors arose at length, who abolished the amphitheatre in its bloodier features. But by that time the genius of the tragic muse had long slept the sleep of death. And that muse had no resurrection until the age of Shakspeare. So that, notwithstanding a gulf of nineteen centuries and upwards separates Shakspeare from Euripides, the last of the surviving Greek tragedians, the one is still the nearest successor of the other, just as Connaught and the islands in Clew Bay are next neighbours to America, although three thousand watery columns, each of a cubic mile in dimensions, divide them from each other.

A second reason, which lends an emphasis of novelty and effective power to Shakspeare's female world, is a peculiar fact of contrast which exists between that and his corresponding world of men. Let us explain. The purpose and the intention of the Grecian stage was not primarily to develope human *character*, whether in men or in women; human *fates* were its object; great tragic situations under the mighty control of a vast cloudy destiny, dimly descried at intervals, and brooding over human life by mysterious agencies, and for mysterious ends. Man, no longer the representative of an august *will*, man the passion-puppet of fate, could not with any effect display what we call a character, which is a distinction between man and man, emanating originally from the will, and expressing its determinations, moving under the large variety of human impulses. The will is the central pivot of character; and this was obliterated, thwarted, cancelled, by the dark fatalism which brooded over the Grecian stage. That explanation will sufficiently clear up the reason why marked or complex variety of character was slighted by the great principles of the Greek tragedy. And every scholar who has studied that grand drama of Greece with feeling,—that drama, so magnificent, so regal, so stately,—and who has thoughtfully investigated its principles, and its difference from the English drama, will acknowledge that powerful and elaborate character, character, for instance, that could employ the fiftieth part of that profound analysis which has been applied to Hamlet, to Falstaff, to Lear, to Othello, and applied by Mrs Jamieson so admirably to the full development of the Shakspearian heroines, would have been as much wasted, nay, would have been defeated, and interrupted the blind agencies of fate, just in the same way as it would injure the shadowy grandeur of a ghost to individualize it too much. Milton's angels are slightly touched, superficially touched, with differences of character; but they are such differences, so simple and general, as are just sufficient to rescue them from the reproach applied to Virgil's "*fortemque Gyan, fortemque Cloanthem;*" just sufficient to make them knowable apart. Pliny speaks of painters who painted in one or two colours; and, as respects the angelic characters, Milton does so; he is *monochromatic.* So, and for reasons resting upon the same ultimate philosophy, were the mighty architects of the Greek tragedy. They also were monochromatic; they also, as to the characters of their persons, painted in one colour. And so far there might have been the same novelty in Shakspeare's men as in his women. There *might* have been; but the reason why there is *not*, must be sought in the fact, that History, the muse of History, had there even been no such muse as Melpomene, would have forced us into an acquaintance with human character. History, as the representative of actual life, of real man, gives us powerful delineations of character in its chief agents, that is, in men; and therefore it is that Shakspeare, the absolute creator of female character, was but the mightiest of all painters with regard to male character. Take a single instance. The Antony of Shakspeare, immortal for its execution, is found, after all, as regards the primary conception, in history: Shakspeare's delineation is but the expansion of the germ already pre-existing, by way of scattered fragments, in Cicero's Philippics, in Cicero's Letters, in Appian, &c. But Cleopatra, equally fine, is a pure creation of art: the situation and the scenic circumstances belong to history, but the character belongs to Shakspeare.

In the great world therefore of woman, as the interpreter of the shifting phases and the lunar varieties of that

[1] And hence, by parity of reason, under the opposite circumstances, under the circumstances which, instead of abolishing, most emphatically drew forth the sexual distinctions, viz. in the *comic* aspects of social intercourse, the reason that we see no women on the Greek stage; the Greek comedy, unless when it affects the extravagant fun of farce, rejects women.

mighty changeable planet, that lovely satellite of man, Shakspeare stands not the first only, not the original only, but is yet the sole authentic oracle of truth. Woman, therefore, the beauty of the female mind, *this* is one great field of his power. The supernatural world, the world of apparitions, *that* is another: for reasons which it would be easy to give, reasons emanating from the gross mythology of the ancients, no Grecian,[1] no Roman, could have conceived a ghost. That shadowy conception, the protesting apparition, the awful projection of the human conscience, belongs to the Christian mind: and in all Christendom, who, let us ask, who, who but Shakspeare has found the power for effectually working this mysterious mode of being? In summoning back to earth "the majesty of buried Denmark," how like an awful necromancer does Shakspeare appear! All the pomps and grandeurs which religion, which the grave, which the popular superstition had gathered about the subject of apparitions, are here converted to his purpose, and bend to one awful effect. The wormy grave brought into antagonism with the scenting of the early dawn; the trumpet of resurrection suggested, and again as an antagonist idea to the crowing of the cock (a bird ennobled in the Christian mythus by the part he is made to play at the Crucifixion); its starting "as a guilty thing" placed in opposition to its majestic expression of offended dignity when struck at by the partisans of the sentinels; its awful allusions to the secrets of its prison-house; its ubiquity, contrasted with its local presence; its aerial substance, yet clothed in palpable armour; the heart-shaking solemnity of its language, and the appropriate scenery of its haunt, viz. the ramparts of a capital fortress, with no witnesses but a few gentlemen mounting guard at the dead of night,—what a mist, what a *mirage* of vapour, is here accumulated, through which the dreadful being in the centre looms upon us in far larger proportions than could have happened had it been insulated and left naked of this circumstantial pomp! In the *Tempest*, again, what new modes of life, preternatural, yet far as the poles from the spiritualities of religion. Ariel in antithesis to Caliban! What is most ethereal to what is most animal! A phantom of air, an abstraction of the dawn and of vesper sun-lights, a bodiless sylph on the one hand; on the other a gross carnal monster, like the Miltonic Asmodai, "the fleshliest incubus" among the fiends, and yet so far ennobled into interest by his intellectual power, and by the grandeur of misanthropy![2] In the *Midsummer-Night's Dream*, again, we have the old traditional fairy, a lovely mode of preternatural life, remodified by Shakspeare's eternal talisman. Oberon and Titania remind us at first glance of Ariel: they approach, but how far they recede: they are like—"like, but, oh, how different!" And in no other exhibition of this dreamy population of the moonlight forests and forest-lawns, are the circumstantial proprieties of fairy life so exquisitely imagined, sustained, or expressed. The dialogue between Oberon and Titania is, of itself, and taken separately from its connection, one of the most delightful poetic scenes that literature affords. The witches in Macbeth are another variety of supernatural life, in which Shakspeare's power to enchant and to disenchant are alike portentous. The circumstances of the blasted heath, the army at a distance, the withered attire of the mysterious hags, and the choral litanics of their fiendish Sabbath, are as finely imagined in their kind as those which herald and which surround the ghost in Hamlet. There we see the *positive* of Shakspeare's superior power But now turn and look to the *negative*. At a time when the trials of witches, the royal book on demonology, and popular superstition (all so far useful, as they prepared a basis of undoubting faith for the poet's serious use of such agencies) had degraded and polluted the ideas of these mysterious beings by many mean associations, Shakspeare does not fear to employ them in high tragedy (a tragedy moreover which, though not the very greatest of his efforts as an intellectual whole, nor as a struggle of passion, is *among* the greatest in any view, and positively *the* greatest for scenical grandeur, and in that respect makes the nearest approach of all English tragedies to the Grecian model); he does not fear to introduce, for the same appalling effect as that for which Æschylus introduced the Eumenides, a triad of old women, concerning whom an English wit has remarked this grotesque peculiarity in the popular creed of that day,—that although potent over winds and storms, in league with powers of darkness, they yet stood in awe of the constable,—yet relying on his own supreme power to disenchant as well as to enchant, to create and to uncreate, he mixes these women and their dark machineries with the power of armies, with the agencies of kings, and the fortunes of martial kingdoms. Such was the sovereignty of this poet, so mighty its compass!

A third fund of Shakspeare's peculiar power lies in his teeming fertility of fine thoughts and sentiments. From his works alone might be gathered a golden bead-roll of thoughts the deepest, subtilest, most pathetic, and yet most catholic and universally intelligible; the most characteristic, also, and appropriate to the particular person, the situation, and the case, yet, at the same time, applicable to the circumstances of every human being, under all the accidents of life, and all vicissitudes of fortune. But this subject offers so vast a field of observation, it being so eminently the prerogative of Shakspeare to have thought more finely and more extensively than all other poets combined, that we cannot wrong the dignity of such a theme by doing more, in our narrow limits, than simply noticing it as one of the emblazonries upon Shakspeare's shield.

Fourthly, we shall indicate (and, as in the last case, *barely* indicate, without attempting in so vast a field to offer any inadequate illustrations) one mode of Shakspeare's dramatic excellence which hitherto has not attracted any special or separate notice. We allude to the forms of life, and natural human passion, as apparent in the structure of his dialogue. Among the many defects and infirmities of the

[1] It may be thought, however, by some readers, that Æschylus, in his fine phantom of Darius, has approached the English ghost. As a foreign ghost, we would wish (and we are sure that our excellent readers would wish) to show every courtesy and attention to this apparition of Darius. It has the advantage of being royal, an advantage which it shares with the ghost of the royal Dane. Yet how different, how removed by a total world, from that or any of Shakspeare's ghosts! Take that of Banquo, for instance: how shadowy, how unreal, yet how real! Darius is a mere state ghost—a diplomatic ghost. But Banquo—he exists only for Macbeth; the guests do not see him, yet how solemn, how real, how heart-searching he is.

[2] Caliban has not yet been thoroughly fathomed. For all Shakspeare's great creations are like works of nature, subjects of unexhaustible study. It was this character of whom Charles I. and some of his ministers expressed such fervent admiration; and, among other circumstances, most justly they admired the new language almost with which he is endowed, for the purpose of expressing his fiendish and yet carnal thoughts of hatred to his master. Caliban is evidently not meant for scorn, but for abomination mixed with fear and partial respect. He is purposely brought into contrast with the drunken Trinculo and Stephano, with an advantageous result. He is much more intellectual than either, uses a more elevated language, not disfigured by vulgarisms, and is not liable to the low passion for plunder as they are. He is mortal, doubtless, as his "dam" (for Shakspeare will not call her mother) Sycorax. But he inherits from her such qualities of power as a witch could be supposed to bequeath. He trembles indeed before Prospero; but that is, as we are to understand, through the moral superiority of Prospero in Christian wisdom; for when he finds himself in the presence of dissolute and unprincipled men, he rises at once into the dignity of intellectual power.

Shakspeare. French and of the Italian drama, indeed we may say of the Greek, the dialogue proceeds always by independent speeches, replying indeed to each other, but never modified in its several openings by the momentary effect of its several terminal forms immediately preceding. Now, in Shakspeare, who first set an example of that most important innovation, in all his impassioned dialogues, each reply or rejoinder seems the mere rebound of the previous speech. Every form of natural interruption, breaking through the restraints of ceremony under the impulses of tempestuous passion; every form of hasty interrogative, ardent reiteration when a question has been evaded; every form of scornful repetition of the hostile words; every impatient continuation of the hostile statement; in short, all modes and formulæ by which anger, hurry, fretfulness, scorn, impatience, or excitement under any movement whatever, can disturb or modify or dislocate the formal bookish style of commencement,—these are as rife in Shakespeare's dialogue as in life itself; and how much vivacity, how profound a verisimilitude, they add to the scenic effect as an imitation of human passion and real life, we need not say. A volume might be written illustrating the vast varieties of Shakspeare's art and power in this one field of improvement; another volume might be dedicated to the exposure of the lifeless and unnatural result from the opposite practice in the foreign stages of France and Italy. And we may truly say, that were Shakspeare distinguished from them by this single feature of nature and propriety, he would on that account alone have merited a great immortality. (T. DE Q.)

[Since this essay on Shakspeare was written, the unwearied research of literary antiquaries, and the national idolatry of our great poet, have established a few additional facts. It seems to be proved, that by the paternal as well as the maternal side, Shakspeare sprung from a race of substantial yeomen (in the female branch, shading into the class of rural gentry), who were long resident at Snitterfield, about three miles from Stratford-on-Avon. His grandfather, Richard Shakspeare, occupied lands belonging to Robert Arden of Wilmecote. Richard Shakspeare had three sons, two of whom lived and died apparently as farmers, at Snitterfield. The other son, the poet's father, settled in Stratford, carrying on business as a glover, but afterwards engaging in the cultivation of land and other occupations. His acquaintance with the Arden family, from whom his father held lands, and on whose estate he was himself born, is easily accounted for; and he succeeded in obtaining the hand of Mary Arden, the seventh daughter of his father's landlord, the rural squire of Snitterfield. This lady inherited, under her father's will, the estate of Asbies, already described, with a sum of L.6, 13s. 4d, and an interest in two tenements in Snitterfield, which, when he fell into difficulties, John Shakspeare disposed of for L.4. The pedigree of the poet thus connects him, as Mr Halliwell remarks, with "the inhabitants of the valley and woodland;" and he carried in his blood the impress of the healthiest and most virtuous class in England. It need form no deduction from this estimate, that the poet's parents could not sign their names. Existing documents bear the marks of both John and Mary Shakspeare, and most of the rural middle class at this time were equally illiterate.

With respect to Shakspeare's marriage-bond, which has been considered to indicate haste and secrecy unfavourable to the reputation of Anne Hathaway, it appears that betrothment or contract of marriage generally preceded actual marriage; and was held to be as sacred and binding. The bond is of the usual tenor common at the time; and the Stratford register shows many cases in which the first child was baptized a few months after the entry of the parents' marriage, without subjecting the parties to the stigma of illegitimacy which, when it occurred, was always carefully noted in the register. The two bondsmen, Sandells and Richardson, were respectable yeomen of Shottery; and as one of the seals bears the initials "R. H.," the bride's father, Richard Hathaway, was most likely present at the ceremony. The Hathaways and John Shakspeare were early acquainted.

Malone conceived that he had completely demolished the tradition of Shakspeare's deer-stealing exploit, by showing that Sir Thomas Lucy had no park at Charlecote, but the *Egerton Papers*, published in 1840, show that Sir Thomas had deer if he had no park; for in 1602 he contributed a buck towards the entertainment of Queen Elizabeth at Harefield, and he is not likely to have purchased a buck for this purpose. The royal visit to Harefield, too, establishes another Shakspearian fact. On this occasion, a sum of L.64, 18s. 10d. was distributed among the "vaulters, players, and dancers," whom Lord Chancellor Egerton had engaged to perform before the Queen, and of this *honorarium* ten pounds were given "to Burbage's players for *Othello*." This fixes the date of *Othello* two years before the earliest date previously assigned to its production. Let us note, that in this classic mansion of Harefield, the "Arcades" of Milton, part of a masque, was subsequently performed, being written for representation by the children of the Earl of Bridgewater. Malone was happy in his conjecture that Shakspeare had purchased his Stratford house, New Place, in 1597. Mr Halliwell ascertained (1848) from the record of the fine levied on the sale, preserved in the Chapter House, Westminster, that the purchase was made at the Easter term 1597, the sum given for the messuage, barns, and garden being L.60—about L.300 of our present money. In 1602, the poet bought another property from the same individual for L.60, besides purchasing in the same year the lands of Old Stratford, for which he paid L.320; and in 1605, he made his largest purchase, giving L.440 for the unexpired term of a lease of certain tithes. These repeated investments attest not only Shakspeare's growing wealth, but his attachment to his native district—a district now, for his sake, classic and hallowed ground.

The question whether Shakspeare was a Roman Catholic has been raised. We hold that no Roman Catholic could have written parts of *King John*, *Henry VIII.*, and other dramas of Shakspeare. The old faith, however, probably held sway in the sequestered hamlet of Snitterfield. In 1844, a document was discovered in the State Paper Office, by which it appears that the poet's father, in 1592, was returned as one of the recusants who "had been heretofore presented for not coming monthly to the church, according to her Majesty's laws." The officer who makes the return reports, that John Shakspeare, and eight other men in Stratford (two of them bearing the well-known names of Fluellen and Bardolph), abstained from coming to church for "fear of process of debt." This plea is scarcely available, as John Shakspeare is found at the sametime going about on ordinary business, and four years afterwards he applied at the Herald's Office for a coat of arms, at the instigation, no doubt, of his son the poet. Whether a process for debt could then be served on Sunday is not mentioned, but we would rather attribute John Shakspeare's continued absence from church to some lingering attachment to the Papal faith, which must have been the religion of his youth. As alderman of Stratford, however, he would, in his busy days, have taken the oath then required from all functionaries. The poet's family were undoubtedly Protestants. They ultimately manifested a Puritanical devotion or seriousness; and Mr Halliwell found in the town-chamberlain's accounts for 1614, this item: "For one quart of sack and one quart of claret wine,

 given to a preacher at New Place, xxd." This was two years before Shakspeare's death. The poet had accommodated the preacher with lodgings, and the corporation, as a peculiar mark of respect, added to his "creature comforts." Perhaps the Puritanical tendencies of Shakspeare's widow and daughters may partly account for the total loss of his papers. Not a scrap has survived, not a fragment of a scene, not one familiar letter.

In commenting on Shakspeare's married life, Malone and others have charged the poet with neglect of his wife in only mentioning her in his will by an after-thought—an interlineation—and then merely giving her his second best bed. Mr Charles Knight has successfully vindicated the memory of the poet from this accusation. His property was nearly all freehold, and the widow, by the ordinary operation of the law, would be entitled to her dower, or a third of the whole. This was no doubt understood between them, and the bequest of the bed was a special and affectionate memento.

Shakspeare's sonnets seem to demand a brief notice. They were published in 1609, printed for T. T., or Thomas Thorpe, a bookseller, who dedicated them to a "Mr W. H.," styling this unknown person "the only begetter of these ensuing sonnets." So early as 1598, a contemporary writer, Meres, had mentioned Shakspeare's "sugared sonnets among his private friends," and Thorpe's collection seems to have been unauthorised and inedited. Some of the sonnets were written apparently in extreme youth, some in a feigned or assumed character, and others in the poet's advanced years. Premature age had fallen upon him in the midst of his busy and thoughtful career. Most of the sonnets are addressed to a male friend of high rank, urging him to marry; and this object of Shakspeare's extravagant admiration and worship is supposed to have been William Herbert, Earl of Pembroke, while others name the poet's patron Henry, Earl of Southampton. Little reliance can be placed on these surmises and speculations. Whatever biographical truth the sonnets possess is of a somewhat painful character, but they abound in vivid imagery and in Shakspearian thought and expression.

We subjoin Mr Knight's chronological table of Shakspeare's plays, showing the positive facts that determine the dates, apart from the internal evidence on which there will always be a diversity of opinion:—

Henry VI. Part I. Alluded to by Nash in *Pierce Penniless*	1592
Henry VI. Part II. Printed as the "First Part of the Contention"	1594
Henry VI. Part III. Printed as the "True Tragedy of Richard, Duke of York"	1595
Richard II. Printed	1597
Richard III. Printed	1597
Romeo and Juliet. Printed	1597
Love's Labour's Lost. Printed	1598
Henry IV. Part I. Printed	1598
Henry IV. Part II. Printed	1600
Henry V. Printed	1600
Merchant of Venice. Printed 1600, mentioned by Meres	1598
Midsummer Night's Dream. Printed 1600, mentioned by Meres	1598
Much Ado about Nothing. Printed	1600
As You Like It. Entered at Stationers' Hall	1600
All's Well that Ends Well. Held to be mentioned by Meres as "Love's Labour's Won."	1598
Two Gentlemen of Verona. Mentioned by Meres	1598
Comedy of Errors. Mentioned by Meres	1598
King John. Mentioned by Meres	1598
Titus Andronicus. Printed	1600
Twelfth Night. Acted in the Middle Temple Hall	1602
Othello. Acted at Harefield	1602
Merry Wives of Windsor. Printed	1602
Hamlet. Printed	1603
Measure for Measure. Acted at Whitehall	1604
Lear. Printed 1608, acted at Whitehall	1607
Taming of the Shrew. Supposed to have been acted at Henslow's Theatre 1593, entered at Stationers' Hall	1607
Troilus and Cressida. Printed 1609, previously acted at Court	1609
Pericles. Printed	1609
The Tempest. Acted at Whitehall	1611
The Winter's Tale. Acted at Whitehall	1611
Henry VIII. Acted as a new play when the Globe Theatre was burned	1613

Out of the thirty-seven plays of Shakspeare, the dates of thirty-one are thus to some extent fixed in epochs. These dates are, of course, to be modified by other circumstances. There are only six plays remaining whose dates are not thus limited by publication, by the notice of contemporaries, or by the record of their performances; and these certainly belong to the poet's later period. They are—

Macbeth.	*Timon of Athens.*	*Antony and Cleopatra.*
Cymbeline.	*Julius Cæsar.*	*Coriolanus.*

The first edition of Shakspeare's dramatic works was published by his fellow comedians, Heminge and Condell, in 1623. Of this a second edition was printed in 1632, a third in 1664, and a fourth in 1685. The first annotated or critical edition of Shakspeare was that of Rowe in 1709, and to this succeeded, before the end of the century, the more elaborate or elegant editions of Pope, Theobald, Sir Thomas Hanmer, Warburton, Johnson, Capell, Steevens, and Malone. The two last were constantly adding to their store of illustrative notes, while Chalmers, Reed, and others joined in overlaying the poet's text with a mass of verbal disquisitions and quotations which, in 1821, swelled out into an edition of twenty-one volumes. This included the notes of Malone, Boswell, and others. During the last thirty or forty years, an amount of learning, of research, and of æsthetic criticism has been brought to bear upon the genius and times of Shakspeare that baffles all computation. The proudest names in our literature have made offerings at this shrine. The scholars and critics of Germany have run a race of generous competition with those of England, and among the earliest in the two countries we may place Schlegel and Coleridge side by side. In our own day, as annotators and editors, in the new and reverent spirit, the best are Mr Dyce, Mr John Payne Collier, and Mr Charles Knight.]

SHAMAKA, or SCHEMACHA, the capital of a government of Asiatic Russia, Transcaucasia, on the Pir Saghat, 69 miles W.N.W. of Baku, and 207 E.S.E. of Tiflis. It was at one time a very flourishing and important place, being the chief seat of commerce between Persia and the north; but having been taken and sacked by Nadir Shah in 1734, it lay for a long time in ruins. Recently it has recovered a great deal of its ancient prosperity, since it was made the capital of the province of Shirvan in 1841; and since 1847, when that province was divided into the governments of Shamaka and Derbent, it has been the capital of the former. It is fortified; and contains a bazaar, with 500 stalls. Here are the most important manufactories of silk in Transcaucasia, producing goods esteemed equal to those of French manufacture. Cotton and woollen cloth is also woven here; and vines and pomegranates are grown in the vicinity. The wine of this district is considered the best in Shirvan; it is chiefly made by the Armenians who inhabit the adjacent villages. The trade of the place is very extensive. Pop. 20,433. The town is called properly Old Shamaka, to distinguish it from Aksu, or New Shamaka, on the Aksu, 20 miles S.W. Here is a castle, once the residence of the khan of Shirvan. The town has a population of 7000; and is also a flourishing place.

SHANGHAE, or SHANGHAI, a city and river-port of China, in the province of Kiang-su, on the left bank of the Woosung, which conveys the water of Lake Tahoo into the estuary of the Yang-tse-keang, 40 miles by water from the sea, and 169 E.S.E. of Nankin. N. Lat. 31. 12.; E. Long. 120. 53. It stands in a rich and well-cultivated plain, planted with wheat, rice, and cotton; and is surrounded by walls about 5 miles in circuit; but there are several extensive suburbs without the walls. Shanghae is the most northerly; and, next to Canton, the most important of the five ports that were opened to foreign trade by the treaty of 1843. Since that time the importance of the place has been very much increased, and its aspect entirely changed, by the introduction of European commerce; and a new and flourishing settlement has risen alongside of the Chinese city. What formerly was an unhealthy swamp, dotted with the wretched huts of the Chinese, is now covered with the handsome mansions of European and American merchants, and gardens, which vie with those of the Chinese, for which Shanghae has long been famous. The river, which is here half-a-mile broad and from six to eight fathoms deep, is lined with commodious quays and warehouses. Numerous large steamers and sailing-vessels are continually anchored in the river; and further up a forest of masts rises from the native craft from all parts of China, while outside the harbour many opium clippers are generally moored. The Chinese part of the city has a very different appearance from that occupied by foreigners. The streets are narrow, and not over clean, paved in general with small tiles, instead of the granite common in other Chinese towns. In the outer portions of the town business is actively carried on, and shops abound; but towards the interior these disappear, and a great deal of ground is occupied by gardens. The shops are generally small, but well stocked with all sorts of Chinese and foreign goods, especially silk, cotton, clothes, &c. Most of the houses are ill-built; and the public buildings are no way remarkable, consisting of many temples or joss-houses, several hospitals, government offices, and a mint. The tea-gardens of Shanghae, occupying a large square, planted with trees, and the large ice-houses, are worthy of observation. Some manufactures are carried on; the chief articles produced being flowered silk, paper, ivory-ware, and glass. It is for its commerce, however, both with other parts of China and with foreign countries, that the city is chiefly important. For both of these purposes its situation is very well adapted. Along the coast of China, from the Bay of Ning-po northwards, to the peninsula of Shantung, a region extending over 5 degrees of latitude, there is no port but this accessible even to moderately-sized vessels, on account of the vast amount of deposit which is brought down by the great rivers Yang-tse-keang and Hoang-ho. At the same time, the land, enriched by these gigantic streams, is the most populous and best cultivated part of China, the province of Kiang-su producing great quantities of silk. Shanghae also stands in connection with many of the distant and inland provinces, by means of the Imperial Canal, which crosses the Woosung above the town, and by the great rivers. Recently, however, the rebellion in the valley of the Yang-tse-keang, the occupation of Ching-kiang-fu, on the canal, and a change in the course of the Hoang-ho, have interrupted these means of communication; but their place has been supplied by a coasting trade between the northern and the southern ports of China. This interruption of communication has materially reduced the quantity of tea exported from Shanghae; but it has not affected the trade in silk, which has greatly increased since 1855. These two are the only goods exported in any great quantities. On the whole, the trade has considerably increased since the opening of the port. The value of the imports and exports in 1858 is exhibited in the following table:—

	Imported.	Exported.
Goods and merchandise	L.5,894,000	L.9,555,400
Specie and bullion	1,226,000	3,007,600
Known total	L.7,115,600	L.12,563,000
Opium	4,944,400	
Grand total	L.12,061,000	

As the opium is a prohibited article, and presumed to be unknown to the Chinese officials, its value can only be estimated. The above estimate includes 25,122 chests of Malwa opium, valued at L.3,617,568, and 7238 chests of Patna opium, valued at L.1,129,128. Among the imports are also included 414,505 pieces of American gray twills, and 36,400 pieces of American sheetings. The quantities of silk and tea exported in the same year were as follows:—

Silk.

Countries.	Raw.	Thrown.	Total.
Great Britain ......bales	24,957	1494	26,451
Hong-Kong	37,804	4971	42,775
Foo-Chow	209	8	217
United States	1,614	19	1,633
Manilla	201	2	203
Total	64,785	6494	71,279

Besides this, there were exported 391 bales of coarse silk, 138 of refuse, and 921 of cocoons, all to Great Britain.

Tea.

Countries.	Black.	Green.	Total.
Great Britain.........lbs.	12,507,037	8,214,620	20,721,657
Foo-Chow, Hong-Kong	765,417	1,146,736	1,912,153
Australia	326,129	143,602	469,731
Montreal	43,914	584,148	628,062
Continent of Europe	529,080	72,775	601,855
United States	71,089	21,951,555	21,122,644
Manilla	...	9,600	9,600
Total	14,242,666	31,223,036	45,465,702

The navigation of the port for the same year is shown in the following table:—

Flag.	Entered		Cleared.	
	Vessels.	Tonnage.	Vessels.	Tonnage.
British	290	120,205	174	77,496
United States	97	56,280	56	38,270
Other countries	367	66,139	148	39,029
Total	754	242,624	378	154,795

Shanghae was taken by the British in June 1842, but restored to the Chinese by the treaty ratified in the following year. In September 1853 it was captured by the insurgent forces, but regained by the Imperialists soon afterwards. The population is variously estimated; it is probably between 115,000 and 135,000, though some accounts make it as much as 300,000.

SHANNON, a river of Ireland, by far the largest in that country, and one of the most important in the United Kingdom. Its source is at the foot of Caileagh, one of the mountains in the county of Cavan, which surround Lough Allen, into which it falls after a course of a few miles. Out of this lake, which is about 10 miles in length, it issues at its southern extremity, and flows in an irregular course, generally southwards, in a narrow, shallow, and somewhat interrupted bed. It receives the Boyle River from Lough Key on the right, and further down it expands into a sheet of water called Lough Bodarrig. Beyond this it flows through a wide expanse of boggy land, till it enters the northern extremity of Lough Ree at Lanesborough. This lake is the second in size of those the Shannon flows through,

being 17 miles in length by 7 in its greatest breadth. It is diversified by many promontories, bays, and creeks, and has very beautiful scenery. Issuing from Lough Ree, a little above Athlone, the Shannon continues to pursue a circuitous and southerly course, through a low, flat, and fertile region, dividing itself at some places into arms which enclose considerable islands. In this part of its course, the Suck, its chief affluent, and little inferior to the main river, joins the Shannon from the west, after a course of 60 miles. The largest lake that the river flows through is Lough Derg; it is 25 miles long, narrow, and much indented. It is also the most beautiful in its scenery; for, unlike the others which lie in low ground, a great portion of this lake, especially its lower end, is environed by mountains; Slievh Boughty rising on the west, and the Arra Mountains on the east. From Killaloe at the foot of Lough Derg, the Shannon flows south-west to Limerick; and about half-way between these places are the falls of Doonass. These are, properly speaking, rapids; the river, which is here 40 feet deep and 300 yards broad, rolling tumultuously over a succession of rugged rocks for about half a mile, in the midst of luxuriant meadows and shaggy woods; while the ruins of Castle Connel occupy a lofty rock overlooking the stream. From Limerick onwards the course of the Shannon is due west, and it is here rather an estuary or arm of the sea than a river, though it is known by the name of the Lower Shannon. It enters the Atlantic between Look Head on the north, and Kerry Head on the south. Several rivers join it in this part of its course, the chief of which is the Fergus, from the north. The whole length of the Shannon, from its source to the sea, is 220 miles. During its course from Lough Allen to below Lough Bodarrig it separates the counties of Leitrim and Roscommon; from thence to the lower part of Lough Derg it divides Leinster and Munster on the one side, from Connaught on the other; Longford, Westmeath, and King's County belonging to the first, Tipperary to the second, Roscommon and Galway to the third of these provinces. The rest of its course lies in Munster, between Clare on the north, Limerick and Kerry on the south. The most remarkable thing about the Shannon is the length of navigable water it has. In this respect it is far superior to any river in the United Kingdom, for vessels may ascend from its mouth as far as Lough Allen, so that there are only 6 or 7 miles out of 220 that cannot be navigated. There are, indeed, at various places obstructions caused by the shoals and rapids of the river; but these have, for the most part, been overcome by lateral canals, or by deepening the channel. Upwards of half a million sterling has been expended on various works for the improvement of the river; and yet, from the want of proper management, it is still in an unsatisfactory state. The value of such a river to the country is necessarily very great, as it connects the most inland places with the sea, and by the Grand and Royal Canals to Dublin inland navigation is extended also to other parts of the island. The highest tides in the Shannon rise about 18 feet, the lowest 14; the velocity in narrow parts of the estuary is frequently very great, and the water assumes an appearance very like that of a bore. Several varieties of fish are found in the Shannon, and the most productive fishery is that of eels.

SHAN-SI, or Shan-see, an inland province of China, bounded on the N. by Mongolia, from which it is separated by the Great Wall, E. by Pe-che-li, S. by Honan, and W. by Shen-si. Area, 55,360 square miles. The surface is in general mountainous, but there are many level tracts. The largest river is the Hoang-ho, which forms the whole of the western and part of the southern boundary. It receives many affluents, which, though small compared with the giant streams of China, would anywhere else be considered of great size. The Tan-ho, the largest of these in this province, has a length of 300 miles. In the north of Shan-si are some of the favourite hunting-grounds of the Chinese emperors. The productions of the province are rice, wheat, millet, coal, iron, lapis lazuli, salt, jaspers, musk, rice, brandy, carpets, &c. The chief town is Tai-yuen-fu. Pop. (1812) 14,004,210, (1843) 15,000,000.

SHAN-TUNG, a maritime province of China, bounded on the N. by the gulf of Pe-che-li, E. and S.E. by the Yellow Sea, S. by Kiang-su and Honan, W. and N.W. by Pe-che-li. Area, 65,216 square miles. The eastern portion forms a peninsula projecting into the sea, and separating the gulf of Pe-che-li from the Yellow Sea. This part is mountainous, but the rest of the province consists of a plain traversed by the Imperial Canal. It is intersected by several rivers, but none of any great size fall into the sea, if we except the Hoang-ho, which only forms the boundary for a short distance. The coast is bold, and has many harbours, but no large seaport towns. The chief productions are wheat, millet, indigo, coarse silk, and carpets. Pop. (1812) 28,958,764, (1843) 30,000,000.

SHAPINSHAY. See Orkney.

SHARP, Abraham, an eminent English mathematician and astronomer, was born at Little Horton, near Bradford, in the year 1651. He was put as apprentice to a merchant at Manchester, but so strongly was he inclined to the study of mathematics that he soon found his situation both irksome and disagreeable. By the mutual consent, therefore, of his master and himself, he quitted the business of a merchant. He then removed to Liverpool, where he devoted himself wholly to mathematical studies, and where, for a subsistence, he taught writing and accounts. Soon after this, a merchant from London, in whose house the celebrated Flamsteed then lodged, engaged Sharp to be his bookkeeper. With this eminent astronomer he soon contracted an intimate friendship, and by his recommendation he obtained a more profitable employment in the dock-yard of Chatham, where he continued till his friend and patron called him to his assistance. Sharp was chiefly employed in the construction of the mural arch, which he finished in the couse of fourteen months, so entirely to the satisfaction of Flamsteed, that he spoke of him in terms of the highest praise. In the opinion of Smeaton, this was the first good instrument of the kind, and Sharp the first artist who cut delicate divisions on astronomical instruments. When this instrument was constructed, Sharp was but twenty-five and Flamsteed thirty years of age. Sharp assisted his friend in making a catalogue of nearly three thousand fixed stars, with their longitudes and magnitudes, their right ascensions and polar distances, with the variations of the same while they change their longitude by one degree. But, from the fatigue of constantly observing the stars by night in a cold thin air, added to a weakly constitution, his health was much impaired. For the recovery of it he requested leave to retire to his house at Horton, where, as soon as he felt himself recovering, he began to fit up an observatory of his own; and the telescopes he made use of were all of his own construction, and the lenses ground and adjusted with his own hands.

It was about this time that he assisted Flamsteed in calculating most of the tables in the second volume of his *Historia Cœlestis*, as appears by their letters, to be seen in the hands of Sharp's friends at Horton. Sharp, in 1717, published an elaborate treatise on Geometry, which he entitled *Geometry Improved*. He possessed a remarkably clear head for contriving, and an extraordinary hand for executing anything, not only in mechanics, but likewise in drawing, writing, and making the most beautiful figures, in all his calculations and constructions. The quadrature of the circle was undertaken by him for his own amusement, in the year 1699, deduced from two different series, by which the truth of it was proved to seventy-two places of figures, as may be seen in Sherwin's *Tables of Logarithms*.

In the same book may likewise be seen his ingenious improvements on the making of logarithms, and the constructing of the natural sines, tangents, and secants.

Sharp kept up a correspondence with most of the eminent mathematicians and astronomers of his time, as Flamsteed, Newton, Halley, Wallis, Hodgson, the answers to whose letters are all written on the backs or empty spaces of the letters he received, in a short hand of his own invention. Being one of the most accurate and indefatigable computers who ever existed, he was many years the common resource for Flamsteed, Sir Jonas Moor, Halley, and others, in all sorts of troublesome and delicate calculations. Sharp was never married, and spent his time as a hermit. He was of a middle stature, very thin, of a weakly constitution, and remarkably feeble during the last three or four years before his death, which happened on the 18th of July 1742, in the ninety-first year of his age. He was very irregular as to his meals, and uncommonly sparing in his diet. A little square hole, resembling a window, formed a communication between the room where he usually studied, and another where a servant could enter; and before this hole he had contrived a sliding board. It often happened, that the breakfast, dinner, and supper remained untouched; and when the servant returned to remove the dishes, the meal was found just as it had been left.

SHARP, Granville. See Slavery.

Sharp, *James*, Archbishop of St Andrews, was born of a good family in Banffshire in the year 1618. He devoted himself early to the church, and was educated for that purpose in the University of Aberdeen. When the solemn league and covenant was framed in 1638, the learned men in that seminary, and young Sharp in particular, declared themselves decidedly against it. To avoid the insults and indignities to which he was subjected in consequence of this conduct, he retired to England, where he contracted an acquaintance with some of the most celebrated divines in that country. At the commencement of the civil wars he returned to Scotland. During his journey thither, he accidentally met with Lord Oxenford, who was so charmed with his conversation that he invited him to his house. While he resided with that nobleman, he became known to the Earl of Rothes, who procured him a professorship at St Andrews. By the interest of the Earl of Crawford, he was soon afterwards appointed minister of Crail, where he conducted himself, it is said, in an exemplary manner. Sharp had always inclined to the cause of royalty, and had for some time kept up a correspondence with his exiled prince. After this he began to declare himself more openly, and seems to have enjoyed a great share of the confidence of Monk, who was at that time planning the restoration of Charles II. When that general marched to London, the presbyterians sent Sharp to attend him, in order to support their interests. At the request of General Monk and the chief presbyterians in Scotland, Mr Sharp was sent over to the king at Breda, to procure from him, if possible, the establishment of presbytery. On his return, he assured his friends that "he had found the king very affectionate to Scotland, and resolved not to wrong the settled government of the church; but he apprehended they were mistaken who went about to establish the presbyterian government."

Charles was soon afterwards restored without any terms. All the laws passed in Scotland since the year 1633 were repealed; the king and his ministers resolved at all hazards to restore prelacy. Sharp, who had been commissioned by the Scotch presbyterians to manage their interests with the king, was prevailed upon to abandon the party; and as a reward for his compliance, he was made archbishop of St Andrews. This conduct rendered him very odious in Scotland. He was accused of treachery and perfidy, and reproached by his old friends as a traitor and renegade. The absurd and wanton cruelties which were afterwards committed, and which were imputed in a great measure to the archbishop, rendered him still more detested. Nor is it probable that these accusations were without foundation. The very circumstance of his having formerly been of the presbyterian party would induce him, after forsaking them, to treat them with severity. Besides, it is certain, that when, after the rout at Pentland Hills, he received an order from the king to stop the executions, he kept it for some time before he produced it to the council.

There was one Mitchell, a preacher, and a desperate fanatic, who had formed the design of taking vengeance for these cruelties by assassinating the archbishop. He fired a pistol at him as he was sitting in his coach; but the bishop of Orkney, lifting up his hand at the moment, intercepted the ball. Though this happened in the midst of Edinburgh, the primate was so much detested, that nobody stopped the assassin, who, having walked leisurely home, and thrown off his disguise, returned, and mixed unsuspected with the crowd. Some years afterwards, the archbishop observing a man eyeing him with keenness, suspected that he was the assassin, and ordered him to be brought before him. It was Mitchell. Two loaded pistols were found in his pocket. The primate offered him a pardon if he would confess the crime. The man complied; but Sharp, regardless of his promise, conducted him to the council. The council also gave him a solemn promise of pardon, if he would confess his guilt, and discover his accomplices. They were much disappointed to hear that only one man was privy to his purpose, who was since dead. Mitchell was then brought before a court of justice, and ordered to make a third confession, which he refused. He was imprisoned for several years, and then tried. His own confession was urged against him. It was in vain for him to plead the illegality of that evidence, and to appeal to the promise of pardon previously given. The council took an oath that they had given no such promise, and Mitchell was condemned. Lauderdale, who at that time governed Scotland, would have pardoned him, but the primate insisted on his execution, observing, that if assassins were permitted to go unpunished, his life must be continually in danger. Mitchell was accordingly executed.

Sharp had a servant, one Carmichael, who by his cruelty had rendered himself particularly odious to the zealots. Nine men formed the resolution of waylaying him in Magus Moor, about three miles from St Andrews. While they were waiting for this man, the primate himself appeared, with very few attendants. This they looked upon as a declaration of Heaven in their favour; and calling out, "The Lord has delivered him into our hands," they ran up to the carriage. They fired at him without effect, a circumstance which was afterwards imputed to magic. They then despatched him with their swords, regardless of the tears and entreaties of his daughter, who accompanied him. On the 3d of May 1679, thus fell Archbishop Sharp, whose memory is even at present detested by the common people of Scotland. His abilities were certainly good, and in the early part of his life he appears with honour and dignity. But his conduct afterwards was too cruel and insincere to merit approbation. His treatment of Mitchell was mean and vindictive. How far he contributed to the measures adopted against the Presbyterians is not certain. They were equally cruel and impolitic; nor did their effects cease with the measures themselves. The unheard-of cruelties exercised by the ministers of Charles II. against the adherents of the Covenant raised such a flame of enthusiasm and bigotry as is not yet entirely extinguished.

Sharp, *John*, Archbishop of York, was descended from the Sharps of little Norton, a family of Bradford Dale in Yorkshire; and was son of an eminent tradesman of Bradford, where he was born in 1644. He was educated at Cambridge, and in 1667 entered into orders. The same

year he became domestic chaplain to Sir Heneage Finch, then attorney-general. In 1672 he was collated to the archdeaconry of Berkshire. In 1675 he was installed a prebendary in the cathedral church of Norwich; and the year following was instituted into the rectory of St Bartholomew, near the Royal Exchange, London. In 1681 he was, by the interest of his patron, Sir Heneage Finch, then lord high chancellor of England, made dean of Norwich, but in 1686 was suspended for taking occasion, in some of his sermons, to vindicate the doctrine of the Church of England in opposition to Popery. In 1688 he was sworn chaplain to James II., being then probably restored after his suspension; for it is certain that he was chaplain to Charles II., and attended as a court chaplain at the coronation of James II. In 1689 he was declared dean of Canterbury, but never could be persuaded to fill up any of the vacancies made by the deprived bishops. Upon the death of Dr Lamplugh, he was promoted to the see of York. In 1702 he preached the sermon at the coronation of Queen Anne; and the same year he was sworn of the privy council, and made Lord Almoner to her Majesty. He died at Bath in 1713, and was interred in the cathedral of York, where a monument was erected to his memory. His sermons were collected after his death and published in seven vols. 8vo. A *Life of Archbishop Sharp*, written by his son, Dr Thomas Sharp, appeared in 2 vols. in 1829.

Sharp, *William*, an eminent line-engraver, was born at London on the 29th of January 1749. He was originally apprenticed to what is called a bright engraver, but gradually becoming inspired by the higher branches of the engraver's art, he exercised his gifts with surprising success on works of the old masters. He engraved the "Doctors Disputing on the Immaculateness of the Virgin," and the "Ecce Homo" of Guido Reni; the "St Cecilia" of Domenichino; the "Virgin and Child" of Dolci; and the portrait of "John Hunter" of Sir Joshua Reynolds. The latter work is considered a masterpiece in freedom and accuracy; and, in a power which Sharp possessed beyond all engravers of his day, of representing the various textures of his subject with wonderful skill. He died at Chiswick on the 25th July 1824. Sharp, although shrewd-minded in worldly matters, was one of the greatest visionaries in matters pertaining to religion. No imposture was too gross for him to accept, no deception too glaring for his eyes to admire. The dreams of Mesmer, the rhapsodies of Brothers, and the ravings of Joanna Southcott, found in Sharp a staunch believer. At his death he enjoyed the honour of being a member of the Imperial Academy of Vienna, and of the Royal Academy of Munich.

SHARPE, Daniel, an English geologist, was born in London in 1806. His mother, who died shortly after his birth, was a sister of the poet Rogers. He was educated at Walthamstow, and showed early a predilection for the study of natural science. He became a member of the Geological Society in June 1829, and read a short memoir the following year on a fine specimen of Ichthyosaurus, from the lias of Stratford-on-Avon. It turned out that this species of reptile had previously been noticed by Conybeare. During the next twenty years Sharpe's attention was much directed to the geology of Lisbon and Oporto, and during these years he read numerous papers before the Geological Society. He had been led thither by his profession of a wine-merchant, and it was to his labours that the society owes the greater part of its knowledge of the geological structure of the district of the Tagus. He examined the relations of the earthquake of 1755 to the geological structure of the site of Lisbon, and found that while all the buildings occupying the tertiary strata had been demolished, those situated on the hippurite limestone and basalt had entirely escaped. In 1848 he gave a detailed account of the coal deposits of Vallongo, in Portugal, and inclined to the opinion that this substance was really of the Silurian age. Next year he combined a general sketch of the geology of Portugal, with a notice of the structure of the district north of the Tagus; and as this necessitated great labour, he gained the assistance of various scientific friends. He was enabled, by his critical examination of organic remains, to present a lucid paper on the comparison of the North American formations with those of Europe in 1847. He reviewed the classifications of Belgium and England in 1852, of South Westmoreland in 1842 and 1843, of the Bala Limestone in 1842, and of North Wales in 1846. Sharpe likewise collected many papers, and devoted much thought and labour to the subject of slaty cleavage, on which he read his first memoir in 1846. He engaged in an investigation of the geology of the Highlands of Scotland with Greenough, with the design of constructing a new geological map of Scotland for the Geological Society of London. The account of his labours on this district will be found in the *Philosophical Transactions* for 1852. He likewise wrote a paper on the Farringdon gravels in 1853, which bespeaks his palæontological industry. His elaborate essays on the ancient coins and inscriptions of Lycia, appended to the works of Fellows, Forbes, and Spratt, display in an eminent degree his knowledge of philology and ethnology. He was Fellow of the Royal, Linnean, and Zoological Societies, and occupied at the time of his death, which happened on the 31st of May 1856 (occasioned by a fall from his horse), the post of President of the Royal Geological Society, to which so much of his labour and so large a portion of his time had been devoted for more than a quarter of a century.

SHASTER. See Brahmins.

SHATZK, or Schazk, a town of European Russia, on the Shatzka, in the government of Tambov, 38 miles N. of Morshansk. It has 5 churches, several schools, a benevolent institution, manufactures of hardware, and a considerable trade. Pop. 6207.

SHAW, Dr Thomas, known to the learned world by his *Travels to Barbary and the Levant*, was born at Kendal, in Westmoreland, about the year 1692. He was appointed chaplain to the English consul at Algiers, in which station he continued for several years; and thence took proper opportunities of travelling into different parts. He returned in 1733, was elected fellow of the Royal Society, and published the account of his travels at Oxford, 1738, folio. In 1740 he was nominated principal of St Edmund Hall, which he raised from a ruinous state by his munificence; and was regius professor of Greek at Oxford until his death, which happened in 1751. Dr Clayton, bishop of Clogher, having attacked these *Travels* in his *Description of the East*, Dr Shaw published, by way of vindication, a supplement, which is incorporated into the second edition of his Travels, prepared by himself, and published in 1757, 4to.

SHAWLS. See Woollen Manufactures and Weaving.

SHEE, Sir Martin Archer, a portrait-painter, and president of the Royal Academy, was born in Dublin on the 23d of December 1770. He was sprung from an old Irish family, and his father, while he exercised the trade of a merchant, regarded the profession of a painter as in no sense a fit occupation for a descendant of the Shees. Young Shee became, nevertheless, a student of art in the Dublin Society, and came early to London, where he was, in 1788 introduced to the notice of Sir Joshua Reynolds by the youth's illustrious friend and countryman Edmund Burke. Having entered as a student in the Royal Academy in 1789, he contributed the same year his first two pictures to the exhibition, the "Head of an Old Man" and "Portrait of a Gentleman." During the next ten years he steadily increased in practice, and was gradually gaining ground among the aristocracy, with whom his suavity and

manners were a great recommendation. Lord Spencer was the first nobleman who honoured his studio with his portrait, and his example was soon followed by dukes and marquises in abundance. Lawrence, however, had an entire monopoly of the ladies. Shee was chosen an associate of the Royal Academy in 1798, shortly after the illustrious Flaxman, and in 1800 he was made a Royal Academician. He now removed to Romney's house in Cavendish Square, and set up as the legitimate successor of that artist. Shee continued to paint with great readiness of hand and fertility of invention, although his portraits were eclipsed by more than one of his contemporaries, and especially by Lawrence, Hoppner, Phillips, Jackson, and Raeburn. He had a fine eye for colour, but one of his most glaring defects was a deficiency in proportion. In 1805 he came out with a poem consisting of *Rhymes on Art*, and it was succeeded by a second part in 1809. Although Byron spoke well of it in his *English Bards and Scotch Reviewers*, and invoked a place for "Shee and Genius" in the temple of fame, yet as nature had not originally conjoined these two, it is to be feared that even a poet's invocation could not materially affect their relations. Shee published another small volume of verses in 1814, entitled *The Commemoration of Sir Joshua Reynolds and other Poems*, but this effort did not greatly increase his fame. He now modified his theatrical experience by writing a tragedy called *Alasco*, of which the scene was laid in Poland. The play was accepted at Covent Garden, and in the fertile fancy of the poet the play had already gained for him a great dramatic fame, when Colman, the licenser, refused it his sanction, on the plea of its containing certain treasonable allusions, and Shee, in great wrath, resolved to make his appeal to the public. This violent threat he carried out in 1824; but unfortunately the public found other business to mind, and *Alasco* is still on the list of unacted dramas.

On the death of Lawrence in 1830, Shee was chosen President of the Royal Academy, more from a regard to his elegant addresses than for any artistic genius with which he was held to be endowed. Wilkie was a candidate, but he had little else than genius in his profession to recommend him, and of course Shee's fluency of speech and courtly address were of much more consequence in the academic chair than the reserved manner and undecided utterance of a much greater man. Shortly after Shee received the honour of knighthood. He continued to paint till 1845, and died five years afterwards, on the 13th of August 1850, in his eightieth year.

SHEERNESS, a seaport and market-town of England, in the county of Kent, on the north-west corner of the Island of Sheppey, at the confluence of the Medway with the Thames, 20 miles N.N.E. of Maidstone, and 47 E. by S. of London. It consists of three parts, Sheerness proper, Bluetown, and Miletown; the first contains the dockyards and fortresses, and this, as well as the second, is encircled by fortifications, beyond which lies the suburb called Miletown. The town has been much improved, especially within recent years, and now contains several handsome streets, with good brick houses. The dockyard and buildings connected with it occupy an area of 60 acres, enclosed by a brick wall. Here there are all the establishments necessary for the building, repairing, and equipment of ships. There is a basin or wet-dock 520 feet by 300, covering an area of 3½ acres; two others of smaller size; three dry docks, each 248 feet by 88; sheers for lifting masts, 127 feet high; a building slip; store-houses, joiners' and smiths' shops; residences for the commander-in-chief, and various other officials; besides an ordinance-office, and heavy batteries of 100 guns. The dockyard is built on piles; and since 1815 about 3,000,000 sterling have been laid out upon its improvement. Near the dock-gates stands a large and handsome chapel, attached to the garrison; and in the town is a Gothic district church, belonging to the parish of Minster. The other places of worship belong to the Wesleyan Methodists, the Baptists, the Roman Catholics, and the Jews. There are also various schools, a mechanics' institute, reading societies, and a savings bank. A county court is held in the town, and there are weekly markets. The trade is very considerable; but depends chiefly on the dockyards, although corn and seeds from the Isle of Sheppey, and oysters from the adjacent banks, are conveyed to London. Copperas is manufactured at a short distance from Sheerness, the materials being supplied in abundance from the multitude of pyrites found in the rocks to the east. Sheerness is resorted to as a sea-bathing place to a considerable extent. There is a pier 1000 yards long, for the steamers that ply daily between this and London. The town is of comparatively recent origin, as it is not yet 200 years since its foundation. In the time of the Commonwealth, the site was a mere swamp, on which a fort with 12 guns was built after the Restoration. But before the works could be completed, the Dutch, in 1667, entered the Thames, and took and destroyed the fort. It was afterwards restored and enlarged, the dockyard was established, which has become one of the finest in Europe, and additions were made to the works at various subsequent times. In 1797, Sheerness was threatened by the mutiny of the fleet at the Nore; but was saved by the suppression of that movement in the same year. The town suffered from an extensive conflagration in 1827, but was speedily restored in a superior style. Pop. 8549.

SHEFFIELD is an ancient manufacturing town, near the southern extremity of the West Riding of Yorkshire, and about 160 miles N.N.W. of London. The manor of Sheffield, with several of the adjacent manors, was anciently called Hallamshire, and its lord had his castle at the confluence of the rivers Sheaf and Don. The name Sheffield is commonly supposed to be derived from the Sheaf. In *Doomsday Book* the town is called Escafelt, and antiquaries derive its name from the British word *ea*, water. The Don is the principal river, and at or near the town it receives the waters of its tributaries, the Sheaf, the Porter, the Loxley, and the Rivelin. All these have their source in the high moors a few miles west, south-west, and north-west of the town. To the abundant water-power thus supplied, and to the coal and iron obtained here at a very early period, may be ascribed the devotion of Sheffield to working in iron and steel. The valleys are studded with grinding-wheels and tilts, worked by water-power. These valleys are separated from each other by bold and steep hills, and though the effect is to render the neighbourhood remarkably picturesque and beautiful, in the town the inequalities of surface have their inconveniences, for some of the streets are so steep as to be quite unsuited for loaded vehicles. A hundred years ago Sheffield was described as a smoky town, but now the reasons for that reproach are increased ten thousand times. A bye-law of the corporation requires the consumption of smoke from steam-engines, and the manufacturers have incurred great expense in endeavouring to obey the law, with only partial success. Besides the Castle of Sheffield, the Earls of Shrewsbury, who were its lords for 200 years, had a lodge or manor-house in a finely wooded park, a mile east of the town. The greater part of the captivity of Queen Mary of Scotland was passed at the castle and manor-house at Sheffield. The castle was demolished by order of parliament in 1648. Only such names as Castlehill, Castlegreen, &c., remain to mark the site. The manor-house has crumbled away under the hand of time, and only a few poor traces are left. The park was divided into farms in 1707, but the district still bears its old name. By the marriage of the heiress of the seventh Earl of Shrewsbury with a member of the house of Howard, the estates have passed to the Duke of Norfolk. The present

duke has had a mansion called "The Farm," immediately adjoining the town, enlarged and furnished for his occasional residence. During the suit brought by Lord Talbot successfully in 1858, to support his claim to the earldom of Shrewsbury, the Shrewsbury vault under the chancel of the parish church was searched for evidence, but without result. The modern history of Sheffield has been for the most part peaceful, but on the night of the 11th January 1840, the town narrowly escaped from a Chartist conspiracy to burn and capture it. The scheme was not disclosed to the authorities till almost the last hour. Sheffield has grown rapidly during the present century. The population of the borough is four times as great as it was at census of 1801, being now computed at 180,000. At the census of 1851 it was 135,307. The rateable value of the property of the borough was L.272,161 in 1848, and L.425,044 in 1859. The parochial and municipal taxes for the years ending in 1858 and 1859 were from L.96,000 to L.98,000 each year.

The town and neighbourhood of Sheffield are indisputably the chief seat of the following important manufactures:—Cast, shear, and blister steel, of all kinds; steel wire; railway and carriage springs; buffers; files; saws; all kinds of joiners', masons', shipwrights', and mechanics' edge-tools generally; scythes, sickles, hay and straw knives; table, pocket, shoe, butchers', and similar cutlery of every variety; all classes of silver, silver-plated, electro-plated, German silver, Britannia, and other white-metal goods; women's and tailors' scissors and shears; razors; silver and silver-plated cutlery; sheep-shears, skates, spades, and shovels; surgical instruments; many kinds of horticultural and agricultural tools; adzes, axes, hatchets, hammers, augers, hoes, bill-hooks, &c., in all varieties of pattern and quality. In a more limited sense, too, this town is an important seat of such manufactures as those of hair-seating and curled hair; combs of all kinds; powder-flasks and shot-belts; optical instruments; needles, fish-hooks, awls; stove-grates, and fine foundry-work of all varieties; many kinds of machinery, and railway and mining tools. The manufacture of snuff is also carried on here on an extensive scale, Messrs Wilson and Co. and J. and H. Wilson producing an article, as snuff-takers know, which has a reputation almost equal to that of the celebrated pocket-knives of the Messrs Rodgers themselves. This list of trades is very different from that given in the charter of the Cutlers' Company in 1624, which enumerated only "knives, scissors, shears, sickles, and other cutlery." The natural advantages of this neighbourhood, however, for the production of hardware are sufficiently pre-eminent to have justified the expectation of a still larger extension of local industry, and of course a proportionate increase in the town itself. There can be no doubt that the dominating power and influence of the trades' unions have tended, by making skilled labour artificially dear, and by stereotyping the occupations of men too much, first, to encourage foreign manufacturers, especially in Germany and the United States; and, second, to discourage attempts to introduce and localise any new and experimental manufactures, to the success of which cheap, abundant, and unprejudiced mechanical skill was absolutely essential. In spite of all this, however, energy and perseverance on the side of the masters, and the crushing effect of reason and experience on the side of the men, have been sufficient, in a great degree, to override the suicidal effects of trade combinations. It is a law in commerce, that if a trade be once fairly wrested from a locality, it never can be wholly, or even materially, recovered. This is the experience of Sheffield. Whatever branches of manufacture the policy of trades' unions has thrown into the hands of the Americans or the Germans, they keep; but they will not easily take any more. Meanwhile, the new employments of the town are rapidly growing into importance. It has been stated by one of the principal manufacturers of railway-springs, that the quantity of them made *weekly* in Sheffield is 150 tons. The buffer trade is increased at a corresponding rate. Twenty years ago it was estimated that about 700 tons of Swedish iron were annually brought to Sheffield, and converted into steel. Since that time experience and competition have forced English irons to a very large amount into use for the purpose of making steel, and hence the importation of Swedish and other foreign marks, though not perhaps on the decline, is almost stationary. Some of the principal railway-spring makers have recently erected puddling furnaces, and produce their own malleable iron from the pig-metal. They can thus combine the various kinds of iron best suited to their purpose. East Indian and Nova Scotian irons are coming into use among other varieties. From the statistics furnished by Messrs Sanderson and Unwin, of Sheffield, to Mr Tylor, for his report on metal work in the Paris Exhibition, we gather that, in 1856, there were in Sheffield 206 converting or blister steel furnaces, and 2113 melting boles, or cast-steel furnaces. At the rate of 250 tons each per annum, the blister steel furnaces were estimated to have produced 51,500 tons of steel, of which 37,800 tons were then made into cast-steel, and the rest sold as bar, German, faggot, spring, and shear steel. If the cast-steel be taken as worth L.40, and the rest at L.25 per ton, it will be found that, in 1856, steel to the value of L.1,854,500 was made in Sheffield. From what has been already said, it will be inferred that the trade of Sheffield is very widely spread. In truth, every country abroad, as well as the whole home-market, are directly or indirectly her customers. Next to the home trade, perhaps no other calls for a larger quantity of goods than that of the United States and British North America. Australia, South America, both east and west coast, and the Cape of Good Hope, are, however, excellent markets; and the demand for steel, files, saws, railway-springs and buffers, and tools generally, of course naturally springs up wherever railways are being constructed, or ships and machinery built. At present Russia, several other European countries, and India, are large purchasers of these classes of goods. From the fact that reliable local statistics are very difficult to procure (the nature of the trades not rendering any attention to these points necessary), it is impossible to say, with much approach to accuracy, how the population is divided as regards employment in the various trades. The rate of wages, however, usually paid in some departments of labour can be ascertained with greater truth. According to returns made at the request of Mr Fonblanque, at the head of the statistical department of the Board of Trade, the average wages, per day, paid in the following trades (taking the trades in whole and not in detail) during 1855–56–57, were:—

Table-knives...	2s. 6d. to 7s. 0d.	Steel...........	3s. 6d. to 8s. 0d.
Pocket-knives	3s. 0d. to 7s. 0d.	Springs	6s. 0d. to 8s. 0d.
Razors	2s. 6d. to 8s. 0d.	Stove-grates...	4s. 0d. to 7s. 0d.
Scissors.........	3s. 3d. to 5s. 6d.	Silver-platers..	4s. 0d. to 8s. 0d.
Files	3s. 9d. to 8s. 0d.	Britannia metal makers.......	1s. 4d. to 6s. 0d.
Saws............	4s. 0d. to 8s. 0d.		
Tools...........	5s. 0d. to 7s. 0d.		

When it is borne in mind, that as a rule the families of the working classes here occupy separate houses, and that cellars or "flats" are unknown as human habitations, it will be obvious that a very great degree of comfort is within the reach of the working-man, and that it is his own fault if, with such wages and such collateral advantages, he is not a thriving man, and his family well fed, well clothed, and decently educated.

In 1832 Sheffield was empowered to return two members to parliament; and in 1843 it was incorporated by royal charter. The parliamentary and municipal borough is co-extensive with the old parish of Sheffield, which consists of six townships. The parliamentary voters are about

Sheffield. 7000, and the names on the burgess-roll about 19,000. It is ascertained that a L.6 *rental* qualification would enfranchise about 20,000 voters; and a L.6 *rating*, 11,000. The town has a bench of borough magistrates, but no separate court of quarter sessions. Persons committed for trial are sent to the West Riding quarter sessions, or to the assizes at York. The old manorial courts, for the recovery of debts to the amount of L.5, have been superseded by the county court, with jurisdiction up to L.50, and holding frequent sittings here. The Sheffield barracks, erected in 1794, having become too small, as well as dilapidated, were pulled down in 1855, having been replaced by new barracks, occupying a site of 25½ acres. They have since been further extended. A free library, maintained by rate, was established in 1856. In 1859 it had 9119 volumes, and the issue of books for the year was 125,555. Most of the church and chapel yards having been closed as places of interment in 1855, and the Sheffield Cemetery, established in 1836, being insufficient to meet the case, several new township cemeteries have been formed. Previous to 1820 Sheffield had only its old parish church, built 1110; St Paul's and St James', built during the last century; and two small chapels of ease in out-townships. Since that time a vast increase of ecclesiastical buildings has taken place. Between 1820 and 1830 four churches were built under "the million act." During the following years, and chiefly during the last fifteen, a crowd of new churches has been built and endowed by voluntary effort. In 1846, the old parish of Sheffield was divided into twenty-five parochial districts, which are for the most part independent of the old parochial head, except that the old parish of Sheffield now forms a deanery, of which the Vicar of Sheffield is the rural dean. Most of the new districts or parishes are already supplied with churches. Of old and new churches there are now twenty-three, and others are projected or in progress. The Nonconformist bodies have nearly doubled their places of worship since 1833. They now number about forty. The Roman Catholics have replaced their small chapel, erected in 1814, by a large and handsome church, with a spire rivaling that of the ancient parish church. In 1856 they erected a smaller church in another part of the town. Both these churches have schools. A school has also been erected near the residence of the Duke of Norfolk, and a convent and school of the Sisters of Notre Dame has been established. All the religious denominations have their Sunday schools, and in connection with many places of worship are efficient day-schools. It is to be regretted that the people do not fully avail themselves of the many facilities for education offered to them.

Among the educational establishments of the town are the People's College, a self-supporting institution, conducting efficient day and evening classes; the Church of England Educational Institute, managed by several of the clergy and influential laymen with great success; and the Mechanics' Institution, which here languishes. The Government School of Art at Sheffield is one of the best conducted of these institutions in the provinces. The Wesley College and the Collegiate School (Church of England), with the old endowed Grammar School, are the principal institutions, excepting private schools, for the education of the middle classes.

The Cutlers' Company, known throughout the kingdom by its anniversary, called the "Cutlers' Feast," had its origin in the sixteenth century in certain trade regulations, wholly opposed to modern ideas, "agreed upon by the whole fellowshippe of cutlers," sanctioned by the then Earl of Shrewsbury, and enrolled among the records of his manor court. The company was incorporated by statute in the 21st James I., but its restrictive powers, having been mitigated in 1801, were swept away in 1814. It has since had little further power than to grant marks to the manufacturers of "knives, sickles, shears, scissors, and other cutlery wares." Application will be made to parliament in 1860 for a new act, to enable the company to admit the "makers of razors, files, forks, saws, edge-tools, and other articles of steel, or steel and iron combined, having a cutting edge, and manufacturers of steel." This measure is necessary to reinvigorate the company, which is the trustee of several important charities. Sheffield is well and cheaply supplied with gas and water by joint-stock companies. The relations of Sheffield to the railway system were for many years unsatisfactory. Surrounded by hills, except on the north-east, it suffered peculiar disadvantages. In 1838, the Sheffield and Rotherham line connected it with the Midland, which was soon after opened. In 1845 a line was opened from Manchester to Sheffield; and in 1849 the line was continued eastward to New Holland, on the Humber, and Grimsby, on the Lincolnshire coast. Till 1857 this line was allied to the London and North-Western, but in that year a treaty was made with the Great Northern, which thus obtained access to Manchester, and put Sheffield on a main line from that town to London. Out of this change of policy arose the memorable war of 1857–8 between the London and North-Western and the Great Northern. By the South Yorkshire Railway, Sheffield has connection with Barnsley, Doncaster, and Goole; and by the canal made in 1818, now in the hands of this company, it has water communication with the Humber. The old private banks of Sheffield have been replaced by joint-stock companies. Freehold land societies, formed to purchase estates, and divide them in allotments among thriving artisans and small tradesmen, were introduced here in 1849, and have been very successful. Up to 1858 these societies had purchased thirty estates, containing 477 acres, for L.96,000. They had spent in drains, roads, and fencing, about L.29,700, and in buildings about L.130,000. They had formed 2600 allotments, at an average cost of L.48. Upwards of seventy acres more have since been purchased. The present value of the allotments, with the buildings upon them, is estimated at L.400,000.

Sheffield is rather behind other large towns in facilities for the amusement and recreation of the inhabitants. There is great want of a capacious public hall for the holding of important meetings and for popular concerts. The town-hall, built fifty years ago, is inadequate to the present necessities of the town. The corporation, instead of erecting a hall, have rented the old assembly rooms. The botanical gardens, consisting of eighteen acres, beautifully situated, are well maintained. The Duke of Norfolk has laid out a park on the east side of the town for the benefit of the public.

The benevolent institutions of the town are well sustained. The infirmary, opened in 1797, has been considerably enlarged. Hospital wards have this year (1859) been added to the public dispensary. The Shrewsbury Hospital, opened in 1673, the Hollis' Hospital of 1703, and the Licensed Victuallers' Asylum of 1848, afford refuge for decayed and deserving old people. The Deakin institution, established in 1852, grants pensions to unmarried females above forty years of age, and has conferred a great boon on a number of ladies reduced to very deplorable circumstances. The savings bank has made moderate progress, and is well managed. In 1832, its deposits were L.89,085; in 1836, L.147,136; in 1858, L.276,738.

During the last thirty years the social habits of the town have greatly changed. It has become the custom of nearly all the manufacturers and richer tradesmen to reside in the suburbs, and luxury has immensely increased. The streets in the centre of the town are now thronged with cabs, omnibuses, and other vehicles, but they still remain narrow, crooked, and steep, as they were fifty years ago. In 1852,

Sheffield.

an act was obtained, under which several much-needed bridges, with approaches, have been made, and a rate at 3d. in the pound is expected to defray the cost in from twenty to thirty years. Two attempts to obtain an act of parliament to improve the town in sanitary and other arrangements, have been defeated by popular hostility. Sheffield is well situated for drainage, but as no power exists to make drains on a comprehensive plan, independently of township boundaries, each township pours its separate contribution into the rivers flowing through the town, by which they are rendered very pernicious and offensive.

In regard to the sanitary state of Sheffield, we are indebted for the following particulars to C. J. Shearman, Esq., M.D., who has been engaged in elaborate investigations on the subject:—

According to the returns of the Registrar-General, the gross mortality of Sheffield is 1 to each 27 of the population, male and female; whereas the normal mortality of England, when free from pre-disposing causes of disease, is 1 in 17. One great cause of this increase of mortality is the prevalence of children's diseases. The mortality of males and females per cent. at each age, calculated for the 7 years 1848–54 inclusive, is below:—

Males.			Females.		
Ages.	Sheffield.	England.	Ages.	Sheffield.	England.
5	1·196	·925	5	1·166	·922
10	·6546	·514	10	·4528	·535
15	1·557	·822	15	1·286	·851
25	·986	·997	25	1·015	1·051
35	1·311	1·260	35	1·390	1·274
45	2·093	1·839	45	1·699	1·589
55	3·502	3·190	55	2·651	2·834
65	6·618	6·721	65	5·172	6·026
75	11·401	14·696	75	9·312	13·446
85	22·03	30·202	85	13·63	27·917
95 and over	...	46·169	95 and over	15·55	45·200

The mortality of children's diseases for the same years being to 100 population—

Smallpox	·07	Hooping cough	·09	Water on the brain	·08
Measles	·11	Croup	·03		
Scarlet fever	·17	Diarrhœa	·03	Scrofula	·008

The births for the same years were in the proportion of 1 to each 24 of the population annually.

From the returns of the Registrar of Sheffield (arranged through the kind permission of the Registrar-General), the following results are deduced as to the mortality in 81 occupations, the majority of which are peculiar to Sheffield:—

Mortality per cent. of out-door heavy occupations	1·5
" " " light "	1·82
" " in-door heavy "	1·18
" " " light "	1·84
" " masons and bricklayers	1·5
" " file-cutters	1·98
" " cutlers, fitters, bench-work tailors, shoemakers, &c.	1·72
" " merchants, manufacturers, and gentlemen	2·9
" " labourers	5·0
" " grinders	4·7

The grinders suffer markedly from diseases of the lungs, of which one disease has been considered peculiar to them —grinder's asthma or rot—induced by inhaling the dust from the grinding-stones. It is most prevalent among dry grinders. This affection is less common than in former years, from the dust being carried off in many factories by a fan. Bronchitis and pneumonia are the other prevailing causes of death in this class. Gentlemen suffer most from intestinal, stomach, liver, and kidney diseases; considerably less than other large towns from tubercular disease, either general or of the lungs; and are prone to the inroad of typhus and other fevers. Cutlers are much affected with diseases of the heart and inflammation of the lungs, with secondary affections of the abdomen, more particularly after the 40th year of age. They suffer less from consumptive disease, but are prone to attacks of continued and remittent fever. The other occupations carried on in shops, as fitters, engaged in brass, Britannia metal, and German silver work, &c., are especially liable to disease of the heart, apoplexy, disease of the liver, and fever; less so to consumption. File-cutters suffer little from tubercular disease of the lungs after 35 years of age; but after that time most markedly from apoplexy, pleurisy, liver disease, and secondary abdominal disease, partly induced by cutting on lead. The other occupations present no great peculiarity of inducing special diseases.

The mortality per cent. from various diseases of Sheffield for the years 1848 to 1854 is annually to the living population as follows:—

Smallpox	·076	Typhus fever	·004	Pleurisy, Pneumonia	·2
Measles	·11	Erysipelas	·008		
Scarlatina	·16	Hydrocephalus	·076	Asthma	·005
Hooping cough	·076	Tabes Mesenterica	·000	Consumptive disease of lung	·48
Croup	·036				
Thrush	·0007	Diabetes	·000		
Diarrhœa	·036	Inebria	·0007	Cardiac	·0035
Dysentery	·000	Scrofula	·004	Hepatitis	·006
Cholera	·0003	Atrophy	·022	Jaundice	·006
Influenza	·000	Quinsey	·0007	Liver disease	·02
Ague	·000	Bronchitis	·0005	Dropsy	·061
Remittent fever	·004	Hydrothera	·001		

Habits of improvidence, fostered by the high scale of wages, marked tendency to free living both in the operative and employer, together with a malarious character of atmosphere, are the chief agents in raising the rate of mortality in Sheffield. The state of the rivers, and the proximity of some of the reservoirs which supply the town, furnish the latter element of disease. The great proportion of publicans to the population (1 to 142 over 20 years of age) is an indication of the state of supply and demand of this agent of disease.

The chief book of authority on the history, antiquities, &c., of Sheffield is *The History of Hallamshire*, by the Rev. Joseph Hunter, F.S.A., published in folio in 1819. (R. L.)

SHEFFIELD, John, *Duke of Buckinghamshire*, an eminent statesman, poet, and wit of England, was born in 1649. He lost his father at nine years of age; and his mother having married again, the care of his education was left entirely to a governor, who did not greatly improve him in his studies. Finding that he was deficient in many parts of literature, he resolved to devote a certain number of hours every day to his studies, and thereby improve himself to the degree of learning which he afterwards attained. Though possessed of a good estate, he did not abandon himself to pleasure and indolence, but entered as a volunteer in the second Dutch war, and was in that famous naval engagement where the Duke of York commanded as admiral; upon which occasion his lordship behaved so gallantly, that he was appointed commander of the Royal Catherine. He afterwards made a campaign in the French service under M. de Turenne. As Tangier was in danger of being taken by the Moors, he offered to head the forces which were sent to defend it, and accordingly was appointed to command them. He was then Earl of Mulgrave, and one of the lords of the bed-chamber to Charles II. The Moors retired on the approach of his Majesty's forces; and the result of the expedition was the blowing up of Tangier. He continued in several great posts during the short reign of James II., till that unfortunate prince was dethroned. Lord Mulgrave, though he paid his respects to King William before he was advanced to the throne, yet did not ac-

cept of any post in the government until some years afterwards. In the sixth year of William and Mary he was created Marquis of Normandy in the county of Lincoln. He was one of the most active and zealous opponents of the bill which took away Sir John Fenwick's life; and exerted the utmost vigour in carrying through the Treason Bill, and the bill for Triennial Parliaments. He enjoyed some considerable posts under King William, and possessed much of his favour and confidence. In 1702 he was sworn lord privy-seal; and in the same year was appointed one of the commissioners to treat of an union between England and Scotland. In 1703 he was created Duke of Normandy, and soon after Duke of Buckinghamshire. In 1711 he was made steward of her Majesty's household and president of the council. During Queen Anne's reign he was but once out of employment; and then he voluntarily resigned, being a confirmed Tory. Her Majesty offered to make him lord chancellor, but he declined the office. He was instrumental in the change of the ministry in 1710. A circumstance that reflects the highest honour on him, is the vigour with which he acted in favour of the unhappy Catalans, who were afterwards so inhumanly sacrificed. He died in 1721.

He was thrice married. By his two first wives he had no children; by his third, who was a daughter of King James by the Countess of Dorchester, and the widow of the Earl of Anglesey; he had besides other children, who died young, a son born in 1716, and who died at Rome in 1735, and put an end to the line of Sheffield. He was admired by the poets of his age; by Dryden, Pope, Prior, and Garth. His *Essay on Poetry* was applauded by Addison, and his *Rehearsal* is still read with pleasure. His writings were splendidly printed in 1723, in two volumes 4to, and have since been reprinted in 1729, in two volumes 8vo. The first contains his poems on various subjects; the second, his prose works, consisting of historical memoirs, speeches in Parliament, characters, dialogues, critical observations, essays, and letters. It may be proper to observe, that the edition of 1729 is castrated, some particulars relating to the revolution having given offence. Dr Johnson remarks on Sheffield, that " criticism is no longer softened by his bounties or awed by his splendour, and being able to take a more steady view, discovers him to be a writer that sometimes glimmers but rarely shines, feebly laborious, and at best but pretty. His songs are upon common topics; he mopes and grieves, and repents and despairs, and rejoices, like any other maker of little stanzas; to be great he hardly tries; to be gay is hardly in his power. . . . His verses are often insipid, but his memoirs are lively and agreeable; he had the perspicuity and elegance of an historian, but not the fire and fancy of a poet." (Cunningham's edition of Johnson's *Lives of the Poets*, 1854.)

SHEHR, a seaport on the south-east coast of Arabia, 32 miles E.N.E. of Makallah; N. Lat. 14. 43., E. Long. 49. 40. It stretches about a mile along the shore, and consists of houses, for the most part large and good, irregularly grouped together. The chief buildings are a castle, where a sultan resides, a custom-house, and several mosques. Coarse cotton-cloth, gunpowder, and arms are manufactured here; and a considerable trade is carried on. There is an open roadstead about a mile from the shore, with good anchorage. Pop. 6000.

SHEIL, Richard Lalor, the son of Edward Sheil, who, in his early years, had made a considerable fortune as a merchant at Cadiz, was born on the 17th of August 1791, at Drumdowney, a small country house, then occupied by his family previously to the completion of Bellevue, near Waterford, which his father had recently purchased. The home of the childhood of Sheil was situated amid charming scenery, on the left bank of the Suir. On the mind of the moody and imaginative boy it made a deep and lasting impression. His first instructions were received in French and Latin from a French Abbé; and he was subsequently conducted to Kensington-House School, London, an institution, presided over by Monsieur le Prince de Broglie, for the children of French refugees. Having spent some short time here, where the instruction was miserably defective, he next proceeded to a Jesuit school at Stoneyhurst, near Clitheroe in Lancashire, on the 24th of October 1804. Here he soon rose to a distinguished position in the school, and seems even then to have formed plans for his future conduct, which implied either a strong natural disposition to dramatic oratory, or an eminent degree of quickness and sagacity in divining where the power of the public speaker lay. In recitation, it was observed, he displayed singular flexibility of intonation, and a matchless ear for rhythm; but laboured under the almost insuperable difficulty, and one from which he never recovered, of having a sharp, squeaking, tuneless voice. He left Stoneyhurst in 1807, and entered Trinity College, Dublin, and subsequently resolved to study for the bar. Meanwhile his father had been ruined by commercial speculations, and his family had removed to Dublin. He took his degree of bachelor of arts in July 1811, and shortly after entered Lincoln's Inn, recently opened to Roman Catholics, to study for the Irish bar. Sheil was a leader in all public societies, both in Dublin and London, constantly declaiming or debating, according to the temper of those among whom he moved. His speeches were more noted for their gorgeous display of imagination than for the harder elements of argument; but the forensic club of Lincoln's Inn did much to correct this extravagant tendency in the young Irish lawyer. One catches a glimpse of a very attractive speech, delivered by Sheil about this time, on the side of the Vetoists, in O'Connell's rude castigation of it, when that brilliant speaker "rose to unravel the flimsy web of sophistry which was hid beneath the tinsel glare of meretricious ornament." Making allowance for the rhetorical tricks in which the great " Agitator" was fond of indulging, this criticism at least lays bare, in a somewhat rough manner, the darling sin of Sheil's early days of speech-making.

Richard Sheil was called to the bar in 1814, and contrived to eke out his scanty revenue by writing some really successful dramas. These were, *Adelaide*, 1816; the *Apostate*, 1817; *Bellamira*, 1818; *Evadne*, a rifacimento of Shirley's *Traitor*, 1819; *Montoni*, 1820; and *The Huguenot*, 1822, the last and the best of his dramatic compositions, but which met with almost total neglect. Could this be accounted for by the absence of the popular actress, Miss O'Neil? At all events, she had appeared hitherto in all Sheil's former dramas, and was only withheld from representing her part in the *Huguenot* by her marriage with Sir William Beecher. This was the opinion of Mr Macready, who sustained his part in this play with his accustomed *eclât*. It was the last dramatic composition in which Sheil indulged. Henceforward he devoted his spare energies to the more remunerative walk of politico-religious agitation.

In the year 1822 appeared the first of those well-known *Sketches of the Irish Bar*, which came out in the *New Monthly Magazine*, then conducted by the poet Campbell. These *Sketches* have since been published, in 2 vols., 1855. Here Sheil achieved a considerable literary reputation; and one can hardly help regretting that so little of the energy of a very superior mind should have been given to what, in the long run, would have proved a more remunerative expenditure for the resources of his genius than the business of an agitator, however successful. But he was possibly compelled, both from temperament and from necessity, to think more of the "bubble reputation" of the hour, than of the slower but more enduring fame which attends all the permanent productions of an exalted mind.

Sheil.

In keen observation, in subtle sensibility, in high imagination, and in acute analysis, these *Sketches* found few equals among the best productions of the day. They are doubtless tinctured, sometimes, too largely with a tendency to extravagance, both in conception and in expression; but the luxuriance is always kept in such fine proportion and subordination to the whole picture, and the idealization is constantly so elevated and grand, that the reader, although finding, on reflection, that it is not all real, is disposed to pardon the writer who has ministered so largely to his enjoyment, by presenting him with a series of dazzling delineations of the passing life and manners of the time. Sheil became a member of the Catholic Association in 1822, and three years afterwards was chosen, in conjunction with O'Connell, to plead at the bar of the House of Commons against the bill introduced for its suppression. The bill was passed into law; and the more incautious of the agitators became so violent in their oratorical zeal, that a prosecution of Sheil ensued, on a charge of having uttered seditious language. This prosecution was suddenly put an end to by the elevation of Mr Canning to the premiership. In the month of June 1827 Sheil received a severe fracture of the leg, caused by a fall from his horse, which confined him to his room for a considerable time. For the past three or four years he had familiarized himself to the Irish people. There had scarcely been a political meeting of any note, all over the country, from Sligo to the Boyne, that had not been inflamed by his speeches. He addressed meetings at night, he declaimed to assemblages by day, he harangued the electors of Clare to choose O'Connell for their representative. Ere the election week was over, the "Agitator" was returned by an immense majority; the wild huzzas of the peasants and the soldiery from the swarming hillsides adjoining rending the still July air, as a signalling of the triumph of what lay near to their hearts. The 24th of October 1828 has likewise to be recorded as one of those occasions on which Richard Sheil gained one of his oratorical triumphs. The meeting was held at Penenden Heath, in Kent, to petition against the passing of the Emancipation Bill; and of Sheil's appearance on that occasion Bentham said, "So masterly an union of logic and rhetoric as Mr Sheil's speech scarcely have I ever beheld." By the year 1829 he had attained considerable eminence at the bar, and next year he received his silk gown. On the 20th July of the same year he contracted a second marriage with Anastasia Laalor, the widow of Mr. Power of Waterford, and from whom he acquired the addition of Lalor to his name, and a considerable addition to his means. Early in the year 1830 Lord Anglesea, then Lord-Lieutenant of Ireland, wrote to Sheil, informing him that he might be returned for Milborne Port, in Dorsetshire. He readily embraced the offer; the long day-dream of his whole life was now to be fulfilled. The eloquent sarcasm and badinage of the agitator was now to be exchanged for the more peaceful and direct, if not less striking, manœuvring of facts to suit the humour of the House. Nature, as has been already said, had been scrimp enough in her justice to Sheil as an orator. Yet Christopher North, in one of his *Noctes Ambrosianæ* (for Aug. 1831), in which he, as usual, abuses those who were not of his own party, says of the Irish orator on his appearance in the House, "Nature has given him as fine a pair of eyes as ever graced human head,—large, deeply set, dark, liquid, flashing like gems, and these fix you like a basilisk, so that you forget everything else about him." Sheil rapidly rose to be one of the foremost speakers in the House of Commons. Except Lord Stanley (now Lord Derby), for Macaulay was then absent in India, he might fairly be said to be without an oratorical rival in the House. Cobden, speaking of the vehemence of his manner, the intensity of his look, and his dramatic power of intonation, in 1842, said, "It was not like any other man I had ever heard making a speech; he seemed to me like one possessed." After the passing of the Reform Act, Sheil had at first refused, but finally consented, to join O'Connell in the repeal agitation. In December 1832, he took his seat for the county of Tipperary, having previously occupied that of Louth. In 1838 he was offered office by the Melbourne administration, and accepted a commissionership of Greenwich Hospital. Henceforward there was no more talk of repeal by him. Next year he was made vice-president of the Board of Trade, and was sworn into the Privy Council. He became Judge-Advocate-General in 1841, when he exchanged Tipperary for Dungarvan. On the advent of Lord John Russell to the premiership in 1846, Sheil was chosen Master of the Mint, a post which he held till November 1850, when he accepted the post of British ambassador to the court of Tuscany, and closed his parliamentary career. For twenty years he had occupied a prominent place in all the controversies of the state. Nearly all the principles for which he had contended had now become law; and the clouds which had gathered angrily in the political heavens when he commenced his career, had now shed away, and he could, in the calm sunset of his days, enjoy the glorious light as it fell soft and rosy over the landscape. But he had to take the prospect for the realization. He had been for many years troubled with the gout, and had taken to colchicum as an emollient of pain. The death of his own son sometime before, and the sad death of his step-son, all combined with this treacherous antidote to prey upon his health. He died at Florence of an attack of gout in the stomach, on the 23d of May 1851, in his fifty-ninth year. (See *Memoirs of the Right Honourable Richard Lalor Sheil*, by W. T. M'Cullagh, 2 vols., 1855.)

Shekel || Shelley.

SHEKEL, the name of a weight and coin current among the ancient Jews. Dr Arbuthnot makes the weight of the shekel equal to 9 pennyweights 2¼ grains troy weight, and the value of the silver coin equal to 2s. 3⅜d. sterling. The golden shekel is supposed to have been worth L.1, 16s. 6d.

SHELBURNE, Earl of. See Great Britain, Reign of George III.

SHELDON, Gilbert, Archbishop of Canterbury, was born on the 19th of July 1598, at Stanton, in Staffordshire. He was admitted into Trinity College, Oxford, in 1613, and obtained his degree of M.A. in May 28th, 1620. He was chosen fellow of All Souls' College, in 1622, and taking holy orders, he became domestic chaplain to Lord Coventry. Sheldon rose through successive stages of preferment, till at last he was appointed Archbishop of Canterbury. He died, enormously rich, on the 9th of November 1677. Besides building the theatre which still bears his name at Oxford, in 1699, he is said to have expended very large sums on charitable purposes.

SHELLEY, Percy Bysshe. Whatever opinion may be held with regard to the relative position occupied by Shelley as a poet, it will be granted by most of those who have studied his writings, that they are of such an individual and original kind, that he can neither be hidden in the shade, nor lost in the brightness, of any other poet. No idea of his works could be conveyed by instituting a comparison, for he does not sufficiently resemble any other among English writers to make such a comparison possible.

Percy Bysshe Shelley was born at Field Place, near Horsham, in the county of Sussex, on the 4th of August 1792. He was the son of Timothy Shelley, Esq., and grandson of Sir Bysshe Shelley, the first baronet. His ancestors had long been large landed proprietors in Sussex.

As a child his habits were noticeable. He was especially fond of rambling by moonlight, of inventing wonderful tales, of occupying himself with strange, and sometimes dangerous, amusements. At the age of thirteen he went to Eton. In this little world, that determined opposition to whatever appeared to him an invasion of human rights and

liberty, which was afterwards the animating principle of most of his writings, was first roused in the mind of Shelley. Were we not aware of far keener distress which he afterwards endured from yet greater injustice, we might suppose that the sufferings he had to bear from placing himself in opposition to the custom of the school, by refusing to fag, had made him morbidly sensitive on the point of liberty. At a time, however, when freedom of speech, as indicating freedom of thought, was especially obnoxious to established authorities; when no allowance could be made on the score of youth, still less on that of individual peculiarity, Shelley became a student at Oxford. He was then eighteen. Devoted to metaphysical speculation, and especially fond of logical discussion, he, in his first year, printed and distributed among the authorities and members of his college a pamphlet, if that can be called a pamphlet which consisted only of two pages, in which he opposed the usual arguments for the existence of a Deity; arguments which, perhaps, the most ardent believers have equally considered inconclusive. Whether Shelley wrote this pamphlet as an embodiment of his own opinions, or merely as a logical confutation of certain arguments, the mode of procedure adopted with him was certainly not one which necessarily resulted from the position of those to whose care the education of his opinions was entrusted. Without waiting to be assured that he was the author, and satisfying themselves with his refusal to answer when questioned as to the authorship, they handed him his sentence of expulsion, which had been already drawn up in due form.

About this time Shelley wrote, or commenced writing, *Queen Mab*, a poem which he never published, although he distributed copies amongst his friends. In after years he had such a low opinion of it in every respect, that he regretted having printed it at all; and when an edition of it was published without his consent, he applied to the Court of Chancery for an injunction to suppress it.

Shelley's opinions in politics and theology, which he appears to have been far more anxious to maintain than was consistent with the peace of the household, were peculiarly obnoxious to his father, a man as different from his son as it is possible to conceive; and his expulsion from Oxford was soon followed by exile from his home. He went to London, where, through his sisters, who were at school in the neighbourhood, he made the acquaintance of Harriet Westbrook, whom he eloped with and married, when he was nineteen and she sixteen years of age. It seems doubtful whether the attachment between them was more than the result of the reception accorded by the enthusiasm of the girl to the enthusiasm of the youth, manifesting itself in wild talk about human rights, and equally wild plans for their recovery and security. However this may be, the result was unfortunate. They wandered about England, Scotland, and Ireland, with frequent and sudden change of residence, for rather more than two years. During this time Shelley gained the friendship of some of the most eminent men of the age; of whom the one who exercised the most influence upon his character and future history was William Godwin. The instructions and expostulations of this eminent writer tended to reduce to solidity and form, the vague and extravagant opinions and projects of the youthful reformer. Shortly after the commencement of the third year of their married life, an estrangement of feeling, which had been gradually widening between them, resulted in their final separation. We are not informed as to the causes of this estrangement, further than that it seems to have been owing, in a considerable degree, to the influence of an elder sister of Mrs Shelley, who domineered over her, and whose presence became at last absolutely hateful to Shelley. His wife returned to her father's house; where, apparently about three years after, she committed suicide. There seems to have been no immediate connection between this act and any conduct of Shelley. One of his biographers informs us, that while they were living happily together, suicide was a favourite subject of speculation and conversation with Mrs Shelley.

Shortly after his first wife's death, Shelley married the daughter of William Godwin. He had lived with her almost from the date of the separation. During this time they had twice visited Switzerland. In the following year (1817), it was decreed in Chancery that Shelley was not a proper person to take charge of his two children, left by his first wife, who had lived with her till her death. The bill was filed in Chancery by their grandfather. The effects of this proceeding upon Shelley may be easily imagined. Perhaps he never recovered from them, for they were not of a nature to pass away. During this year he resided at Marlow, and wrote *The Revolt of Islam*, besides portions of other poems. In the following year (1818), he left England, not to return. The state of his health, for he had appeared to be in a consumption for some time, and the fear lest his son, by his second wife, should be taken from him, combined to induce him to take refuge in Italy from both impending evils. At Lucca he began his *Prometheus*, and wrote *Julian and Maddalo*. He moved from place to place in Italy, as he had done in his own country. Their two children dying, they were for a time left childless; but the loss of these grieved Shelley less than that of his eldest two, who were taken from him by the hand of man. In 1819, Shelley finished his *Prometheus Unbound*, writing the greater part at Rome, and completing it at Florence. In this year also he wrote his tragedy, *The Cenci*. This attracted more attention during his lifetime than any other of his works. The *Ode to a Skylark* was written at Leghorn in the spring of 1820; and in August of the same year, the *Witch of Atlas* was written, near Pisa. In the following year Shelley and Byron met at Pisa. They were a good deal together; but their friendship, although real, does not appear to have been of a very profound nature; for though unlikeness be one of the necessary elements of friendship, there are kinds of unlikeness which will not harmonize. During all this time, he was not only maligned by unknown enemies, and abused by anonymous writers, but attempts of other kinds are said to have been made to render his life as uncomfortable as possible. There are grounds, however, for doubting whether Shelley was not subject to a kind of monomania upon this and similar points. In 1821, he wrote his *Adonais*, a monody on the death of Keats. Part of this poem had its origin in the mistaken notion, that the illness and death of Keats were caused by a brutal criticism of his *Endymion*, which appeared in the *Quarterly Review*. The last verse of the *Adonais* seems almost prophetic of his own end. Passionately fond of boating, he and a friend of his, Mr Williams, united in constructing a boat of a peculiar build, a very fast sailer, but difficult to manage. On the 8th of July, 1822, Shelley and his friend Williams sailed from Leghorn for Lerici, on the Bay of Spezia, near which lay his home for the time. A sudden squall came on, and their boat disappeared. The bodies of the two friends were cast on shore; and, according to quarantine regulations, were burned to ashes. Lord Byron, Leigh Hunt, and Mr Trelawney, were present when the body of Shelley was burned; so that his ashes were saved, and buried in the Protestant burial-ground at Rome, near the grave of Keats, who had been laid there in the spring of the preceding year. *Cor Cordium* were the words inscribed by his widow on the tomb of the poet.

The character of Shelley has been sadly maligned. Whatever faults he may have committed against society, they were not the result of sensuality. One of his biographers, who was his companion at Oxford, and who does not seem inclined to do him *more* than justice, asserts that

while there his conduct was immaculate. The whole picture he gives of the youth, makes it easy to believe this. To discuss the moral question involved in one part of his history would be out of place here; but even on the supposition that a man's conduct is altogether inexcusable in individual instances, there is the more need that nothing but the truth should be said concerning that, and other portions thereof. And whatever society may have thought itself justified in making subject of reprobation, it must be remembered that Shelley was under less obligation to society than most men. Yet his heart seemed full of love to his kind; and the distress which the oppression of others caused him, was the source of much of that wild denunciation which exposed him to the contempt and hatred of those who were rendered uncomfortable by his unsparing and indiscriminating anathemas. In private, he was beloved by all who knew him; a steady, generous, self-denying friend, not only to those who moved in his own circle, but to all who were brought within the reach of any aid he could bestow. To the poor he was a true and laborious benefactor. That man must have been good to whom the heart of his widow returns with such earnest devotion and thankfulness in the recollection of the past, and such fond hope for the future, as are manifested by Mrs Shelley in those extracts from her private journal given us by Lady Shelley.

As regards his religious opinions, one of the thoughts which most strongly suggest themselves is,—how ill he must have been instructed in the principles of Christianity! He says himself in a letter to Godwin, "I have known no tutor or adviser (*not excepting my father*) from whose lessons and suggestions I have not recoiled with disgust." So far is he from being an opponent of Christianity properly so called, that one can hardly help feeling what a Christian he would have been, could he but have seen Christianity in any other way than through the traditional and practical misrepresentations of it which surrounded him. All his attacks on Christianity are, in reality, directed against evils to which the true doctrines of Christianity are more opposed than those of Shelley could possibly be. How far he was excusable in giving the name of Christianity to what he might have seen to be only a miserable perversion of it, is another question, and one which hardly admits of discussion here. It was in the *name* of Christianity, however, that the worst injuries of which he had to complain were inflicted upon him. Coming out of the cathedral at Pisa one day,[1] Shelley warmly assented to a remark of Leigh Hunt, "that a divine religion might be found out, if charity were really made the principle of it instead of faith." Surely the founders of Christianity, even when they magnified faith, intended thereby a spiritual condition, of which the central principle is coincident with charity. Shelley's own feelings towards others, as judged from his poetry, seem to be tinctured with the very essence of Christianity.[2] He did not, at one time at least, believe that we could know the source of our being; and seemed to take it as a self-evident truth, that the Creator could not be like the creature. But it seems injustice to fix upon any utterance of opinion, and regard it as the religion of a man who died in his thirtieth year, and whose habits of thinking were such, that his opinions must have been in a state of constant change. Coleridge says in a letter: "His (Shelley's) discussions, tending towards atheism of a certain sort, would not have scared *me;* for *me* it would have been a semi-transparent larva, soon to be sloughed, and through which I should have seen the true *image*—the final metamorphosis. Besides, I have ever thought that sort of atheism the next best religion to Christianity; nor does the better faith I have learned from Paul and John interfere with the cordial reverence I feel for Benedict Spinoza."

Shelley's favourite study was metaphysics. The more impulse there is in any direction, the more education and experience are necessary to balance that impulse: one cannot help thinking that Shelley's *taste* for exercises of this kind was developed more rapidly than the corresponding *power*. His favourite physical studies were chemistry and electricity. With these he occupied himself from his childhood; apparently, however, with more delight in the experiments themselves, than interest in the general conclusions to be arrived at by means of them. In the imbodiment of his metaphysical ideas in poetry, the influence of these studies seems to appear. For the forms chosen are of an external physical kind, belonging, in their association with the idea, to the realm of the fancy, rather than chosen by the imaginative power, because of an inward vital resemblance. Logic had considerable attractions for him. To geometry and mathematics he was quite indifferent. One of his biographers states, that "he was neglectful of flowers," because he had no interest in botany; but one who derived such full delight from the contemplation of their external forms, could hardly be expected to feel very strongly the impulse to dissect and explore. He derived exceeding pleasure from Greek literature, especially from the works of Plato.

Several little peculiarities in Shelley's tastes are worth mentioning, because, although in themselves insignificant, they seem to correspond with the nature of his poetry. Perhaps the most prominent of these was his passion for boat-sailing. He could not pass any piece of water without launching upon it a number of boats, constructed from what paper he could find in his pockets. The fly-leaves of the books he was in the habit of carrying with him, for he was constantly reading, often went to this end. He would watch the fate of these boats with the utmost interest, till they sank or reached the opposite side. He was just as fond of real boating, and that frequently of a dangerous kind; but it is characteristic of him, that all the boats he describes in his poems are of a fairy, fantastic sort, barely related to the boats which battle with earthly winds and waves. Pistol-shooting was also a favourite amusement. Fire-works, too, gave him great delight. Some of his habits were likewise peculiar. He was remarkably abstemious, preferring bread and raisins to anything else in the way of eating, and very seldom drinking anything stronger than water. Honey was a favourite luxury with him. While at college his biographer Hogg says he was in the habit, during the evening, of going to sleep on the rug, close to a blazing fire, heat seeming never to have other than a beneficial effect upon him. After sleeping some hours he would awake perfectly restored, and continue actively occupied till far into the morning. His whole movements are represented as rapid, hurried, and uncertain. He would appear and disappear suddenly and unexpectedly; forget appointments; burst into wild laughter, heedless of his situation, whenever anything struck him as peculiarly ludicrous. His changes of residence were most numerous, and frequently made with so much haste that whole little libraries were left behind, and often lost. He was very fond of children, and used to make humorous efforts to induce them to disclose to him the still-remembered secrets of pre-existence. He seemed to have a peculiar attraction towards the unknown, and was ready to believe there was a secret hidden, where no one

[1] From *Shelley Memorials*, edited by Lady Shelley, which the writer of this paper has principally followed in regard to the external facts of Shelley's history.

[2] His *Essay on Christianity* is full of noble views, some of which are held at the present day by some of the most earnest believers. At what time of his life it was written we are not informed; but it seems such as would insure his acceptance with any company of intelligent and devout Unitarians.

Shelley. else would have thought of one. His room, while he was at college, was in a state of indescribable confusion. Not only were all sorts of personal necessaries mingled with books and philosophical instruments, but things belonging to one department of service were not unfrequently pressed into the slavery of another. He dressed well but carelessly. In person he was tall, slender, and stooping; awkward in gait, but in manners a thorough gentleman. His complexion was delicate; his head, face, and features, remarkably small; the last not very regular, but in expression, both intellectual and moral, wonderfully beautiful. His eyes were deep blue, "of a wild, strange beauty;" his forehead high and white; his hair dark brown, curling, long, and bushy. His appearance in later life is described as singularly combining the appearances of premature age and prolonged youth.

The only art in which his taste appears to have been developed was poetry. Even in his poetry, taken as a whole, the artistic element is not generally very manifest. His earliest verses (none of which are included in his collected works) can hardly be said to be good in any sense. He seemed in these to find poetry a fitting material for the imbodiment of his ardent, hopeful, indignant thoughts and feelings; and provided he could say what he wanted to say, does not seem to have cared much about the *how*. Indeed, there is too much of this throughout his works; for if the *utterance*, instead of the *conveyance* of thought, were the object sought in art, of course, not merely imperfection of language, but absolute external unintelligibility, would be unobjectionable. But his art constantly increases with his sense of its necessity; so that the *Cenci*, which is the last work of any pretension that he wrote, is decidedly the most artistic of all. There are beautiful passages in *Queen Mab*, but it is the work of a boy-poet; and as it was all but repudiated by himself, it is not necessary to remark further upon it. *The Revolt of Islam* is a poem of twelve cantos, in the Spenserian stanza; but in all respects, except the arrangement of lines and rhymes, it, in common with all other imitations of the Spenserian stanza, has little or nothing of the spirit or individuality of that stanza. The poem is dedicated to the cause of freedom, and records the efforts, successes, defeats, and final triumphant death of two inspired champions of liberty—a youth and maiden. The adventures are marvellous, not intended to be within the bounds of probability, scarcely of possibility. There are very noble sentiments and fine passages throughout the poem. Now and then there is grandeur. But the absence of art is too evident in the fact that the meaning is often obscure; an obscurity not unfrequently occasioned by the difficulty of the stanza, which is the most difficult mode of composition in English, except the rigid sonnet. The words and forms he employs to express thought seem sometimes mechanical devices for that purpose, rather than an utterance which suggested itself naturally to a mind where the thought was vitally present. The words are more a *clothing* for the thought than an *imbodiment* of it. They do not lie near enough to the thing which is intended to be represented by them. It is, however, but just to remark, that some of the obscurity is owing to the fact, that, even with Mrs Shelley's superintendence, the works have not yet been satisfactorily edited, or at least not conducted through the press with sufficient care.

The Cenci is a very powerful tragedy, but unfitted for public representation by the horrible nature of the historical facts upon which it is founded. In the execution of it, however, Shelley has kept very much nearer to nature than in any other of his works. He has rigidly adhered to his perception of artistic propriety in respect to the dramatic utterance. It may be doubted whether there is sufficient difference between the modes of speech of the different actors in the tragedy; but it is quite possible to individualize speech far too minutely for probable nature; and in this respect, at least, Shelley has not erred. Perhaps the action of the whole is a little hurried, and a central moment of awful repose and fearful anticipation might add to the force of the tragedy. The scenes also might, perhaps, have been constructed so as to suggest more of evolution; but the central point of horror is most powerfully and delicately handled. You see a possible spiritual horror yet behind, more frightful than all that has gone before. The whole drama, indeed, is constructed around, not a prominent point, but a dim, infinitely-withdrawn, underground perspective of dismay and agony. Perhaps it detracts a little from our interest in the Lady Beatrice, that after all she should wish to live, and should seek to preserve her life by a denial of her crime. She, however, evidently justifies the denial to herself on the ground that, the deed being absolutely right, although regarded as most criminal by her judges, the only way to get true justice is to deny the fact, which, there being no guilt, she might consider as only a verbal lie. Her very purity of conscience enables her to utter this with the most absolute innocence of look, and word, and tone. This is probably a historical fact, and Shelley has to make the best of it. In the drama there is great tenderness, as well as terror; but for a full effect, one feels it desirable to be brought better acquainted with the individuals than the drama, from its want of graduation, permits. Shelley, however, was only six-and-twenty when he wrote it. He must have been attracted to the subject by its embodying the concentration of tyranny, lawlessness, and brutality in old Cenci, as opposed to, and exercised upon, an ideal loveliness and nobleness in the person of Beatrice. Shelley.

But of all Shelley's works, the *Prometheus Unbound* is that which combines the greatest amount of individual power and peculiarity. There is an airy grandeur about it, reminding one of the vast masses of cloud scattered about in broken, yet magnificently suggestive forms, all over the summer sky, after a thunderstorm. The fundamental ideas are grand; the superstructure, in many parts, so ethereal, that one hardly knows whether he is gazing on towers of solid masonry, rendered dim and unsubstantial by intervening vapour, or upon the golden turrets of cloudland, themselves born of the mist which surrounds them with a halo of glory. The beings of Greek mythology are idealized and etherealized by the new souls which he puts into them, making them think his thoughts and say his words. In reading this, as in reading most of his poetry, we feel that, unable to cope with the evils and wrongs of the world as it and they are, he constructs a new universe, wherein he may rule according to his will; and a good will in the main it is—good always in intent, good generally in form and utterance. Of the wrongs which Shelley endured from the collision and resulting conflict between his lawless goodness and the lawful wickedness of those in authority, this is one of the greatest,—that during the right period of pupillage, he was driven from the place of learning, cast on his own mental resources long before those resources were sufficient for his support, and irritated against the purest imbodiment of good by the harsh treatment he received under its name. If that reverence which was far from wanting to his nature, had been but presented, in the person of some guide to his spiritual being, with an object worthy of its homage and trust, it is probable that the yet free and noble result of Shelley's individuality would have been presented to the world in a form which, while it attracted still only the few, would not have repelled the many; at least, not by such things as were merely accidental in their association with his earnest desires and efforts for the wellbeing of humanity.

That which chiefly distinguishes Shelley from other writers is the unequalled exuberance of his fancy. The reader, say for instance in that fantastically brilliant poem, *The Witch of Atlas*, the work of three days, is overwhelmed

in a storm, as it were, of rainbow snow-flakes, and many-coloured lightnings, accompanied ever by "a low melodious thunder." The evidences of pure imagination in his writings are unfrequent as compared with those of fancy: there are not half the instances of the direct imbodiment of idea in form, that there are of the presentation of strange resemblances between external things.

One of the finest short specimens of Shelley's peculiar mode is his *Ode to the West Wind*, full of mysterious melody of thought and sound. But of all his poems, the most popular, and deservedly so, is the *Skylark*. Perhaps the *Cloud* may contest it with the *Skylark* in regard to popular favour; but the *Cloud*, although full of beautiful words and fantastic cloud-like images, is, after all, principally a work of the fancy; while the *Skylark*, though even in it fancy predominates over imagination in the visual images, forms, as a whole, a lovely, true, individual work of art; a *lyric* not unworthy of the *lark*, which Mason apostrophises as "sweet feathered lyric." The strain of sadness which pervades it is only enough to make the song of the lark human.

In *The Sensitive Plant*, a poem full of the peculiarities of his genius, tending through a wilderness of fanciful beauties to a thicket of mystical speculation, one curious idiosyncrasy is more prominent than in any other; curious, as belonging to the poet of beauty and loveliness: it is the tendency to be fascinated by what is ugly and revolting, so that he cannot withdraw his thoughts from it till he has described it in language, powerful, it is true, and poetic, when considered as to its fitness for the desired end, but, in force of these very excellencies in the means, nearly as revolting as the objects themselves. Associated with this is the tendency to discover strangely unpleasant likenesses between things; which likenesses he is not content with seeing, but seems compelled, perhaps in order to get rid of them himself, to force upon the observation of his reader. But the admirer of Shelley is not pleased to find that one or two passages of this nature have been omitted in the last editions of his works.

Few men have been more misunderstood or misrepresented than Shelley. Doubtless this has in part been his own fault, as Coleridge implies, when he writes to this effect of him: that his horror of hypocrisy made him speak in such a wild way, that Southey (who was so much a man of forms and proprieties) was quite misled, not merely in his estimate of his worth, but in his judgment of his character. But setting aside this consideration altogether, and regarding him merely as a poet, Shelley has written verse which will last as long as the English literature lasts; valuable not only from its excellence, but from the peculiarity of its excellence. To say nothing of his noble aims and hopes, Shelley will always be admired for his sweet melodies, lovely pictures, and wild prophetic imaginings. His indignant remonstrances, intermingled with grand imprecations, burst in thunder from a heart overcharged with the love of his kind, and roused to a keener sense of all oppression by the wrongs which sought to overwhelm himself. But as he recedes further in time, and men are able to see more truly the proportions of the man, they will judge, that without having gained the rank of a great reformer, Shelley had in him that element of wide sympathy and lofty hope for his kind which is essential both to the *birth* and the subsequent *making* of the greatest of poets. (G. M'D.)

SHELLEY, *Mary Wollstonecraft Godwin*, was the daughter of the distinguished author of *Caleb Williams*, and the second wife of Percy Bysshe Shelley, and was born in 1798. Her earliest production of any note was her novel of *Frankenstein*, which was conceived in 1816 when travelling with her husband and Lord Byron among the romantic scenery of Switzerland. It is wild and improbable, yet there are many holds on human interest comprised in this wonderful story. It was at once pronounced a classic by the novel readers, but time, as it generally does, has slightly reversed this judgment. *Frankenstein*, however, with all its faults, and they belong much more to conception than construction, was undoubtedly far ahead of the frantic terrors excited by Mrs Radcliffe, or the coarse and horrible delineations in which Maturin delighted to indulge his readers. Mrs Shelley did not again tempt the public for many years with the products of her fantastic genius. Her care for her husband was tender and ceaseless, and she had just published her *Valperga*, a novel, when the news of his death reached her. She subsequently wrote *Falkland*, *The Last Man*, *Lodore*, and the *Fortunes of Perkin Warbeck*, but much of her inspiration had flown with the death of Shelley. She likewise wrote a pleasing account of her *Rambles in Germany and Italy*; and in 1839 she published an edition of her husband's poems, and the following year this was followed up by a selection from his letters, and a few specimens of his prose writings. She died in London on the 1st of February 1851.

SHENDY, a town of Nubia, on the right bank of the Nile, 529 miles S. of Assuan, on the borders of Upper Egypt, and 207 N. of Sennaar; N. Lat. 16. 38., E. Long. 33. 15. It was formerly a place of much importance, having been the capital of the region that anciently formed the celebrated state of Meroe, and containing a population of 50,000; but it was laid waste by the Egyptian forces in 1822, and has never since recovered its former prosperity. The place now consists of a mere collection of mud huts, and has no buildings of any importance. Some trade is still carried on. European wares are imported through Egypt, and coffee from Abyssinia; while slaves and cattle are exported to Egypt. The population has now dwindled to about 4000.

SHEN-SI, a province of China, lying between N. Lat. 32. and 39. 30., E. Long. 106. and 111.; bounded on the N. by Mongolia, from which it is separated by the Great Wall, E. by the provinces of Shan-si and Honan, S. by those of Hou-pe and Se-chuen, and W. by that of Kan-su. Area, 67,504 square miles. Most of the surface is hilly; for in the south the Peh-ling range, between the valleys of the Hoang-ho and Yang-tze-keang, traverses the country; while in the north the ground is less elevated, and has a general slope towards the east. The principal river is the Hoang-ho, which flows along the eastern boundary of the province. It receives here several affluents of considerable size, such as the Loh, Wu-ting, and Wei-ho. The southern portion of the province is watered by several affluents of the Yang-tze-keang. Shen-si is not so productive as some of the other Chinese provinces. It yields wheat, millet, musk, rhubarb, cinnabar, lead, woollen fabrics, &c. The capital is Se-gan-foo, which was for a long time the metropolis of China. Pop. (1812) 10,207,256; (1843) 10,500,000.

SHENSTONE, WILLIAM, an admired English poet, the eldest son of a plain country gentleman, who farmed his own estate in Shropshire, was born at Leasowes in November 1714. He learned to read of an old dame, whom his poem of the *Schoolmistress* has delivered to posterity; and he soon received such delight from books, that he was always calling for new entertainment, and expected that, when any of the family went to market, a new book should be brought him. As he grew older, he went for a while to the grammar-school in Hales-Owen, and was placed afterwards with an eminent schoolmaster at Solihull, where he distinguished himself by the quickness of his progress. From school he was sent, in 1732, to Pembroke College, Oxford, where he continued his name for ten years, though he took no degree. After the first four years he put on the civilian's gown, but without showing any intention to engage in the profession. At Oxford he applied to

English poetry, and in 1737 published a small *Miscellany*, without his name. He published, in 1741, his *Judgment of Hercules*, addressed to Mr Lyttleton, whose interest he supported with great warmth at an election. This was afterwards followed by the *Schoolmistress* in 1742, unquestionably Shenstone's best poem. Gray said of it, in a letter to Walpole, that it was "excellent of its kind, and masterly." Now began his delight in rural pleasures, and his passion for rural elegance; but in time his expenses occasioned clamours that overpowered the bleat of the lamb and the song of the linnet, and his groves were haunted by beings very different from fauns or fairies. He spent his estate in adorning it, and his death was probably hastened by his anxieties. It is said, that if he had lived a little longer, he would have been assisted by a pension. He died at the Leasowes, of a putrid fever, on the 11th of February 1763.

In his private opinions Shenstone adhered to no particular sect, and hated all religious disputes. Tenderness, in every sense of the word, was his peculiar characteristic; and his friends, domestics, and poor neighbours, daily experienced the effects of his benevolence. This virtue he carried to an excess that seemed to border upon weakness; yet if any of his friends treated him ungenerously, he was not easily reconciled. On such occasions, however, he used to say, "I never will be a revengeful enemy; but I cannot, it is not in my nature, to be half a friend." If we consider the perfect paradise into which he had converted his estate, the hospitality with which he lived, his charities to the indigent, and all out of an estate that did not exceed L.300 a-year, one should rather wonder that he left anything behind him, than blame his want of economy. He yet left more than sufficient to pay all his debts, and by his will appropriated his whole estate to that purpose. Shenstone never married. His works have been published by Dodsley, in three volumes 8vo. The first volume contains his poetical works, which are particularly distinguished by an amiable elegance and beautiful simplicity; the second volume contains his prose works; the third his letters and other pieces. His life has been written by Johnson in his *Lives of the Poets.* (See Cunningham's Edition, 1854.) There is likewise an edition of his poetical works, published in Edinburgh in 1854, with a biography.

SHEPTON-MALLET, a market-town of England, in the county of Somerset, on a small affluent of the Brue, at the eastern foot of the Mendip Hills, 4½ miles E. of Wells, and 116 W.S.W. of London. It is an ancient place, with numerous narrow lanes, and one principal street, which is broad and lined with good houses. Near the centre is a market-place, in which there is a handsome hexagonal cross of the fifteenth century. On the east side of the market-place stands the parish church, a large edifice in the form of a cross. It is in the early English style, and has a tower and spire. There are also in the town places of worship for Wesleyans, Independents, Roman Catholics, and Unitarians. A free grammar-school, founded here in 1627, had, in 1854, 50 scholars; and there is a national school, besides various similar establishments, a literary institution, and almshouses. Various manufactures are carried on here, employing in all about 2000 hands. Silk, velvet, crape, and ribbons are the chief articles produced. An extensive trade is carried on in corn, for which there are weekly markets. Three annual fairs are held for cattle and cheese. Pop. 3885.

SHERBET, a compound drink, first brought into England from Turkey and Persia, consisting of water, lemon-juice, and sugar, in which are dissolved perfumed cakes made of Damascus fruit, containing an infusion of some drops of rose-water to give it perfume. Another kind of sherbet is made of violets, honey, and juice of raisins.

SHERBORNE, a market-town of England, Dorsetshire, on the slope of a hill in the fertile valley of Blackmore, watered by a branch of the Yeo, 18 miles N. by W. of Dorset, and 117 S.W. by W. of London. It is compactly built, has some ancient houses, and several handsome public buildings. Among the latter is the parish church, formerly a cathedral, built at various dates, and in various styles. It has recently been restored at great expense, and it has a very fine tower in the Norman style, with a ponderous bell, presented by Cardinal Wolsey. Near the church are the handsome town-hall, the market-house, and the free grammar-school, which occupies some of the buildings of the old abbey restored. This school was founded by Edward VI., in 1550; it has an endowment of L.1000 a-year, and several exhibitions at the universities. It contained, in 1854, 109 scholars. There are various other schools in the town, also places of worship for Wesleyans, Quakers, and Independents, the last a very handsome edifice. In the vicinity stands Sherborne Lodge, or Castle, the seat of the Earl of Digby, originally built by Sir Walter Raleigh. The remains of the Castle of Sherborne, which was demolished in the time of the Commonwealth, occupy a rocky hill at the east end of the town. Many of the inhabitants are employed in sewing gloves for manufacturers in Yeovil; and there are large silk-mills, which employ a considerable number of hands. The town is ancient, having existed in the time of the Saxons, when it was the seat of a bishop, subsequently removed to Old Sarum, and still later to Salisbury. The strength of its castle made it a place of importance in the various civil wars of the middle ages. Its staple manufacture was at one time woollen cloth, after that buttons and haberdashery, now silk. Pop. 3878.

SHERBURN, a market-town of England, in the West-Riding of Yorkshire, 13 miles S.S.W. of York. It has a handsome old parish church, other places of worship for Wesleyans and Roman Catholics, a free grammar-school, national school, and others. In the neighbourhood there are orchards, stone-quarries, and flour-mills. Pop. of the parish, 3754; of the township, 1440.

SHERBURNE, Sir Edward, descended from a good family at Stainhurst in Lancashire, was born in London on the 18th September 1618. He received his early education from the celebrated Thomas Farnaby, and subsequently from Charles Aleyn. In 1640 he accomplished the grand tour, as it was called, of Europe, and returned just in time to follow his father to the grave in 1641. He was appointed to his father's office of clerk of the Ordnance, but the rebellion which subsequently ensued removed him from this post. It did more. Fastening on him as a royalist and staunch Roman Catholic, the usher of the black rod held him in durance during a long and expensive confinement. On his release he was as active as ever in behalf of the king, who appointed him commissary-general of his artillery. He fought for the king, attended him at Oxford, and he took his master's degree there in 1642. On going up to London in 1646, he was compelled to hide himself for a space about the chambers of the Middle Temple. Freed from this annoying surveillance, he was appointed by Sir George Saville, in 1651, superintendent of his affairs, and afterwards was chosen travelling tutor to Sir John Coventry. Sherburne regained his old office at the Ordnance on the Restoration, only to lose it again at the Revolution of 1688. He had been knighted in 1682; but it is to be feared his later years were clouded with poverty. In 1696 we find Sherburne presenting a supplicatory memorial to the Earl of Romney, then Master-General of the Ordnance, and an humble petition to the king. Whether any of these memorials was attended to, or whether this loyal subject was left, as thousands of others were, to drag out a life of penury, invoking the public for a bit of bread or a drop of water in the name of the king, cannot now be determined

He was compelled to observe a very strict retirement, until death, in November 4, 1702, put an end to all his sorrows. Sherburne, who had been a man of a very amiable temper, made the acquaintance of Thomas Stanley, author of the *History of Philosophy*, 1655–60, and of James Shirley, the dramatist, with whom he remained in close friendship during the rest of their lives. Sherburne translated the *Medea* (1648), and the *Troades* (1679) of Seneca. He is now best known by his version of Manilius, which contains a valuable appendix, comprising notices of the translator's contemporaries.

SHERIDAN, Frances, wife of Thomas Sheridan, was born in Ireland about the year 1724, but descended from a good English family which had removed thither. Her maiden name was Chamberlaine, and she was granddaughter of Sir Oliver Chamberlaine. The first literary performance by which she distinguished herself was a little pamphlet at the time of a violent party dispute relative to the theatre, in which Sheridan had newly embarked his fortune. So well-timed a work exciting the attention of Sheridan, he sought out his fair patroness, to whom he was soon afterwards married. She was a person of the most amiable character in every relation of life, with the most engaging manners. After lingering some years in a very weak state of health, she died at Blois, in France, in the year 1766. Her *Sidney Biddulph* attained to great popularity, and her *Nourjahad* delighted all readers of romance.

Sheridan, *Richard Brinsley*, a distinguished dramatist and politician, was born at Dublin in the month of September 1751, and baptized in St Mary's Church on the fourth of the following month. His grandfather and father each attained a celebrity, by the friendship with which the former was honoured by Swift, and by the competition, and even rivalry, which the latter so long maintained with Garrick. His mother, too, was a woman of considerable talents. Her affecting novel, Sidney Biddulph, could boast amongst its panegyrists Mr Fox and Lord North; and in the tale of Nourjahad she employed the graces of oriental fiction to deceive her readers into a taste for true happiness and virtue.

At the age of seven years, Richard Brinsley Sheridan was, with his eldest brother Charles Francis, placed under the tuition of Mr Samuel Whyte of Grafton Street, Dublin; and after being little more than a year under his care, they were removed to England, where Mr and Mrs Sheridan had lately gone to reside. In the year 1762, Richard was sent to Harrow, Charles being kept at home as a fitter subject for the instructions of the father. At that time, Dr Sumner was at the head of the school, and Dr Parr, who to the massy erudition of a former age joined the free and enlightened intelligence of the present, was one of the under masters. Both he and Dr Sumner endeavoured, by all possible means, to awaken in Sheridan a consciousness of those powers which he manifestly possessed; but remonstrance and encouragement were equally thrown away upon the good-humoured indifference of their pupil. One of the most valuable acquisitions he derived from Harrow, however, was that friendship with Dr Parr, which lasted throughout his life, and which identity of political opinion tended not a little to invigorate.

On his leaving Harrow, where he continued until about his eighteenth year, he was brought home by his father, who, with the elder son, Charles, had lately returned from France, and taken a house in London. Here the two brothers for some time received private tuition from Mr Lewis Kerr, an Irish gentleman, who had formerly practised as a physician; and they also attended the fencing and riding schools of Mr Angelo, at the same time receiving from their father instructions in English grammar and oratory. Of this advantage, however, the elder son appears alone to have availed himself; and Richard, determined to owe all to nature, was found as impracticable a pupil at home as at school. But, however inattentive to his studies he may have been at Harrow, it is evident, from a letter of his school-fellow, Mr Halhed, that he had already distinguished himself in poetry, and, in conjunction with his friend, had translated the seventh Idyl, and many of the lesser poems of Theocritus. In the year 1770, when Halhed was at Oxford, and Sheridan with his father at Bath, they commenced a correspondence (of which Halhed's share only remains), and, with all the hope and spirit of young adventurers, began and prosecuted several works, of which none but their translation of Aristænetus ever saw the light.

In this copartnership of genius, their first joint production was a play in three acts, called *Jupiter*, written in imitation of the burletta of Midas. Of this piece Halhed, who had furnished the burlesque scenes, entertained great hopes; nor were those of Sheridan less earnest and sanguine; yet that habit of dilatoriness, which is too often attendant upon genius, and which, throughout life, was remarkable in the character of Mr Sheridan, prevailed so far, that though he received from his friend the sketch of this piece in 1770, it was not till May next year that the probability of the arrival of the manuscript was announced to Mr Foote. Another of their projects was a periodical miscellany, the idea of which originated with Sheridan. The title intended by him for this paper was Hernan's Miscellany, to which Halhed objected, and proposed The Reformer, as a newer and better name. But this paper, for want of auxiliaries, never proceeded beyond the first number, which was written by Sheridan. It is the characteristic of fools to be always beginning; and this is not the only point in which folly and genius resemble each other. Amongst the many literary works projected by Sheridan at this period, were a collection of Occasional Poems, and a volume of Crazy Tales, to the former of which Halhed suggests, that "the old things they did at Harrow, out of Theocritus," might form a useful contribution. But neither of these came to any thing; and the translation of Aristænetus was the only fruit of their literary alliance that, as we have already stated, ever arrived at sufficient maturity for publication.

The passion, however, that now began to take possession of his heart was little favourable to his advancement in serious studies. In the neighbourhood of Miss Linley, the arts and the sciences were suffered to fall asleep, and even the translation of Aristænetus itself proceeded but slowly. After various fortune, however, it at length made its appearance in August 1771, contrary to the advice of the bookseller, and, as it might have been expected, from the unpropitious season at which it appeared, complete failure was the consequence. The disappointment of the authors was no doubt proportioned to the sanguine expectations they had indulged. But as to Mr Sheridan, he sought for consolation in the society of Miss Linley, who had now become the star of his attraction, and the centre round which revolved all his hopes. This lady, indeed, notwithstanding the drawback of her profession as a singer, appears to have spread her gentle conquests to an extent almost unparalleled in the annals of beauty. "Her personal charms, the exquisiteness of her musical talents, and the full light of publicity which her profession threw upon both," says Mr Moore, "naturally attracted round her a crowd of admirers, in whom the sympathy of common pursuit soon kindled into rivalry, till she became at length an object of vanity as well as of love. Her extreme youth, too (for she was little more than sixteen when Sheridan first met her), must have removed, even from minds the most fastidious and delicate, that repugnance they might have justly felt to her profession, if she had lived much longer under its tarnishing influence, or lost, by frequent exhibitions before the public, that fine gloss of feminine modesty, for whose absence not all the talents and accomplishments of the whole sex can atone."

Even at this early age, she had been on the point of marriage with Mr Long, an old gentleman of considerable fortune in Wiltshire; but, on her secretly representing to him, that she never could be happy as his wife, he generously took upon himself the whole blame of breaking off the alliance, and even indemnified the father by settling L.3000 upon his daughter. Mr Sheridan, who owed to this liberality not only the possession of the woman he loved, but the means of supporting her during the first years of their marriage, uniformly spoke of Mr Long with all the kindness and respect which such a disinterested character merited. Meanwhile, in love, as in all besides, the power of a mind like Sheridan's made itself felt through all obstacles; and he won the entire affections of the Syren, though the number and wealth of his rivals, amongst whom were a brother and friend, the ambitious views of the father, and the temptations to which she was hourly exposed, kept his fears and jealousies continually on the watch. But, whilst this was the case, a new and unexpected difficulty awaited him.

Captain Mathews, a married man, and intimate with Miss Linley's family, had for some time harassed her with those discreditable addresses, which it is equally painful to disclose and intolerable to endure. To the threat of self-destruction, he is said to have added the still more unmanly menace of ruining her reputation, if he could not undermine her virtue. Terrified by his perseverance, she confided her distresses to Sheridan, who lost no time in expostulating with him upon the cruelty, libertinism, and hopelessness of his pursuit. Such a remonstrance, however, was but little calculated to conciliate the forbearance of this professed man of gallantry; so that, early in 1772, Miss Linley adopted the resolution of flying to France, and taking refuge in a convent. At this time Sheridan was little more than twenty, and Miss Linley just entering her eighteenth year. Landing at Dunkirk, they proceeded to Lisle, where they procured an apartment in a convent, with the intention of remaining there until Sheridan should have the means of supporting her as his wife. On the first discovery of the elopement, Mathews busied himself making inquiries into the affair. During the four or five weeks that the young couple were absent, he never ceased to haunt the Sheridan family with all sorts of exaggerated rumours; and at length, urged on by the restlessness of revenge, he inserted a violent and inflammatory advertisement in the Bath Chronicle, in which he publicly posted Mr Sheridan as a scoundrel and a liar. The consequences of this were such as might have been expected. The party now returned from the Continent, and, without loss of time, Sheridan called out Mathews. His second on the occasion was Mr Ewart, and the particulars of the duel, which was fought with swords, are stated by himself in a letter addressed to Captain Knight, the second of Mathews. From this it appears that Mathews, being worsted, was obliged to beg his life; after which he signed an ample apology, in which he retracted the expressions he had made use of, as "the effects of passion and misrepresentation," and begged pardon for his advertisement in the Bath Chronicle.

With the odour of this transaction fresh about him, Mr Mathews retired to his estate in Wales, and there found himself universally shunned. An apology may be, according to circumstances, either the noblest effort of manliness, or the last resource of fear; and, from the reception which this gentleman everywhere experienced, it is evident that to the latter class of cases his late retraction had been referred. In this crisis, a Mr Barnett, who had but lately come to reside in his neighbourhood, took upon himself the duty of urging a second meeting with Sheridan, as the only means of removing the stigma left by the first; offering, at the same time, to be the bearer of the challenge. This offer was accepted, and the parties met at Kingsdown, where a desperate encounter ensued, in which Mr Sheridan's sword was broken, and himself severely wounded. A narrative of this affair, drawn up by Mr Barnett, and sanctioned by the concurrence of Captain Paumier (Sheridan's friend) in the truth of its material facts, was soon afterwards published; whilst the comments which Sheridan thought it necessary to make have been found in an unfinished state amongst his papers. As soon as Sheridan was sufficiently recovered of his wounds, his father sent him to pass some months at Waltham Abbey, Essex, where he continued, with but a few short intervals of absence, from August or September 1772, till the spring of the following year.

During this period, he evinced considerable industry, particularly in an abstract which he made of the History of England, and in a collection of remarks on Sir William Temple's works, especially his essay on Popular Discontents, on which his observations are tasteful and just. Still his situation was at this time singularly perplexing. He had won the heart, and even the hand, of the woman he loved, yet saw his hopes of possessing her farther off than ever. He had twice risked his life against an unworthy antagonist, yet found the vindication of his honour incomplete. He felt within himself all the proud consciousness of genius, yet, thrown upon the world without a profession, he looked in vain for a channel through which to direct its energies. Even the precarious hope which his father's favour held out had been purchased by an act of duplicity, which his conscience condemned; for he not only had promised that he would instantly abandon the pursuit, but had even taken an oath that he would never marry Miss Linley. To a mind so young and so ardent, the pressure of these various anxieties must, of course, have been great; in fact they could only have been adequately described by him who felt them; and there still exist some letters, written by him during this time, which betray a sadness and despondency, sometimes breaking out into aspirings of ambition, sometimes rising even into a tone of cheerfulness, that ill concealed the melancholy underneath. But it was impossible that Sheridan could be always under a cloud. Misunderstandings there no doubt were, arising probably from those paroxysms of jealousy into which he must have been continually thrown; but reconcilement was with no great difficulty effected; and at length Mr Linley, convinced that it was impossible to keep them much longer asunder, consented to their union, which took place on the 13th of April 1773.

A few weeks previous to his marriage, Sheridan had been entered a student of the Middle Temple. It was not to be expected, however, that talents like his would submit to toil for the distant and dearly-earned emoluments which a life of labour in this profession might secure; nor, indeed, did his circumstances admit of any such patient speculation. A part of the sum which Mr Long had settled upon Miss Linley, and occasional assistance from her father, were now the only resources left him, besides his own talents. Mrs Sheridan's celebrity as a singer was a ready source of wealth, and offers of the most advantageous kind were pressed upon them by the managers of concerts, both in town and country. But her husband at once rejected all thoughts of allowing her to re-appear in public, and, instead of profiting by the display of his wife's talents, adopted the manlier resolution of seeking independence by his own. How decided his mind was upon the subject, appears by a letter written to Mr Linley about a month after the marriage. At East Burnham, whence this letter is dated, they were now living in a small cottage, to which they had retired immediately on their marriage; and to it they often looked back with a sigh, in after times, when they were more prosperous and less happy. Towards winter they went to lodge for a short time with Storace, the intimate friend of Mr Linley, and in the following year attained that first step

Sheridan. towards independence, a house to themselves. During the summer of 1774, they passed some time at Mr Canning's and Lord Coventry's; but so little did these visits interfere with the literary industry of Mr Sheridan, that he had not only at that time finished his play of the Rivals, but was on the point of "sending a book to press."

On the 17th of January 1775, the comedy of the Rivals was brought out at Covent Garden. This play failed on its first representation, chiefly owing to the bad acting of Mr Lee in Sir Lucius O'Trigger. Another actor was, however, substituted in his stead, and the play being lightened of this and some other incumbrances, rose at once in public favour and patronage. The best comment on this lively play is to be found in the many smiling faces that are lighted up whenever it appears. With much less wit, it exhibits more humour than the School for Scandal, and the dialogue is more natural, as coming nearer the current of ordinary conversation. The characters, however, are not such as occur very commonly in the world, and for our knowledge of them we are indebted to their confessions rather than to their actions. Lydia Languish, in proclaiming the extravagance of her own romantic notions, prepares us for events much more ludicrous and eccentric than those in which she is concerned; in the composition of Sir Lucius O'Trigger, his love of fighting is the only characteristic strongly brought out; and the wayward, captious jealousy of Falkland, though so highly coloured in his own representation, is productive of nothing answerable to such an announcement. The character of Sir Anthony Absolute is perhaps the best sustained and most natural of any, and the scenes between him and Captain Absolute are genuinely dramatic. Mrs Malaprop's mistakes have often been objected as improbable from a woman in her rank of life; but though some of them are extravagant and farcical, they are almost all amusing; and the luckiness of her simile, "as headstrong as an *allegory* on the banks of the Nile," has been acknowledged by all whose taste is not too refined to be moved by the genuine comic.

Mr Sheridan now employed the summer recess in writing the Duenna, whilst his father-in-law, Mr Linley, assisted in selecting and composing the music for it. In hands so willing, the work made speedy progress, and, on the 21st November, the Duenna was performed at Covent Garden. The run of this opera has, we believe, no parallel in the annals of the drama. The Beggar's Opera had a career of sixty-three nights; but the Duenna, more fortunate, was acted no less than seventy-five times during the season, the only intermissions being a few days at Christmas, and the Fridays in every week. In order to counteract this great success of the rival house, Garrick found it necessary to bring forward all the weight of his best characters; and he had even recourse to the expedient of playing off the mother against the son, by reviving Mrs Frances Sheridan's comedy of the Discovery, and acting the leading character in it himself. The Duenna, in fact, is one of the very few operas in our language which combine the merits of legitimate comedy with the attractions of poetry and song. The "sovereign of the soul," as Gray calls music, always loses by being made exclusive sovereign; and the division of her empire with poetry and wit, as in the instance of the Duenna, doubles her real power. The intrigue of this piece is constructed and managed with considerable adroitness, having just material enough to form three acts, without being encumbered by too much intricacy, or weakened by too much extension. And as to the wit of the dialogue, except in one or two instances, it is of that accessible kind which lies near the surface, and which, as it is produced without effort, may be enjoyed without wonder.

Towards the close of the year 1775, Garrick intending to part with his moiety of the patent of Drury Lane theatre, and retire from the stage, Mr Sheridan made him an offer as purchaser, and eventually became patentee and manager. The progress of the negociation cannot be better related than in some of Sheridan's own letters, addressed to Mr Linley, which Mr Moore has printed. It appears, indeed, that the contract was perfected in June 1776; and in a paper drawn up by Mr Sheridan many years afterwards, the shares of the respective purchasers are thus stated, viz. Mr Sheridan, two fourteenths of the whole, L.10,000; Mr Linley, the same, L.10,000; and Dr Ford, three fourteenths, L.15,000. Whence Mr Sheridan's supply came, or to whom he was indebted for this seasonable aid, has never been known. Not even to Mr Linley, whilst entering into all other details, does he hint at the fountain-head from which it was to come; and, indeed, there was something mysterious about all his acquisitions, whether in love or in learning, in wit or in wealth. Finally, in reference to this subject, the first contribution which the new manager furnished to the stock of the theatre was an alteration of Vanburgh's comedy, the Relapse, which was brought out on the 24th of February 1777, under the title of a Trip to Scarborough.

Mr Sheridan was now approaching the summit of his dramatic fame. He had already produced the best opera in the language, and there now remained for him the glory of writing also the best comedy. As this is a species of composition which, more perhaps than any other, seems to require a knowledge of human nature and the world, it is not a little extraordinary that nearly all our first-rate comedies should have been the productions of very young men. Those of Congreve were all written before he was five-and-twenty. Farquhar produced the Constant Couple in his two-and-twentieth year, and died at thirty. Vanburgh was a young ensign when he sketched out the Relapse and the Provoked Wife; and Sheridan crowned his reputation with the School for Scandal at six-and-twenty. And it is still more remarkable to find, as in the instance before us, that works, which we might suppose to have been the offspring of a careless but vigorous fancy, should, on the contrary, have been the slow result of many doubtful experiments, gradually unfolding beauties unseen even by him who produced them, and at length arriving step by step at perfection. That the School for Scandal was produced by this tardy process, is evident from the sketches of its plan and dialogue which Mr Moore has produced, and which serve to throw a remarkable light on the first slow workings of genius, out of which its finest transmutations arise. The reader who may feel curious on this subject is referred to Mr Moore's clear and masterly exposition. Suffice it to mention, that there are two distinct sketches, in the second of which particularly, is shown the condensing process which his wit must have gone through before it attained its present proof and flavour. There appear also to have been originally two plots, which the author incorporated into one; yet, even in the details of the new plan, considerable alterations were subsequently made, entire scenes suppressed or transposed, and the dialogue of some completely rewritten.

This play was produced on the 8th of May 1777, and its success was decided and triumphant. Indeed, long after its first uninterrupted run, it continued to be played regularly two or three times a week; and on comparing the receipts of the first twelve nights with those of a later period, it will appear how little the attraction of the piece had abated by repetition. The beauties of this comedy are so universally known, that it cannot be necessary to dwell upon them. With but little interest in the plot, no very profound or ingenious development of character, and a group of personages, not one of whom has any legitimate claims upon either our affection or esteem, it yet, by the admirable skill with which its materials are managed, the happy contrivance of the situations, that perpetual play of wit which never tires, and a finish almost faultless, it unites the suffrages at once of the refined and the simple, and is not less successful in

 satisfying the tastes of the one, than in ministering to the enjoyment of the other. And this is the true triumph of genius in all the arts. In painting, sculpture, music, or literature, those works which have pleased the greatest number for the longest space of time, may be pronounced the best; for, however mediocrity may enshrine itself in the admiration of the few, the palm of excellence can only be awarded by the many. The defects of the School for Scandal, if they can be allowed to amount to defects, are in a great measure traceable to the amalgamation of two distinct plots, out of which the piece was formed. From this cause has devolved that excessive opulence with which the dialogue is almost overloaded, and which Sheridan himself used to mention as a fault which he was conscious of in his work. From beginning to end, it is a continued sparkling of point and polish; and the whole of the characters might be comprehended under one common designation of wits, even Trip, the servant, being as shining and brilliant as the rest. "In short," says Mr Moore, "the entire comedy is a sort of El Dorado of wit, where the precious metal is thrown about by all classes, as carelessly as if they had not the least idea of its value."

Soon after the appearance of this comedy, Sheridan made a further purchase of theatrical property, amounting to L.17,000; and amongst the visible signs of his increased influence in the affairs of the house, was the appointment, this year, of his father to be manager. At the beginning of the year 1779, Garrick died, and Sheridan, who had followed his body to the grave, wrote a monody to his memory, which was recited after the play in the month of March following. In the course of the same year he produced the entertainment of the Critic, which was his last legitimate offering at the shrine of the dramatic muse. In this incomparable farce, we have a striking instance of the privilege which genius assumes of taking up subjects that had passed through other hands, and giving them new value and currency. The plan of the Rehearsal was first adopted for the purpose of ridiculing Dryden; but although there is much laughable humour in some of the dialogue, the salt was not of a very conservative nature, and the piece continued to be served up to the public long after it had lost its relish. Fielding tried the same plan in a variety of productions, but without much success, except, perhaps, in the comedy of Pasquin. It was reserved for Sheridan to give vitality to this form of dramatic humour, and to invest even his satirical portraits with a generic, which, without weakening the particular resemblance, makes them representatives of the whole class to which the original belonged. Bayes, on the other hand, is a caricature made up of little more than personal peculiarities, but may amuse as long as reference may be had to the prototype, but fall lifeless the moment the individual that supplied them is no more.

Having terminated his dramatic career, in which he had been eminently successful, Sheridan now prepared to act a part in a widely different scene. His thoughts had been gradually drawn to the seducing subject of politics, on which he had tried his hand at some very fair remarks on absenteeism; he had also rendered some service to the party with which he had connected himself, by taking an active share in a periodical publication called the Englishman; and his first appearance before the public was made in conjunction with Mr Fox, at the beginning of 1780, when the Resolutions on the State of the Representation, together with a Report on the same subject, were laid before the public. The dissolution of parliament, which took place in the autumn of 1780, at length afforded the opportunity to which his ambition had so eagerly looked forward; and Stafford was destined to have the honour of first choosing him for its representative. It is not our intention, however, to investigate his political with the same minuteness as his literary life; and this is the less necessary, seeing that the amplest narrative would probably be the heaviest, and that the masterly pen of Lord Brougham has sketched an outline which must be fully sufficient to satisfy the inquiries of the most curious and inquisitive.

"His first effort," says Lord Brougham, "was unambitious, and it was unsuccessful. Aiming at but a low flight, he failed in that humble attempt. An experienced judge, Woodfall, told him it would never do; and counselled him to seek again the more congenial atmosphere of Drury Lane. But he was resolved that it should do; he had taken his part; and as he felt the matter was in him, he vowed not to desist till he had brought it out. What he wanted in acquired learning and natural quickness, he made up by indefatigable industry. Within given limits, towards a present object, no labour could daunt him; no man could work for a season with more steady and unwearied application. By constant practice in small matters, or before private committees, by diligent attendance upon all debates, by habitual intercourse with all dealers in political wares, from the chiefs of parties and their more refined coteries, to the providers of daily discussion for the public, and the chroniclers of parliamentary speeches, he trained himself to a facility of speaking, absolutely essential to all but first-rate genius, and all but necessary even to that; and he acquired what acquaintance with the science of politics he ever possessed, or his speeches ever betrayed. By these steps he rose to the rank of a first-rate speaker, and as great a debater as a want of readiness, and need for preparation, would permit.

"He had some qualities which led him to this rank, and which only required the habit of speech to bring them out into successful exhibition; a warm imagination, though more prone to repeat with variations the combinations of others, or to combine anew their creations, than to bring forth original productions; a fierce, dauntless spirit of attack; a familiarity, acquired from his dramatic studies, with the feelings of the heart and the ways to touch its chords; a facility of epigram and point, the yet more direct gift of the same theatrical apprenticeship; an excellent manner, not unconnected with that experience; and a depth of voice which perfectly suited the tone of his declamation, be it invective, or be it descriptive, or be it impassioned. His wit, derived from the same source, or sharpened by the same previous habits, was eminently brilliant, and almost always successful. It was, like all his speaking, exceedingly prepared, but it was skilfully introduced, and happily applied; and it was well mingled also with humour, occasionally descending to farce. How little it was the inspiration of the moment, all men were aware who knew his habits; but a singular proof of this was presented by Mr Moore when he came to write his life; for we there find given to the world, with a frankness which must almost have made the author shake in his grave, the secret note-books of this famous wit; and are thus enabled to trace his jokes, in embryo, with which he had so often made the walls of St Stephen's shake, in a merriment excited by the happy appearance of sudden unpremeditated effusion.

"The adroitness with which he turned to account sudden occasions of popular excitement, and often at the expense of the Whig party, generally too indifferent to such advantages, and too insensible to the damage they thus sustained in public estimation, is well known. On the mutiny in the fleet, he was beyond all question right; on the French invasion, and on the attacks upon Napoleon, he was almost as certainly wrong; but these appeals to the people, and to the national feelings of the House, tended to make the orator well received, if they added little to the statesman's reputation; and of the latter character he was not ambitious. His most celebrated speech was certainly the one upon the Begum charge, in the proceedings against Hastings; and nothing can exceed the accounts left us of

its unprecedented success. Not only the practice then first began, which has gradually increased till it greets every good speech, of cheering, on the speaker resuming his seat, but the minister besought the House to adjourn the decision of the question, as being incapacitated from forming a just judgment under the influence of such powerful eloquence; whilst all men on all sides vied with each other in extolling so wonderful a performance. Nevertheless, the opinion has now become greatly prevalent, that a portion of this success was owing to the speech having so greatly surpassed all the speaker's former efforts, to the extreme interest of the topics which the subject naturally presented, and to the artist-like elaboration and beautiful delivery of certain fine passages, rather than to the merits of the whole. Certain it is, that the repetition of great part of it, presented in the short-hand notes of the speech on the same charge, in Westminster Hall, disppoints every reader who has heard of the success which attended the earlier effort. In truth, Mr Sheridan's taste was very far from being chaste, or even moderately correct. He delighted in gaudy figures; he was attracted by glare, and cared not whether the brilliancy came from tinsel or gold, from broken glass or pure diamond; he overlaid his thoughts with epigrammatic diction; he 'played to the galleries,' and indulged them, of course, with an endless succession of claptraps. His worst passages by far were those which he evidently preferred himself, full of imagery, often far-fetched, oftener gorgeous, and loaded with point that drew the attention of the hearer away from the thoughts to the words; and his best by far were those where he declaimed, with his deep clear voice, though somewhat thick utterance, with a fierce defiance of some adversary, or an unappeasable vengeance against some oppressive act; or reasoned rapidly, in the like tone, upon some plain matter of fact, or exposed as plainly to homely ridicule some puerile sophism; and in all this his admirable manner was aided by an eye singularly piercing,[1] and a countenance which, though coarse, and even in some features gross, was yet animated and expressive, and could easily assume the figure of both rage, and menace, and scorn. The few sentences with which he thrilled the House, on the liberty of the press, in 1810, were worth, perhaps, more than all his elaborated epigrams and forced flowers on the Begum charge, or all his denunciations of Napoleon, 'whose morning orisons and evening prayers are for the conquest of England, whether he bends to the God of Battles or worships the Goddess of Reason;' certainly far better than such pictures of his power, as his having 'thrones for his watchtowers, kings for his sentinels, and for the palisades of his castle sceptres stuck with crowns.' 'Give them,' said he in 1810, and in a far higher strain of eloquence, 'a corrupt House of Lords; give them a venal House of Commons; give them a tyrannical prince; give them a truckling court,—and let me but have an unfettered press; I will defy them to encroach a hair's breadth upon the liberties of England.' Of all his speeches, there can be little doubt that the most powerful, as the most chaste, was his reply, in 1805, upon the motion which he had made for repealing the Defence Act. Mr Pitt had unwarily thrown out a sneer at his support of Mr Addington, as though it was insidious. Such a stone, cast by a person whose house, on that aspect, was one pane of glass, could not fail to call down a shower of missiles; and they who witnessed the looks and gestures of the aggressor, under the pitiless pelting of the tempest which he had provoked, represent it as certain that there were moments when he intended to fasten a personal quarrel upon the vehement and implacable declaimer.

"When the just tribute of extraordinary admiration has been bestowed upon this great orator, the whole of his praise has been exhausted. As a statesman, he is without a place in any class, or of any rank; it would be incorrect and flattering to call him a bad, or a hurtful, or a short-sighted, or a middling statesman; he was no statesman at all. As a party man, his character stood lower than it deserved, chiefly from certain personal dislikes towards him; for, with the perhaps doubtful exception of his courting popularity at his party's expense, on the two occasions already mentioned, and the much more serious charge against him of betraying his party in the Carlton House negociation of 1812, followed by his extraordinary denial of the facts when he last appeared in parliament, there can nothing be laid to his charge as inconsistent with the rules of the strictest party duty and honour; although he made as large sacrifices as any unprofessional man ever did to the cause of a long and hopeless opposition, and was often treated with unmerited coldness and disrespect by his coadjutors. But as a man his character stood confessedly low. His intemperate habits, and his pecuniary embarrassments, did not merely tend to imprudent conduct, by which himself alone might be the sufferer; they involved his family in the same fate; and they also undermined those principles of honesty which are so seldom found to survive fallen fortunes, and hardly ever can continue the ornament and the stay of ruined circumstances, when the tastes and the propensities engendered in prosperous times survive through the ungenial season of adversity."

Sheridan was indeed most unfortunate. Whilst death was fast gaining on him, the miseries of life were thickening around him; nor did the last corner where he now lay down to die, afford him any asylum from the clamours of his legal pursuers. Writs and executions came in rapid succession, and bailiffs at length got possession of the house. A sheriff's officer arrested the dying man in his bed, and was about to carry him off in his blankets to a spunging house, when he was prevented by an intimation of the responsibility he must incur, if, as was but too probable, his prisoner should expire on the way. In the mean time, the attention and sympathy of the public were awakened to the desolate condition of Sheridan, by an article which appeared in the Morning Post, written, it seems, by a gentleman who, though on no very cordial terms with him, forgot every other feeling in a generous pity for his fate, and in honest indignation against those who had deserted him. But it was now too late. Its effect, indeed, was soon visible in the calls made at Sheridan's door, amongst which the Duke of York and the Duke of Argyll appeared as visiters; but the spirit that these unavailing tributes might once have comforted was fast losing the consciousness of every thing earthly; and, after a succession of shivering fits, he fell into a state of exhaustion, which continued till his death. He expired on Sunday, the 7th of July 1816, in the sixty-fifth year of his age, and was buried on the Saturday following, many royal and noble persons crowding round his insensible clay, whose notice, had it been earlier, might have soothed and comforted his death-bed, and saved his heart from breaking. (J. B—E.)

SHERIDAN, *Dr Thomas*, the intimate friend of Dean Swift, is said by Shiels, in the book known as *Cibber's Lives of the Poets*, to have been born about 1684, in the county of Cavan, where, according to the same authority, his parents lived in no very elevated state. They are described as being unable to afford their son the advantages of a liberal education; but he, being observed to give early indications of genius, attracted the notice of a friend of his family, who sent him to Trinity College, Dublin. He afterwards entered into orders, and set up a school in Dublin, which long maintained a high reputation. From this very popular seminary he is said occasionally to have derived L.1000 a-year. It does not appear that he had any considerable prefer-

[1] It had the singularity of never winking.

ment; but his intimacy with Swift procured for him, in 1725, a living in the south of Ireland, worth about L.150 a-year, which he went to take possession of, and, by an act of inadvertance, destroyed all his future expectations of rising in the church; for, being at Cork on the 1st of August, the anniversary of King George's birthday, he preached a sermon which had for its text, "Sufficient for the day is the evil thereof." On this being known, he was struck out of the list of chaplains to the lord-lieutenant, and henceforward forbidden the Castle. This living Dr Sheridan afterwards changed for that of Dunboyne, which, by the knavery of the farmers, and the power of the gentlemen in the neighbourhood, fell so low as L.80 per annum. He gave it up for the free school of Cavan, where he might have lived well in so cheap a country on a salary of L.80 a-year, besides his pupils; but the air being, as he said, too moist and unwholesome, and being disgusted with some persons who lived there, he sold the school for about L.400; and having soon spent the money, he fell into bad health, and died on the 10th of September 1738, in his fifty-fifth year. One of the volumes of Swift's miscellanies consists almost entirely of letters between him and Sheridan. He published a prose translation of Persius; to which he added the best notes of former editors, together with many judicious ones of his own. This work was printed at London, 1739, in 12mo.

Lord Cork has given the following character of him:—"Dr Sheridan was a schoolmaster, and in many instances perfectly well adapted for that station. He was deeply versed in the Greek and Roman languages, and in their customs and antiquities. He had that kind of good nature which absence of mind, indolence of body, and carelessness of fortune, produce; and although not over strict in his own conduct, yet he took care of the morality of his scholars, whom he sent to the university remarkably well founded in all kinds of classical learning, and not ill instructed in the social duties of life. He was slovenly, indigent, and cheerful. He knew books much better than men; and he knew the value of money least of all. In this situation, and with this disposition, Swift fastened upon him as upon a prey with which he intended to regale himself whenever his appetite should prompt him." His lordship then mentions the event of the unlucky sermon, and adds, "This ill-starred, good-natured, improvident man returned to Dublin, unhinged from all favour at court, and even banished from the Castle. But still he remained a punster, a quibbler, a fiddler, and a wit. Not a day passed without a rebus, an anagram, or a madrigal."

SHERIDAN. *Thomas*, author of the *General Dictionary of the English Language*, was the son of Dr Sheridan, and the father of Richard Brinsley Sheridan, and was born at Quilca, in Ireland, the residence of Dean Swift, in 1721. He was treated with uniform kindness by the great satirist, who was his godfather, and who showed him what tenderness he could during his life. He received his early education in his father's house, and was subsequently sent to Westminster, till the funds failed, when he was compelled again to retrace his steps. He entered Trinity College, Dublin, where he took his degree. On his father's death, in 1738, he found himself suddenly unprovided for. Having caught up, or having been born with, a grand idea of the extraordinary moral effects to be accomplished by the use of the oratorical art, he resolved to devote his life to its exposition. As the first step in his great vocation, he entered a theatre in Smock Alley, where he personated Richard III., "with the greatest encouragement," in January 1743. Next year he went to London, to reap new laurels at Covent Garden, and in 1745 he was set up as a rival to Garrick, who could brook no competitor. Sheridan found it to be for his interest to return to the Irish metropolis, whose inhabitants had not yet forgotten the enthusiastic orator of a few years ago. Here he became manager of the theatre, and during the ensuing eight years of his superintendence, the metropolitan stage seems to have risen considerably in respectability. At an unlucky hour he attempted to humour the political tastes of the public by playing Miller's *Mahomet.* This took exceedingly well. But where was it to end? Like a tiger that has tasted blood, the fierce mob became restless and wild, and insisted upon its accustomed treat. The manager said gravely that there must be an end to these brawls, when the audience rose, and, in its fury, slashed the scenery with sword-blades, tore up the benches and boxes, and ended by totally despoiling the building. Thus ended Sheridan's first school of oratory. In 1751 appeared his greatest contribution to the art of oratory, for this was the year in which his illustrious son, Richard Brinsley Sheridan, was born. His faith in the omnipotence of this ancient art continued. He published a plan for an academy to educate "youth in every qualification necessary for a gentleman," and in which oratory was to be the beginning, middle, and end of their scholastic accomplishments. The orator gave three separate orations to prove the quality of the future superintendent, and to illustrate the vital force of his great discovery. The audience shrugged their shoulders, and gave the conduct of their institution into other hands.

Sheridan was not to be daunted. In 1759 he was lecturing the English on his favourite hobby. He had published an essay on *British Education: the source of the disorders in Great Britain*, 1755, in which he humbly attempted to show the British public, that the source of all their evils, both public and private, was to be traced to a neglect of the ancient and venerable art of public speaking. The British public seem temporarily to have been taken by it. Sheridan lectured himself into an M.A. at Cambridge, and achieved other wonders equally notable by the fascination of his speech at London and Oxford. In 1760 he again tried Drury Lane, but Garrick still recollected his old affront, and Sheridan had to go about his business. He published *A Course of Lectures on Elocution* in 1762, fraught with the old burden. George III. granted him a pension, on which he might have practised oratory to the great edification of the British people and the no small delight of himself; but some busybody whispered the fact to Samuel Johnson, who blustered out, in his violent way, "What, give him a pension! then I must give up mine." On this coming to Sheridan's ears it wounded him mightily; but he had recourse again to oratory as his panacea. Next he moved northward, to try the effect of his eloquence upon the cool heads of the Scottish metropolis. The northern worthies seem to have been moved by the force of his persuasive tongue. Blair, Ferguson, and Robertson were enrolled as directors of a society for the promotion of public speaking. How long this Irish importation flourished in Edinburgh does not appear. Moving south, he published in 1769 his *Plan of Education for the Young Nobility and Gentry of Great Britain.* Ireland found herself again excluded from the benevolent endeavours of this reforming educationist. He dedicated, in his loftiest manner, this small work to the king, observing at the same time, that "if the design be not executed by myself, it never will be by any other hand." It must have gratified his majesty to find so devoted a subject; but nothing seems to have come out of all this kneeling and prostration at the foot of the throne. He continued to lecture and vend sarcasms against the miserable taste of the age, when America suddenly declared her independence. He then informed his audience that he had come to the resolution of "benefiting the new world with the advantages ungratefully neglected by my own country." Sheridan subsequently performed at the Haymarket and at Covent Garden, up to 1776; and on Garrick's retirement from Drury Lane he was appointed

manager. He held this post for the next three years. He published, on his retirement, his *Dictionary of the English Language*, 2 vols. 1780; and an edition of Swift's works, in 17 vols. 1784, with a *Life of Swift* prefixed, a lumbering work, which had better not have been written. He visited Ireland in 1786, and returned to England, where he died at Margate, on the 14th of August 1788, in his sixty-seventh year. There is ascribed to Sheridan a farce called *Captain O'Blunder*.

SHERIF-ED-DEEN-YEZDI, Moolah Ali, a celebrated Persian historian, of whom hardly anything is known, was born at Yezd, in Persia, during the fifteenth century of our era. He was a doctor of the Moslem law, and lived at Shiraz, where he wrote the work by which he is now known, and on which his reputation is founded. This was the *Zuffer-Nameh*, or book of Victories of the celebrated Timur or Tamerlane. This work, which is greatly too much overloaded with metaphor and ornate expression for the occidental taste, possesses, nevertheless, great merit for the oriental beauty in which it is so lustrously set. "His geography and chronology," says Gibbon, in his *History of the Decline and Fall of the Roman Empire*, vol. xii., "are wonderfully accurate; and he may be trusted for public facts, though he servilely praises the virtue and fortune of his hero." His encomiums on Timour are indeed carried to the most fulsome extent of oriental panegyric; but both gratitude and interest would combine to produce this effect; and the bias thus shown is in some measure useful as enabling us to qualify the equally exaggerated invectives of another biographer of Timour, the Syrian Arabshah. Yezdi's book is a panegyric of Tamerlane, and an eastern panegyric too. This work has been translated into French and Turkish.

SHERIFF. See Scotland.

SHERLOCK, William, a learned English divine, was born at Southwark in 1641, and educated at Eton school, where he distinguished himself by the vigour of his genius and his application to study. From this he was removed to Cambridge, where he took his degrees. In 1669 he became rector of the parish of St George, Botolph Lane, in London; and in 1681 was collated to the prebend of St Pancras, in the cathedral of St Paul's. He was likewise chosen master of the Temple, and had the rectory of Therfield, in Herefordshire. After the Revolution he was suspended from his preferment, for refusing the oaths to William and Mary; but at last he took them, and publicly justified what he had done in his publication of the *Allegiance of the Two Sovereign Powers*. His case excited immense sensation. According to Lord Macaulay (*Hist. of Eng.* vol. vi. p. 48, 1858), "the replies to the doctor, the vindications of the doctor, the pasquinades on the doctor, would fill a library." In 1691 he was installed as dean of St Paul's. His *Vindication of the Doctrine of the Trinity* engaged him in a warm controversy with Dr South and others. Bishop Burnet tells us he was "a clear, a polite, and a strong writer; but apt to assume too much to himself, and to treat his adversaries with contempt." He died in 1707. His works are very numerous, among which are —*A Discourse concerning the Knowledge of Jesus Christ*, (against Dr Owen) 1674; *Several pieces against the Papists, the Socinians, and Dissenters; A Practical Discourse on Death*, 16th edition, 1715, which has been more frequently reprinted than any of Sherlock's other works; *A Practical Discourse on Providence*, 1715; *A Practical Discourse on the Future Judgment*, 1699.

Sherlock, *Dr Thomas*, Bishop of London, was the son of the preceding, and was born in 1678. He was educated in Catherine Hall, Cambridge, where he took his degrees, and of which he became master. He was made master of the Temple when very young, on the resignation of his father; and it is remarkable, that this mastership was held by father and son successively for more than seventy years. He was at the head of the opposition against Dr Hoadley, Bishop of Bangor, during which contest he published a great number of pieces. He attacked Collins's *Grounds and Reasons of the Christian Religion*, in a course of six sermons, preached at the Temple Church, which he entitled, *The Use and Intent of Prophecy in the Several Ages of the World*, 1725. In 1728, Dr Sherlock was promoted to the bishopric of Bangor, and was translated to Salisbury in 1734. In 1747 he refused the archbishopric of Canterbury, on account of his ill state of health; but recovering in a good degree, he accepted the see of London the following year. On occasion of the earthquake in 1750, he published an excellent *Pastoral Letter* to the clergy and inhabitants of London and Westminster, of which it is said there were printed in quarto 5000, in octavo 20,000, and in duodecimo about 30,000, besides pirated editions of which not less than 50,000 were supposed to have been sold. Under the weak state of body in which he lay for several years, he revised and published four volumes of *Sermons*, in octavo, which are particularly admired for their ingenuity and elegance. He died in 1762, worth L.150,000. "His learning," says Dr Nicholls, "was very extensive. God had given him a great and an understanding mind, a quick comprehension, and a solid judgment. These advantages of nature he improved by much industry and application. His skill in the civil and canon law was very considerable; to which he had added such a knowledge of the common law of England as few clergymen attain to. This it was that gave him that influence in all causes where the church was concerned, as knowing precisely what it had to claim from its constitutions and canons, and what from the common law of the land." Dr Nicholls then mentions his constant and exemplary piety, his warm and fervent zeal in preaching the duties and maintaining the doctrines of Christianity, and his large and diffusive munificence and charity; particularly by his having given large sums of money to the corporation of clergymen's sons, to several of the hospitals, and to the Society for Propagating the Gospel in Foreign Parts, and also bequeathing to Catherine Hall, in Cambridge, the place of his education, his valuable library of books, and his donations for the founding a librarian's place and a scholarship, to the amount of several thousand pounds. The works of Dr Sherlock were published in 1830, in five vols. 8vo, by the Rev. T. S. Hughes.

SHERWIN, John Keyse, an English engraver of considerable excellence, was born in Sussex about 1751. Being of humble origin, he learned early to handle the instrument of toil. The attention of his master, a Mr Mitford of Petworth, having been drawn to some remarkable drawings which he had executed, he was induced to send one to the Society of Arts, which obtained the silver pallet as a reward. Having subsequently gone to London to learn the art of engraving, he studied under Ashley and Bartolozzi. He won the silver and gold medals at the Royal Academy, and carried off numerous honours from the Society of Arts. Sherwin was appointed engraver to his Majesty and the Prince of Wales in 1785, and continued to drink, brag, and handle the graver, with surprising assiduity. He certainly had genius, but he foolishly supposed that this endowed him also with the right of bullying everybody, both of those above and of those beneath him. His attention was confined mostly to portraits and historical subjects, though he occasionally attempted oil-painting, as in his "Leonidas," but with indifferent success. He died on the 20th September 1790, in very melancholy circumstances, in his thirty-ninth year. (See *Gentleman's Magazine* for 1790–91.)

SHETLAND, or Zetland Islands, a group belonging to Scotland, the most northerly land included in the United

Shetland. Kingdom. Exclusive of the Fair Isle, midway between Orkney and Shetland, and of Foula, which lies 20 miles to the west, the group lies between N. Lat. 59. 52. and 60. 48., W. Long. 0. 45. and 1. 40. These islands are far removed from any other land; Orkney on the S.W. being 50 miles off; the Faroe group, on the N.W., 180 miles; and the coast of Norway, on the E., 210 miles. The whole number of islands and rocks is upwards of 100, but of these only 32 are inhabited. The following is a list of the inhabited islands, beginning from the south:—

	Pop. (1851).		Pop. (1851).
Fair Isle	280	Linga	8
Munsa	10	Mickle Roe	290
Bressay, East and West Burra, Papa, and Halvera	885	Little Roe	11
		Whalsay	679
		Skerries (three)	105
Noss	21	Yell and Bigga	2696
Linga	10	Hascussay	13
Oxna	21	Samphrey	30
Trondray	169	Fetlar	658
Mainland	21,613	Unst and Batta	2961
Little Papa	1	Uya	16
Vaila	2		
Foula	240	Total	31,078
Papa Stour	359		

The entire area is 5588 square miles, about half of which belongs to the Island of Mainland. This island extends about 60 miles in length, from Sumburgh Head, its southern extremity, to Feideland Point in the north. To the N.E. lies Yell, separated from Mainland by the Sound of Yell; and still farther N.E. is Unst. The other islands, which are much smaller, for the most part fringe the coast of Mainland. These coasts are exceedingly irregular, being indented by extensive land-locked bays, whose mouths are sheltered by islands, and by long narrow arms of the sea called *voes*. So much is this the case, that no part of the island is more than 3 miles from the sea in one direction or another. Yell and Unst are also irregular in outline, but not so much so as the larger island; the former of these is 20 miles long by 6 broad; the latter 11 by 6. The general appearance of Shetland from a distance is not very striking; for the land is all low, though there is a great deal of bold and romantic cliff scenery. The highest point in the islands is Roeness, in the north of Mainland, which only attains the height of 1500 feet above the sea, On approaching Shetland from the south, the first point that appears conspicuously is Fitfiel Head, an abrupt and craggy promontory of Mainland, exceeding in altitude Sumburgh Head further to the east. At the latter point the tides from opposite sides of Shetland meet, causing a tumultuous current, which makes a dark line on the ocean, dying away towards Fair Isle. This is known by the name of the Roust of Sumburgh; and is a good place for the fishery of seethe or coal-fish (*Gadus corbonarius*). About Dunrossness and Quendel, in the south of Mainland, there are some fine corn-lands. Northwards from this, the land consists of bleak hills and heaths, without a tree or even a shrub; and is generally enveloped in damp mists. The coasts are pierced with numerous creeks and inlets, and lined with rugged cliffs and rocks; while the monotony of the scene is occasionally relieved by groups of cottages, with their patches of green corn-land enclosed with stone-dykes. North of the narrow strip of land that forms the southern portion of the island, lies the picturesque bay and village of Scalloway on the west coast, the green vale of Tingwall about the middle of the island, and the town of Lerwick on the Sound of Bressay, which separates Mainland from the island of that name to the east. Beyond Bressay lies the Island of Noss, which communicates with a rock called the Holm of Noss by a wooden trough or cradle, suspended by ropes over a chasm 160 feet deep. North of Lerwick, Mainland extends to a greater breadth, and consists for some distance of extensive boggy meadows, containing several lakes. On the Island of Whalsey, off the east coast of Mainland, an excellent system of farming is carried on; and in the Outskerries, the most easterly of all the islands, there are extensive establishments for deep sea-fishing of ling. The north-western part of Mainland is as wild and grand in its scenery as any other portion of the island. Here are seen the bare red summit of Roeness Hill, several lakes surrounded by heath and rocks, and the surges of the Atlantic for ever dashing on the precipitous cliffs that line the shore. Here is the large bay of St Magnus, at the south side of which lies the Island of Papa Stour, remarkable for its porphyritic rocks and underground caverns. Yell is a dull uninteresting island, but a great fishing station; and Unst is of a bleak precipitous character. The Island of Fetlar, to the east of Yell, contains very fertile valleys. Foula, supposed to be the Ultima Thule of the ancients, consists of five conical hills, rising abruptly out of the sea to the height of 1300 feet. It is occupied by vast flocks of sea-birds in summer, but they all take their flight when winter sets in. The geological character of the islands is very varied. In the southern portion of the Mainland there is a central line of primitive clay-slate, forming the range called the Cliff Hills; on the east of which lies a series of blue and red sandstone, and on the west beds of blue limestone. Further north a great deposit of gneiss occupies the districts of Whiteness, Aithsting, and Delting in the centre of Mainland; the Islands of Burra, Oxna, and Trondray on the west; Whalsay, the Skerries, and Yell, with parts of Fetlar and Unst on the east. Mica slate occurs in the peninsula of Eswick, on the east of Mainland, and at Fadelant Point, in the extreme north. Roseness Hill and the adjoining country are composed of hard red granite, flanked on the south-east by greenstone; and the peninsula in the west forming the parish of Walls, consists of primary quartz rocks. Granite is found in some other parts of Mainland; and the hills of Fetlar and Unst are for the most part composed of serpentine. The mineral riches of the country are not very great; copper veins are found in the Fair Isle and elsewhere; iron, mica, and pyrites in some places; and Unst is especially remarkable for its chromate of iron. The climate is, owing to the insular position of the land, less cold than is common in such a high altitude; but the temperature is liable to very great and sudden changes; and the weather is not unfrequently wet, foggy, and tempestuous. The winter is very dark and gloomy; but, on the other hand, in the summer the sun hardly sinks below the horizon, and bright twilight continues the whole night. Thus from the middle of May to the end of July there is hardly any darkness in Shetland. The soil of the islands is in general very unfavourable for agriculture; and only a very small portion of it is arable. Indeed fishing, not farming, is the chief object of attention both to landlords and tenants; and the climate is so unpropitious that little else but the commonest kinds of barley and oats are raised. In 1857 the islands contained 1026 acres under a rotation of crops; of which 3 were of wheat, 4 of barley, 349 of oats, 91 of bere, 124 of turnips, 64 of potatoes, 371 of grass and hay, &c. The plants and animals of Shetland resemble very much those of Orkney. The country is not so much distinguished by the presence of peculiar species as by its more limited vegetation, and by the absence of many plants common elsewhere. It has been estimated that there are 74 species of plants peculiar to Shetland, 40 common to Shetland and Iceland, 37 to Shetland and Faroe, and 146 to all the three. The most characteristic animals of the islands are the small ponies or shelties. These are very diminutive, but strong and hardy; they run wild on the heaths and pastures of the island, and are exported in great numbers. The cattle, sheep, and hogs of the islands are also small and of peculiar breeds; and the fleeces of the sheep are very much

 esteemed. The islands contained in 1857, 486 horses; 1094 cattle; 6486 sheep; and 57 swine; in all, 8123 live stock. The most important source of wealth to the Shetlanders is the fisheries, in which by far the most of them are employed. There are three different classes of fisheries; the *haaf*, or deep-sea fishing; the herring fishery; and that of the coal-fish. Of these the first is the most important; cod, ling, and tusk being the chief kinds of fish obtained, and furnishing the staple articles of export from Shetland. A large bank of these fish extends from the north of Orkney to the west of Shetland. This fishing is only carried on for two or three months in summer, and it is an occupation accompanied with much danger. The total number of cod and ling taken in the Shetland Isles in 1857 was 1,342,172, being more than a third of the whole number of these fish taken in Scotland. This fishery, as well as that of herring, was at one time almost exclusively in the hands of the Dutch, who sent over annually about 2000 boats to engage in them. Although towards the end of the seventeenth century, and subsequently, this number was greatly reduced, it is not one hundred years since there were only three British vessels engaged in the fisheries here. But from the beginning of the present century, herring fishing has made rapid progress among the Shetlanders; and in 1857 it employed 669 boats, with a tonnage of 1327. The number of fishermen and boys in the same year was 2990; the total number of persons employed 4121; and the number of barrels of herrings cured 17,858. The total value of boats, nets, and lines employed in fishing in Shetland was, for the same year, L.15,822. Very few manufactures are carried on in Shetland, the only one of any importance being hosiery from the fine wool of the sheep. The plaiting of straw was formerly pursued in Lerwick, but this has fallen off. Kelp is also prepared, but not to so great an extent as in the Western Isles. The trade consists in the exportation of fish, hosiery, shelties, &c., in exchange for the various necessaries and luxuries of life which nature has denied to the Shetland Islands. The inhabitants of Shetland are all of Scandinavian origin, and differ entirely from the Highlanders of Scotland. They are small, light, nimble and hardy, lively and versatile, and fond of excitement. They do not speak Gaelic, nor are any of the names of places Celtic; but they have retained many Norse words and idioms, and speak with a quick pronunciation, quite different from that of the Highlanders. The dress of the fishermen is peculiar, consisting of wide, neat skin-boots, reaching to the knee, woollen breeches, a leather surtout, and a worsted cap. The first people whom we know to have inhabited Shetland was a tribe of Saxon rovers, but they were expelled by Theodosius A.D. 368. In the sixth century it is probable that the Scandinavians, from whom the present inhabitants are sprung, had already settled here. Harold Harfager, who first united Norway into one kingdom in 875, reduced to subjection all the northern and western islands, which had been previously held by petty chieftains and pirates. Caithness, Orkney, and Shetland were then made one earldom, and conferred on Siguard, who afterwards considerably extended his dominions. The authority of the earls over Shetland was, however, very slight, for it was not the feudal system, but a totally different form of government that prevailed here. The arable land was held free from any tax or impost, and hence was called *udal*; the pastures, for which a tax was paid, were known by the name of *scattald*. The country was under a civil governor appointed by the king, and was subdivided into lesser districts, each governed by a *foude* or inferior magistrate, from whom there lay an appeal to the grand *foude*, or annual assembly of all the *udal* proprietors. The Earl of Orkney had no right to interfere with the civil affairs of the people; he was only their military protector, under whose standard they had to fight in case of invasion. In 1468 James III. of Scotland received with the Princess Margaret of Denmark a dowry of 60,000 florins, in pledge for which Orkney and Shetland were given; and in 1470 he purchased the whole right to these islands and annexed them to the crown. The various changes that took place in the earldom of Orkney, which included Shetland, after its annexation to the Scottish crown, are narrated in the article ORKNEY. Under the various earls, especially those of the Stuart family, the people were very much oppressed, from the constant attempts to substitute the feudal system for their original *udal* right. The ancient constitution was finally abolished in the reign of Charles II. The islands now form, along with Orkney, a county, which returns one member to the Imperial Parliament, a privilege not possessed by Shetland before the Reform Act of 1832. In ecclesiastical affairs Shetland forms a synod of the Established Church, composed of three presbyteries and twelve parishes. The whole number of places of worship in Orkney and Shetland, according to the census of 1851, was 123, with 39,761 sittings—of the former 41 belonged to the Established Church; 23 to the Free Church; 18 to the Wesleyans; 16 to the Independents; 14 to the United Presbyterians; 9 to the Baptists; and 2 to the Original Seceders. At the same period there were 111 public schools, and 36 private schools in the county. The number of proprietors in Shetland is 574, and the valuation of rent for 1858–9 was L.24,698. Lerwick is the chief town, and it seems to have been erected since the beginning of the seventeenth century. There are many interesting remains of antiquity in the Shetland Islands. Among these are many Pictish towers, especially one in Munsa, which is one of the most perfect Teutonic forts in Europe. The castle of Scalloway is of a much later date, having been erected in 1600; but it is now reduced to a mere shell. In the valley of Tingwall is still to be seen the place where the chief magistrate of Shetland used to hold his court in the open air, at the head of a small loch. The population of Shetland in 1801 was 22,379; in 1811, 22,915; in 1821, 26,145; in 1831, 29,392; in 1841, 30,558; and in 1851, 31,078.

SHIELD, WILLIAM, a very popular English composer of music, was born at Swalwell, in the county of Durham, in 1749. His father, a teacher of singing, taught him the elements of music, and he very early showed considerable talent as a violinist. When nine years old he lost his father, and was apprenticed to a boat-builder at North Shields. His master treated him kindly, and encouraged his musical pursuits. At the end of his apprenticeship he resolved to adopt music as a profession; and having become favourably known as a violinist at Newcastle, attracted the notice of Charles Avison, who gave him instructions in harmony. Having been invited to lead the concerts at Scarborough, he there became acquainted with Borghi the violinist, and Fischer the famous oboeist, who induced him to go to London, and obtained for him an engagement as a violinist in the opera-house orchestra, then led by Giardini. Soon after he was appointed principal viola by Cramer, the new leader at the opera, and held that place for eighteen years. In 1778 he made his first essay as a dramatic composer in *The Flitch of Bacon*, which was very successful. He was next engaged as composer to Covent Garden Theatre, where his compositions became highly popular. In 1791 he revisited Swalwell, and showed much kindness and attention to his mother. While there he made a collection of English *Border Tunes*, some of which he published in his *Rudiments of Thorough Bass*. In the same year he visited France and Italy, and in 1792 returned to England, and composed again for Covent Garden Theatre, but soon after gave up his engagement. In 1800 he published his *Introduction to Harmony*, a second edition of which appeared in 1817. In that year Shield suc-

ceeded Sir William Parsons as Master of the King's Band, with a yearly salary of L.250. He died of dropsy on 25th January 1829, leaving a widow but no children, and was buried in the cloisters of Westminster Abbey. Shield's great popularity arose from the simplicity and appropriateness of his melodies, whether in ballad or opera-song. Always vocal and pleasing, his melodies at once caught the public ear, and became popular. Among his sea-songs, some are peculiarly excellent, such as "The Arethusa," and "For England when with Favouring Gale;" in his operas of "The Lock and Key," and "Hartford Bridge." He was not a trained and profound harmonist, as his instrumental music and accompaniments prove. He was strong in melody, but feeble in harmony. He composed thirty-four operatic works, and a great many detached songs, besides six canzonets, and a cento of ballads, rounds, &c. His instrumental compositions consist of a concerto; duets for two violins; trios for two violins and a bass. In these trios, he introduced an example of that jerking and unmanageable rhythm, $\frac{5}{4}$. (G. F. G.)

SHIELD. See ARMY.

SHIELD. See HERALDRY.

SHIELDS, NORTH and SOUTH, two towns of England, on opposite sides of the mouth of the Tyne, situated 8 miles below Newcastle, 16 miles N.N.E. of Durham, and 176 N.N.W. of London.

North Shields is a market-town in Northumberland, forming, along with the adjacent village of Tynemouth, a municipal and parliamentary borough. It extends for about a mile along the river, and consists of an older and a more recent portion; the former containing narrow alleys and lanes, and the latter having many good houses, broad streets, and spacious squares. There are several good public buildings. Among these are the parish church of Tynemouth, which stands at the east end of North Shields, a handsome chapel of ease in the town, places of worship belonging to the English Presbyterian Church, Wesleyan and New Connexion Methodists, Baptists, Independents, Quakers, and Roman Catholics. The educational establishments are many and various, including national, British, and infant schools. There is also a subscription library, mechanics' institute, theatre, assembly rooms, and baths. Manufactures are extensively carried on at North Shields, but they are chiefly of those articles that are connected with navigation. There are here ship-building yards, rope-works, manufactories of sail-cloth, iron-foundries, forges for anchors and chain-cables, and steam-engine manufactories; besides salt-pans, breweries, brick and tile works, a large pottery, &c. In the vicinity there are numerous collieries, furnishing the chief article of trade to the town. North Shields is connected by railway with Newcastle and Tynemouth, and by a steam-boat ferry with South Shields. A county court is held in the town, and there are weekly markets and annual fairs. The town sprung up in the time of Edward I., under the protection of the Prior of Tynemouth; but the jealousy of the people of Newcastle put a stop to its progress for a long time. Oliver Cromwell passed an act for the formation of quays and a market here; but many restrictions were imposed upon the trade till the end of the seventeenth century, when they were removed, and the prosperity of the place thus greatly increased. Pop. 8882.

South Shields is a market-town, parliamentary and municipal borough, in the county of Durham. The older part consists chiefly of a long, narrow, crooked street, extending for about two miles on the low ground by the river's side; but on the hills behind there stand many well-built houses of more modern origin. Near the centre of the town is a large market-place, in which stands the neat town-hall, also used as an exchange and news-room. Below this building is the market-house. The parish church is ancient, but has been so much repaired and altered, that little of its original fabric except the tower can be traced. There are two other established churches, and also places of worship belonging to the English Presbyterian Church; the United Presbyterians; Wesleyan, Primitive, and New Connexion Methodists; Independents; and Baptists; several of which sects have more than one place of worship. To most of them Sunday schools are attached; and South Shields possesses also national and charity schools, as well as numerous benevolent institutions. Among the latter is a set of comfortable houses for superannuated master-mariners. Besides the public buildings already mentioned, the town contains a custom-house, theatre, public baths, mechanics' institute, and subscription library. None of the buildings, however, are by any means imposing. The manufactures and trade of the place constitute its chief importance. Like North Shields, it manufactures chiefly those articles that are used for maritime purposes. There are large docks for ship-building and repairing, also rope-works, breweries, manufactories of soda and alum, a pottery, and extensive glass-works. Formerly the town was chiefly known for its many salt-pans, of which there were at one time nearly 150; but this department of manufacture is hardly at all pursued at present. In the immediate neighbourhood there are some coal-pits. The refuse from these, as well as from the glass-works and salt-pans, has formed numerous hillocks, some of which have been built upon. The borough is governed by a mayor, eight aldermen, and twenty-four councillors; and it returns a member to the House of Commons. Markets are held every Saturday, and fairs twice a-year. It appears from an ancient inscription and remains found here, that there was a Roman station on the site of South Shields. The present town, however, cannot be traced so far back, but seems to owe its origin to the fishermen of the Tyne, who lived in *sheels*, or sheds, along the water's edge. Hence the name of the place. From the fifteenth to the seventeenth century, it was chiefly remarkable for its salt-pans; but the modern prosperity of South Shields is coeval with the extension of the coal trade. The population of the parliamentary borough in 1851 was 28,974.

The port of Shields, including both the towns, is formed by the river between them, which is here about two-thirds as broad as the Thames below London Bridge. Along both sides there are spacious quays, which, like those in the port of London, are lined with several tiers of vessels. The entrance to the harbour is somewhat difficult, as there is a bar with only 7 feet of water. There are two light-houses in North Shields, one 123 and the other 77 feet high, which lead to the entrance of the port. Inside the bar the depth increases to 24 feet; and the harbour is large enough to hold 2000 merchant-vessels, and admits those of 300 tons close up to the quays. The number of sailing vessels registered at the port, December 31, 1857, was 967; tonnage, 262,659: of steam-vessels, the number was 130; tonnage, 2936. In the year ending at that date, there entered 1861 sailing vessels, tonnage 300,538; and 10 steamers, tonnage 1321—in all, 1871 vessels, tonnage 301,859: and there cleared 2187 sailing vessels, tonnage 274,274; and 14 steamers, tonnage 556—in all, 2201 vessels, tonnage 274,830. The chief trade of the port consists in the export of coals to London, and other places on the east coast of England and Scotland. Many of the vessels belonging to Shields are engaged in the whale-fishery of Greenland and Davis Straits.

SHIFFNAL, a market-town of England, Shropshire, 17 miles E.S.E. of Shrewsbury, and 135 N.W. by W. of London. It contains no remarkable building except the large and handsome parish church, which is in the form of a cross, with a fine carved roof and some Norman remains. The other places of worship belong to the Baptists and Independents. There are also national schools and a

blue-coat school. Many of the inhabitants are employed in the mines and coal-pits in the vicinity, and in a paper manufactory. Pop. of the parish, 5617.

SHIKARPOOR, a town of British India, the most commercial and probably the most populous in Sinde, though not the capital of that province. stands in a low flat region, 20 miles W. of the Indus; N. Lat. 28., E. Long. 68. 39. Its appearance is not attractive, either viewed from a distance or on a nearer approach; the wall that once encircled it is in ruins, the streets are narrow, and a great part of the area consists of open spaces. There are no public buildings of any note; the most conspicuous edifices being the massive gloomy houses of the rich Hindu merchants. Near the centre stands the bazaar, 800 yards long, and covered with a thatched roof, which renders the atmosphere beneath very close and oppressive. The trade of the place is very great, as it stands on one of the great routes from Sinde, through the Bolan Pass to Afghanistan and Khorasan; on another leading northwards to the Derajat; and on a third leading to the port of Kurrachee. It is thus a transit trade that is chiefly carried on here, including large banking and other monetary transactions. There are many great capitalists in the town. The population is estimated at 30,000, of whom about 20,000 are Hindus, and the rest Mohammedans.

SHILLING. See Coinage.

SHILOH (שִׁילֹה), is a term famous among interpreters and commentators upon Scripture. It is found (Gen. xlix. 10) to denote the Messiah. The patriarch Jacob foretells His coming in these words:—"The sceptre shall not depart from Judah, nor a lawgiver from between his feet, until Shiloh come; and unto him shall the gathering of the people be." All Christian commentators agree that Shiloh ought to be understood of the Messiah, or Jesus Christ; but all are not agreed about its literal and grammatical signification. St Jerome, who translates it by *Qui mittendus est*, manifestly reads *Shiloach*, "sent," instead of *Shiloh*. The Septuagint have it, "Until the coming of him to whom it is reserved;" or, "till we see arrive that which is reserved for him." It must be owned that the signification of the Hebrew word Shiloh is not well known. Some translate, "the sceptre shall not depart from Judah, till he comes to whom it belongs. Others render it, "Till the coming of the peace-maker," or "the pacific;" or "of prosperity," *prosperatus est*. Others, again, "till the birth of him who shall be born of a woman that shall conceive without the knowledge of a man;" otherwise, "the sceptre shall not depart from Judah till its end, its ruin; till the downfall of the kingdom of the Jews." Some rabbin have taken the name Siloh or Shiloh, as if it signified the city of this name in Palestine: "The sceptre shall not be taken away from Judah till it comes to Shiloh; till it shall be taken from him to be given to Saul at Shiloh." But in what part of Scripture is it said that Saul was acknowledged as king or consecrated at Shiloh? A more modern author derives Shiloh from a word which signifies to be weary, or to suffer; "till his labours, his sufferings, his passion, shall happen."

But it is sufficient to show that the ancient Jews are in this matter agreed with the Christians. They acknowledge that this word stands for the Messiah, the King. It is thus that the paraphrasts Onkelos and Jonathan, that the ancient Hebrew commentaries upon Genesis, and that the Talmudists themselves, explain it. The curious reader may consult Jacobi's *Alting Schilo*, iii. 8, for further information respecting this matter.

SHING-KING, or Leao-Tong, a maritime province of the Chinese empire, lying to the north of the Yellow Sea, shut off from China proper on the S.W. by the Great Wall, and by another fortification from Mongolia, Manchoorie, and Corea on the N. and E. Area, 25,000 square miles. It is mountainous, and watered by the Leao, which flows southwards into the Gulf of Leao-Tong. The east side of this gulf is formed by a long peninsula called the Regent's Sword. The climate is mild and salubrious; and the soil produces wheat, barley, pulse, millet, and buckwheat. The mountains are covered with fine timber. Moukden is the capital of the province. Pop. 942,043.

SHIP-BUILDING.

To a people whose power is essentially maritime it is not necessary to use any arguments in proof of the importance of ship-building. Without pausing to dwell on the various struggles by which England has maintained her position amongst nations, it must be seen by all who study her history, that it has been by keeping invaders from her shores, by means of her wooden bulwarks, that she has withstood the repeated attacks of the powerful nations of the continent. And whilst the navy must be looked upon as the proper means of defence to this sea-girt land, who can visit the docks of London, Liverpool, the Clyde, or any of her other commercial ports, and not feel that her very heart's strength lies in those forests of masts which bring wealth to her merchants and manufacturers, and the means of employment to her artizans, forming, at the same time, a nursery and a reserve of seamen, who will be ready in the hour of need to vindicate her claim to pre-eminence on the ocean? Who, it may also be asked, can look upon the changes effected by her instrumentality in all quarters of the globe, and not own that her winged messengers have, under God's blessing, been the means of spreading civilization and truth through a large portion of the world?

The love of a sailor's life, common to all ranks amongst her sons, owes perhaps its origin to their Norman forefathers; but, however begotten, and however fostered, England owes much to it, and to the spirit of adventure which it has engendered amongst them. Individual enterprise has led to national achievements, till the name and power of Great Britain have been so extended that the sun never sets upon her possessions.

In an age when science is lending its mighty aid to every peaceful and warlike art, when mighty armies may be suddenly concentrated by railroads, and a nation's fate may hang on the electric wire, England must not trust in the multitude alone of her ships. Every fresh struggle for wealth or power proves that it is the amount of mind and intellect put forth in that struggle, and the amount of energy, and of means used to effect the end desired, which, humanly speaking, ensure success; and, as knowledge is always increasing, nations or individuals must not rest upon what has been done, if they desire to keep pace with the world in its eager rush of advancement and improvement. With regard to ship-building, not only must ingenuity and skill be brought to bear to assist the artisan in the practical construction of the fabric, but men of science must lend their aid, and use their powers of investigation, to assist in designing a complete whole, adapted to meet the ever-increasing competition for mastership on that element on which not only the welfare of England but of the whole world seems to hang.

The limits of a treatise of this nature are such that a very general view only of the many branches of inquiry in-

History. volved in this important subject can be given. It could not, however, be considered complete without a short outline of the rise and progress of the art, or without some reference to the authors from whose works further information may be obtained. It is always interesting and instructive in every art to trace the various stages it has gone through before arriving at its existing state. The retrospect of the art of ship-building shows that there has been no standing still in its course without corresponding injury to the prosperity and power of the nation which has neglected it, and that there must be no relaxation of exertion to meet the demands of a commercial and warlike people.

RISE AND PROGRESS OF NAVAL ARCHITECTURE.

In tracing the progress of naval architecture among the nations of antiquity, in order to connect it with its advance in more modern times, the chronological divisions adopted by that indefatigable investigator, Charnock, in his valuable *History of Marine Architecture*, present a very succinct idea of the probable rise, progress, decline, and revival of the art, and therefore offer a valuable guide for investigation. It would not be consistent with the purpose of this article to enter into the detail that would be necessary to ascertain the state of naval architecture during the periods embraced in each of the sections he has assigned to this subject. Some few facts only will be collected from various authors in illustration of the probable size and nature of the shipping of the ancient world, with an outline of what little is known of the rude vessels which, during the darkness of the middle ages, bore the marauders of the northern nations on their predatory excursions. Charnock divides maritime history into seven sections. The first comprehends the time previous to the foundation of Rome, until which he considers that all history is founded on surmise. The second section comprises a period somewhat less obscure, in which the collateral testimony of various authors may be examined and compared; and therefore there certainly appears less difficulty in ascertaining facts. It extends from the foundation of Rome to the destruction of her rival, Carthage. The termination of the third is at the conversion of the Republic into an empire. The death of Charlemagne ends the fourth epoch. The fifth extends from this period to the discovery of the mariner's compass. The sixth ends with the discovery of cannon, and with their adaptation to naval warfare commences the seventh epoch.

The Ark. The first vessel of which we have any description is the ark as built by Noah under the directions of the Almighty. Its proportions possess some interest, because, though not intended for a voyage, it may be inferred that it was constructed to float with as little motion as possible, considering that it "went upon the face of the waters" for about five months. It was no doubt exposed to the action of the winds and waves during that period, for before it rested "a wind was made to pass on the earth, and the waters asswaged." Assuming a cubit to be about 18 inches of our measure, its length was about 450 feet, its breadth about 75 feet, and its depth about 45 feet, with an arch or round-up of the upper deck of about 18 inches. Its draught of water must have varied greatly during the period of its occupation, as twelve months' provisions must have formed a very large proportion of the original weight, and these must have been gradually consumed. Its length is thus seen to have been six times its breadth, and it is perhaps curious that ship-builders should not sooner have given this, or a greater proportion of length to their vessels; seeing that these were intended for locomotion, with as much speed as possible, and consequently that an increase of length must have been proportionally advantageous to them, by giving them a finer form. The remembrance of this huge vessel, or floating house, would remain long on the minds of Noah's posterity; but it was not likely to influence them in the construction of petty floating vessels, to meet any of their limited requirements. Wickerwork frames of rushes, or reeds, or of the rind of the papyrus, smeared with mud or pitch, similar to the ark in which Moses was exposed, appear to have been at a very early age brought into use, and basketwork, covered with skin, has continued in constant use among many nations, even up to the present time. They are still in use in some parts of this and other countries under the name of coracles. Canoes, formed out of the trunk of a tree, require tools or implements for their construction, and were, therefore, no doubt of later introduction.

Vessels of Ancient Egypt. As early authentic records on the subject of ship-building, the paintings and sculptures of Upper and Lower Egypt may be referred to. These show regularly formed boats, constructed of sawn planks of timber, propelled by numerous rowers, and also by sails. Some are represented as formed with inclined planes, forward and aft in the same manner as the barges on the Thames, and in this respect are more correct in theory and in reality as to ease of propulsion than many canal-boats of the present day, constructed of a wedge-like form. The Hebrews in the time of Solomon must have possessed vessels of considerable size, as mention is made, in the sacred writings of that date, of "stately ships" and of voyages made to bring trees of considerable size to be used in the building of the temple. In addition to the trade in the Mediterranean from Joppa and Tarshish, it is also recorded that Solomon despatched a navy of ships from the Red Sea to fetch gold from Ophir, the position of which, though disputed, was probably on the east coast of Africa.

Phœnician shipping. The Phœnicians were connected with the Hebrews in their maritime expeditions, and this people appear to have been the most enterprizing in navigation of all the nations of antiquity. There can be no doubt from the accounts given by that most pains-taking and careful historian, Herodotus, that an expedition fitted out by this people sailed round the Cape of Good Hope. They started from the Red Sea, and after passing Ophir, if situated, as previously supposed, on the east coast of Africa, and to which they were in the habit of trading, they rounded the Cape, and keeping by the shore they entered the Mediterranean through the pillars of Hercules, or Straits of Gibraltar, and arrived in Egypt in the third year of their expedition. Vessels capable of performing such a voyage must have been of considerable size.

Grecian shipping. The Phœnicians were also engaged, in concert with other nations, in wars with the Greeks; and it was from them that the latter nation learned in their wars what they knew of ships and of navigation. Amongst the Grecian states, the Corinthians appear to have most distinguished themselves by improving the forms of the galleys, and increasing their size. The people of Tuscany and the Carthaginians also became important maritime powers about this time.

Roman shipping. The Romans in the earlier stage of their history paid little attention to navigation, until it was forced upon them by the necessity of competing with their great rivals the Carthagenians. The galleys of this period ranged from a single bark up to the quinquireme of five banks of oars. The oars in these large galleys being arranged in sets or *banks*, the number of these could be increased to any extent by giving additional length to the galley. The trireme, or three-banked galley, appears to have been generally open in the middle where the rowers sat, with decks or platforms at both ends for the soldiers; but this was not always the case, as in the representation of a trireme found at Pompeii, it is decked over for its whole length, and with a house or inclosed space at the stern. The galleys of greater size than the triremes appear to have been always decked-vessels, and the upper or fourth and fifth oars of

each bank were probably pulled from the deck, in the same manner as the long oars of the present day, called sweeps, while the three lower oars were pulled through port-holes by men seated below the deck.

The chief information on the vessels of this period is gathered from the accounts of naval expeditions and engagements as recorded in the histories of the Peloponnesian war by Thucidydes; the wars of Alexander the Great, especially the siege of Tyre, by Curtius and Arrian; the battle between Demetrius and Ptolemy, by Diodorus Siculus; the first Punic war, by Polybius, in which a very minute account is given of the engagement between the Romans and the Carthaginians; and of the battle of Actium, by Dionysius Cassius. Cæsar, in his *Commentaries*, also gives an account of the vessels used in the invasion of Britain, which seem to have been of greater draught of water than common at that period, as he considers it worthy of recording, that the men on disembarking were breast-high in the water, and that at last the galleys were ordered in between these larger vessels and the shore, to protect the disembarkation.

Classes of Roman shipping. The Roman ships were divided into three classes: the *naves longæ*, or ships of war; the *naves onerariæ*, or ships of burthen; and the *naves liburnæ*, which were ships built expressly for great velocity, and may be supposed to have been used as despatch-boats, and for making passages with important personages. There is repeated evidence to prove that these vessels were invariably built of pine, cedar, or other light woods, excepting about the bows, which were of oak, strongly clamped and strengthened with iron or brass, in order to withstand the shock of opposing vessels; the tactics being comprised in the attempt to sink or damage the enemy's vessel, by violently propelling this armed bow against the weaker broadside of the enemy, or else endeavouring to break and cripple the oars. **Oak first used in ship-building.** Oak was first applied to ship-building by the Veneti, on the testimony of Cæsar in his treatise *De Bello Gallico*, lib. iii. cap. 13. **Copper.** Copper or brass was introduced for fastenings, in consequence of the quick corrosion of the iron, about the time of Nero. This is stated on the authority of Vegetius, and also of Athenæus; and Pliny mentions that flax was used **Caulking.** for the purpose of caulking the seams of the plank.

Exhumation of a Roman vessel. The following quotation is from Locke's History of Navigation:—"Sheathing of ships is a thing in appearance so absolutely new, that scarce any will doubt to assert it altogether a modern invention; yet how vain this notion is, will soon appear. Leo Baptisti Alberti, in his book of *Architecture* (lib. v. cap. 12), has these words: But Trajan's ship weighed out of the lake of Riccia at this time, while I was compiling this work, where it had lain, sunk and neglected, for above 1300 years; I observed that the pine and cypress of it had lasted most remarkably. On the outside it was built with double planks, daubed over with Greek pitch, caulked with linen rags; and over all a sheet of lead fastened on with little copper nails. Raphael Volaterranus, in his *Geography*, says this ship was weighed by the order of Cardinal Prospero Colonna. Here we have caulking and sheathing together above 1600 years ago; for I suppose no man can doubt that the sheet of lead nailed over the outside with copper nails was sheathing, and that in great perfection, the copper nails being used rather than iron, which, when once rusted in the water, with the working of the ship, soon lose their hold and drop out."

During the dark ages which followed the downfall of Rome, little progress was made in navigation, and but little is known of the vessels in which the northern hordes made their predatory and conquering excursions.

Royal Society of Northern Antiquarians. The investigations of the Royal Society of Northern Antiquarians at Copenhagen have thrown considerable light on the subject of this early navigation, and of the discoveries of the Scandinavians in the west; and it cannot be supposed that it was in coracles that frequent voyages were made to Newfoundland, and colonies established there, which it appears proved were in existence as early as the tenth century. But to recur to the description given by Cæsar of the ships of the Gaulish Veneti. **Gaulish Veneti.** "Their bottoms were somewhat flatter than ours, their prows were very high and erect, as likewise their sterns, to bear the hugeness of the billows and the violence of the tempests. The body of the vessel was entirely of oak. The benches of the rowers were made of strong beams about a foot in breadth, and fastened with iron nails an inch thick. Instead of cables, they secured their anchors with chains of iron; and made use of skins and a sort of thin pliant leather, by way of sails, probably because they imagined that canvas sails were not so proper to bear the violence of tempests, the rage and fury of the winds, and to govern ships of that bulk and burthen. . . . . . Neither could our ships injure them with their beaks, so great was their strength and firmness, nor could we easily throw our darts, because of their height above us, which also was the reason that we found it extremely difficult to grapple the enemy and bring him to close fight." And again, speaking of the manner in which these ships were eventually taken possession of: "They," the Romans, "had provided themselves with long poles, armed with long scythes; with these they laid hold of the enemies' tackle, and drawing off the galley by the extreme force of oars, cut asunder the ropes that fastened the sailyards to the masts; these giving way, the sailyards came down, insomuch that, as all the hopes and expectations of the Gauls depended entirely on their sails and rigging, by depriving them of this resource, we at the same time rendered their vessels wholly unserviceable."

The account proceeds to state, that many attempted to escape from this unforeseen means of aggression; but that the wind falling, and a perfect calm coming on, they were obliged to remain inactive on the water, and were taken possession of, one after the other, by the simultaneous attack of several Roman galleys. It would appear from this that they were vessels only intended for sailing, and that, since oars were used, from the mention made of seats for the rowers, they could have been as very partial accessories to the sails, or probably even only for steering. Another fact is mentioned by Cæsar, that the Veneti sailed from their port to meet the Roman fleet, and several of the vessels escaped to their port from the fleet. This, though not conclusive of the fact of sailing on a wind, is worthy of notice.

Hengist and Horsa. It is probable that it was ships such as these which brought Hengist and Horsa to England about the middle of the fifth century, since it is recorded that their force, which consisted of 1500 men, found accommodation in only three vessels. It is hardly to be imagined that the coracles, or skin-boats of the northern nations, were ever of sufficient dimensions to accommodate a force of 500 men, with arms and means of active aggression.

Rise of Venice. The earlier irruptions of the northern barbarians into Italy had desolated the Roman province of Venetia, and driven a remnant of its inhabitants to the refuge afforded by the small marshy islands at the extremity of the Adriatic. There they are described by Cassiodorus, who assimilates them to water-fowl, as subsisting on fish, and steeped in poverty, their only manufacture and their only commerce being salt. From such humble beginnings arose the state destined to connect the old world with the new, and to lead the van of modern commercial and maritime enterprise. The mercantile prosperity of Venice diffused its influence throughout the shores of the Mediterranean, which thus became once again the nursery of civilization. For many centuries Venice was the great school of the arts connected with navigation, and her shipwrights and seamen were long the most instructed in Europe. While the north-

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ern seas were navigated by the Scandinavian sea-kings, in their rude and frail boats, in quest of plunder or of a home, ships floated on the waters of the Mediterranean bearing the banner of St Mark, which, it is said, were, even as early as the tenth century, of the burthen of 1200 up to 2000 tons. The vessels, however, generally adopted by the Mediterranean states were either copies or modifications of the ancient galley.

Mediterranean galley.

It is a fact worth notice, that while the continuation of the use of this species of vessel in the comparatively tranquil waters of the Mediterranean fostered the arts of commerce and navigation, its introduction into the northern seas, to which it was ill adapted, appears to have checked, in a most remarkable degree, the maritime enterprise which had hitherto so characterized the population of their coasts. It is even probable that the barrier thus opposed to commerce entailed on the states of Northern and Western Europe centuries of comparative barbarism.

Alfred.

Alfred was the first ruler of England who clearly understood that the policy of Britain was rather to prevent than to resist invasion; and the bygone history of his country told him plainly that its military strength was not only insufficient to awe invaders from its shores, but that all the military resources at his command were inadequate to preserve the liberties of his people. He therefore turned the energies of his mighty mind to the task of creating a naval force, which should be more powerful than that of his untiring persecutors the Danes. In this he succeeded; and at length, under the protection of the fleets which his genius had created, he was enabled to establish that framework of internal policy and government, from the wisdom of which England has even to this day benefited. It is historically certain that Alfred himself superintended the formation of his fleet, and that he gave the design of vessels to be superior to those of the Danes.

His ships.

These vessels were galleys, generally rowed with forty oars, some even with sixty, on each side; and they were twice as long, deeper, nimbler, and less "wavy" or rolling, than the ships of the Danes. The information on this subject is obtained by Selden from a Saxon chronicle of the time of Alfred, which is in the Cottonian Library.

Reasons for their introduction.

It should be remembered, that when Alfred thus introduced the Mediterranean galley into these northern seas, his object was not so much to form a vessel adapted for the purpose of navigating those seas, as to obtain one which would afford space for a large force of fighting men. For this the galley was admirably qualified; and indeed it maintained its place as the appropriate ship for the purposes of war until the invention of cannon rendered other arrangements necessary.

Their success.

The immunity which it insured from the attacks of the Danish marauders caused its general adoption along the coasts hitherto open to their incursions, on all of which it thus superseded the sailing vessels that have been already described; and voyages which, until its introduction, were boldly and successfully achieved, became of rare occurrence and of hazardous issue during the subsequent ages, until the galleys once again gave place to sailing vessels. It also gradually checked the enterprise of the Northmen, by the curb which it placed upon their successes.

Saxon rule.

It is not proposed to give more than a slight sketch of the naval history of Britain through the line of her Saxon princes; for little data can be found on which to base any speculation even, as to the progress of naval architecture during these ages. The galley of the Mediterranean continued to be used for the defence of the coasts; and the policy of Alfred appears to have been well understood by many of his successors—that England only enjoyed peace from invasion when her fleets were powerful enough to repel it from her shores. It is also to be inferred that the use of sailing vessels was not wholly abandoned; for in the reign of Athelstan, the third in descent from Alfred, as recorded by Hackluyt, it was decreed, that "if a marchant so thrived, that he passed thrise over the wide seas of his owne crafte, he was thenceforth a Thein's right worthie."

Mercantile shipping.

This establishes two rather interesting facts: one is, that at so early a period there were merchants of importance enough to engage in such a traffic; and the other is, that from the richness of the reward held out to successful enterprise, the difficulty of the task assigned must have been estimated as great. It may be assumed that these long voyages were made in ships more adapted for the purpose than galleys; in fact, in the vessels which the galleys had been intended to supersede. But the spirit of maritime enterprise had, as before observed, evidently received a check, since one of the highest rewards in the power of the monarch to bestow was held out to the merchant as an incitement to an adventure, which the vague hope of plunder would alone have been sufficient to induce that merchant's progenitors to attempt and successfully perform. However, it is probable that at no time was the art of navigating vessels, which depended principally, although perhaps not wholly, upon their sails, lost in the northern seas. Gibbon says, that at the early crusades the vessels of the "Northmanni et Gothi" (the Norwegians and Danes) differed from those of the other powers, among all of whom the ships partook of the character of the Mediterranean galley. These northern crusaders are described by him as navigating "*navibus rotundis*—that is to say, ships infinitely shorter in proportion to their length than galleys." This was not later than the beginning of the twelfth century, and therefore not so far removed from the periods in question as to render the inference proposed to be deduced from it erroneous, particularly when referring to times of such slow improvement as the middle ages.

Decline of naval enterprise.

Edgar.

The "mighty" fleets maintained by Edgar afford no information on the subject of this article, excepting that the facts connected with that monarch's annual circumnavigation of his territories prove them to have consisted of row-galleys. They must, however, have formed comparatively a "mighty" fleet; for, from a grant of land made by Edgar to Worcester cathedral, it is found that he assumed to himself the title of "Supreme Lord and Governor of the Ocean lying round about Britain." That they were but of slight construction may be inferred from the low state of the navy so shortly after the death of Edgar as the reign of Ethelred, who, in order to re-establish it, instituted a regular tax for providing and maintaining a navy. It was enacted, according to Selden, that whoever possessed "310 hides of land was charged with the building of one ship or galley; and owners of more or less hides, or part of one hide, were rated proportionally"—the hide being, according to the best authorities, as much ground as a man could turn up with one plough in a year. But this tax appears to have been inadequate to the purpose of providing a sufficient fleet, for all the exertions of Ethelred could not preserve Britain from again being ravaged by the Danes, and, after the short reign of his son Edmund Ironsides, England was ruled by Danish monarchs. From the known talent of Canute, the first of these princes, and from the crowns of Denmark, Norway, and Britain being united in his person, it may be presumed that the naval affairs of England were not suffered to retrograde. There is, indeed, a record of their advance during this second Danish rule. It may also be inferred from the present which was made by Earl Godwin to Hardicanute, the third Danish sovereign, of a galley, sumptuously gilt, and rowed by fourscore men, each of whom wore on his arm a bracelet of gold weighing sixteen ounces; not that the mere gorgeousness of the gift would prove any advance in the art of ship-building, but it may be supposed, from its nature, that naval affairs found favour in the sight of this monarch. Of this there is also other historical evidence, as Hardicanute raised L.11,048,

Ethelred.

Canute.

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in the first two years of his reign, for the purpose of building thirty-two ships; and the taxes he levied for the support of his navy were so grievous that, Florentius says, scarcely any man was able to pay them.

Norman conquest.

The marine of England seems to have been maintained on a comparatively powerful footing up to the period of the Norman conquest; and from the naval resources at the command of Harold the Saxon, in comparison with the insignificance of the shipping which brought William and his Normans across the channel, there can be no doubt that had Harold relied upon his naval strength, the conquest of England would never have been achieved; but, by some fatality, his fleet, which had been long stationed off the Isle of Wight, was dispersed, in consequence of a report that William had abandoned his enterprise.

Fleet of William.

The flotilla of William the Conqueror is variously stated; by some at 900, by others at 3000 vessels. Either number proves their insignificance, as the invading force consisted of about 60,000 troops, which would give in the one case about 66 men to each vessel, in the other 20 men only (figs. 1 and 2).

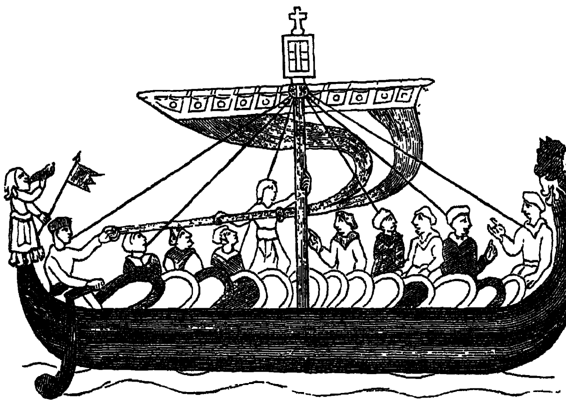

Fig. 1.

The conquest of England being completed, the shores on either side of the narrow seas between England and

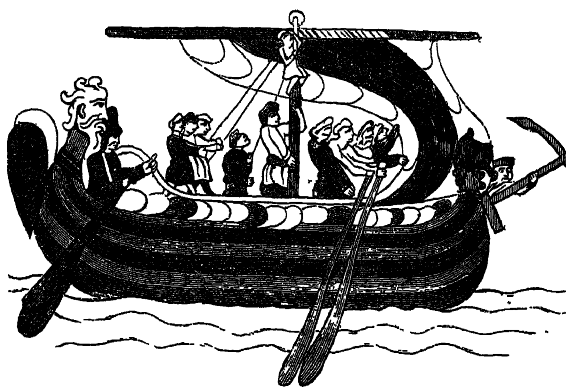

Fig. 2.

Normandy were under the same rule. William, therefore, claimed sovereignty over them, which right was maintained by his successors. There can be no doubt that the constant intercourse between the two portions of the empire, which continued throughout the Norman sway, and indeed for a period of upwards of three centuries, must have done much towards fostering a maritime spirit among the population of England, and accustoming it to consider that fame and fortune were the rewards of nautical adventure.

Probable size of ships.

There is but slight evidence as to the state of naval architecture during the early period subsequent to the Conquest. There are a few facts scattered among the records of these times, from which some vague conclusions as to the probable size and nature of the vessels used may be drawn. When Prince William, son to Henry I., was drowned, by the loss of the vessel in which he was crossing from France to England, it is recorded that 300 souls perished with him. As of this number a large portion, historians say 140, were men of rank, and as there were many ladies, since the prince was accompanied by his sister, the vessel must have been of considerable burthen. A similar event, namely, a shipwreck, that occurred during the reign of Henry II., by which nearly the same number of persons perished, tends to prove that such was about the extent of the accommodation afforded by the shipping of this period. Galleys still continued to be used for the purposes of war; but as commerce began to be extended, it became necessary to recur to the use of sails, and they were therefore gradually recovering their importance, and superseding oars. Indeed, it is difficult to conceive commerce to be profitably engaged in when attended with the immense expense of the crews necessary to propel the larger galleys.

State of trade.

This must have had an important influence in the improvement of navigation and of naval architecture, for the commercial intercourse between the portions of the empire on either side of the channel must have been considerable. There is constant reference in the early chronicles to the great extent of the wine trade, and of the commerce in wool and woollen cloths.

The introduction of vessels propelled by sails for the purposes of commerce would necessarily cause a change in the constitution of the fleets assembled for the services of war; and this will be found to have been the case.

Richard Cœur de Lion.

The expedition of Richard Cœur de Lion, in 1190, to join the crusade to the Holy Land, consisted of nine ships, which are described as being of extraordinary size, 150 others of inferior dimensions, and only 38 galleys. After the reduction of Cyprus, and the addition of the vessels captured there, with others which he had hired at Marseilles and in Sicily, his armament consisted of 254 "tall shippes, and about three score galliots." The increase was, therefore, almost wholly in the ships. This, together with the recorded fact, that he captured a Saracenic vessel of such size as to be capable of containing 1500 Saracens, and a large quantity of military stores, destined for the relief of Achon, tends to prove that the progress of naval architecture, under the influence of the commercial powers of the Mediterranean, had been more rapid than in these northern seas, where the commerce was much more confined in its nature, and the nations bordering on which were in constant warfare with each other.

Sovereignty of the seas.

The Norman monarchs appear to have been very tenacious of their claim to the sovereignty of the narrow seas; and not only their claim, but their power to maintain their right, is admitted by the French historians. The Père Daniel sanctions the claim of Henry II. to this sovereignty.

John.

In the reign of John the fleets of England were of such importance that the claim was extended; for it was then enacted, that if the masters of foreign ships should refuse to strike their colours, and thus pay homage to the English flag, such ships should be considered as lawful prizes. This monarch most carefully fostered the naval power of England; and it is in the records of the thirteenth year of this reign that mention is first made of any public naval establishment.

Early origin of Portsmouth dockyard.

There is in the close rolls, published by the Record Commission, an order, which is dated the 29th of May 1212, from the king to the sheriff of the county of Southampton, in which he is directed without delay to cause the king's docks at Portsmouth to be enclosed by a good and strong wall, in order to protect the king's galleys and ship's; and also to build storehouses against this wall, for the preservation of the fittings and equipment of the said vessels; all of which works are to be performed under the direction of William, archdeacon of Taunton, and the

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greatest diligence is to be used, in order that the whole may be completed during the summer.

Edward I.

The naval power of England appears to have continued sufficient to maintain the sovereignty assumed by John. For the occurrence of predatory excursions by some Genoese, during the reign of Edward I., caused all the nations of Europe, bordering on the sea, to appeal to the kings of England, whom they acknowledged to be in peaceable possession of the "Sovereign Lordship and Dominion of the Seas of England, and Islands of the same;" which proves that their claim was generally acknowledged. This document, Evelyn says, was still extant in his time, in the archives of the Tower. The right to the absolute sovereignty of the seas was maintained up to the reign of James I. Queen Elizabeth insisted on and maintained her power to refuse or grant passage through the narrow seas, according to her pleasure. In 1634 Charles I. asserted his right to their sovereignty; and in 1654 the Dutch were compelled, after a severe struggle, to submit to it, and consent to "strike their flags and lower their top-sails on meeting any ship of the English navy on the British seas;" which homage the commanders of English men-of-war were instructed to exact from all foreign vessels until so lately as the close of the last war, when it was judiciously abandoned, for the following reasons, as given by Sir John Barrow. In his *Life of Howe*, with reference to Trafalgar, he says, "That battle, moreover, having so completely humbled the naval powers of France and Spain, suggested to the consideration of the Board of Admiralty, with the approbation of the government, the omission of that arbitrary and offensive article which required naval officers to demand the striking of the flag and lowering of the top-sail from every foreign ship they might fall in with. That invidious assumption of a right, though submitted to generally by foreigners for some centuries, could not probably have been maintained much longer, except at the cannon's mouth; and it was considered, therefore, that the proper time had come when it might, both morally and politically, be spontaneously abandoned."

It is generally supposed that ships intended only for sailing were first built by the Genoese, and that not until the beginning of the fourteenth century. It is perhaps more probable, that in the Mediterranean they date from an earlier period than this; and that although the general adoption of the galley in Western Europe had much checked the art of navigation by means of sails, it had never been wholly lost, but that sailing vessels, though probably very few in number, and imperfect in rig, had been constantly in use. To judge from the few hints handed down to us by history, they were probably luggers, and were adopted for mercantile purposes along the coast of the Channel and the Bay of Biscay. In the north of Europe sails had never been discontinued, although the more warlike galleys of England and France had gradually prevented the incursions of the northern nations into these more southern seas. The beginning of the fourteenth century is, however, decidedly an epoch in the histories both of navigation and of naval architecture, and from it may be dated the progress of navigation by means of sails. It is generally supposed that the "large ships" mentioned in the enumeration of the fleets of this period, were ships built only for sailing, and intended for those long voyages which the invention of the compass by Flavio Gioio, a Neapolitan, about the year 1300, had rendered of comparatively easy performance.

Mariner's compass.

It has been surmised that the compass was brought to Europe from the East about forty years previous to this date, by Paulus Venetus. It is certain that the Portuguese found the knowledge of the magnetic needle generally and long diffused among the eastern navies. Evelyn says, that "it was, near eighty years after its discovery, unknown in Britain." This is not improbable, for there does not remain much record of maritime affairs in the interval between the reigns of John and Edward III. This monarch's reign was, after a most severe struggle with France for supremacy on the seas, the era of a series of naval triumphs, and both navigation and naval architecture made most decided advances.

Edward III.

Naval battle.

In an engagement which took place in 1340, the French force amounted to 400 vessels, of which 120 were "large ships," these being principally Genoese mercenaries. Edward III. commanded the English fleet in person, which consisted of but 260 sail. The French are variously reported to have lost 20,000 and 30,000 men, and 200 vessels are said to have been captured. The loss to the English was only 4000 men. Two facts are elicited by the accounts of this engagement; one is, that there is no mention of galleys as forming any part of the fleets; the other is, that in the James of Dieppe, which was captured by the Earl of Huntingdon, 400 persons were found slain; consequently the size of the vessel must have been very considerable.

Royal fleet.

In 1344 Edward summoned commissioners from all the ports, to meet in the metropolis, provided with the state of their "navies." The roll of this fleet is inserted in the first volume of Hackluyt, from a copy in the Cottonian Library. The total numbers were 710 ships, and 14,151 mariners; and there were 38 foreign ships, with 815 mariners. From this roll it will be seen that galleys had ceased to be used by England, either in her wars or in her commerce, as neither among the king's ships nor among those furnished by merchants is there any mention of them. This fleet was that engaged in the celebrated siege of Calais, and it was probably at this time that cannon were first employed by the English. Camden, in his *Remains*, says, "Certain it is, that King Edward III. used them at the siege of Calais in 1347."

Use of cannon.

Sizes of Edward's ships.

Although from the fact of there being a royal dock-yard at Portsmouth so early as the reign of John, it is probable that the kings of England were possessed of a navy almost from the conquest; yet this roll of Edward's fleet contains the first enumeration of ships belonging to the sovereign, and employed in the service of the state, which occurs in English history; and consequently it is from the reign of Edward III. that the formation of a royal navy must be dated. The king's ships were 25 in number, and were manned by 419 mariners. It appears that the vessels belonging to the sovereign were inferior in force to many of those which were supplied by subjects; for the average number of the crews of the king's ships were 17 men to each vessel, while the average of the fleet was rather above 20. Of course these numbers only include the mariners employed in navigating the vessels, and not the soldiers to be afterwards embarked on board them. Considering the simplicity of the rig of these ships, in comparison to the wilderness of canvas and cordage covering the tall masts of a modern merchantman, there is more reason to be astonished at the large number of hands employed, than at the smallness of the averages, 17 and 20. There is good reason to suppose that the addition of the bowsprit to the rig of ships dates no farther back than late in the reign of Edward III., which is alone quite sufficient to prove the very imperfect state of the navigation at that period, and also to excite astonishment that, with such apparently inadequate means, so much was effected; for history would almost lead us to suppose that, for all the purposes of war and commerce, fleets as proudly or as industriously ploughed the main then as now, "with all appliances and means to boot."

Richard II.

First navigation act.

In the year 1381, the fourth of the reign of Richard II., the first navigation act was passed in England, for the encouragement of the naval interest and the augmentation of our maritime power, by discountenancing the employment of foreign shipping. It enacted, "That for increasing the

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Royal ships hired by merchants. It has been remarked above, that the royal navy of England must date from the reign of Edward III. There is proof that it continued to be customary for the sovereign to possess ships; they were, however, used both for war and commerce. This practice, which does not at all militate against the existence of a royal navy, appears to have commenced when "large ships" were substituted for the galleys as vessels for war; and it long continued to be usual for merchants to hire shipping from the sovereign for commercial voyages. The proceedings of the privy council, which have been printed by the Record Commission, show

Henry IV. that in June of the year 1400, Henry IV. ordered his "new ship," together with such others as were in the port of London, to proceed against the enemy. There is also a

Letter to Henry V. letter in the Cottonian Library, which has been printed in Ellis's *Collection of Letters*, from John Alcetre to King Henry V., concerning a ship building for that monarch at Bayonne. The letter is of the date of 1419; and as it contains more minute details than might be expected to have descended to us from such an early period, we give the following extract:—"At the makyng of this letter yt was in this estate, that ys, to wetyng xxxvj. strakys in hyth y bordyd, on the weche strakys hyth y layde xj. bemys; the mast beme ys yn leynthe xlvj. comyn fete, and the beme of the hameron afore ys in leynthe xxxix. fete, and the beme of the hameron by hynde is in leynthe xxxiij. fete; fro the onemost ende of the stemme in to the post by hynde ys in leynthe a hondryd iij$^{xx.}$ and vj. fete; and the stemme ys in hithe iiij$^{xx.}$ and xvj. fete; and the post xlviij. fete; and the kele y in leynthe a hondryd and xij. fete; but he is y rotyt, and must be chaungyd."

We have also evidence of the existence of ships which belonged to the monarch, in contradistinction to ships which belonged to the "commons," in the quaint rhymes of an anonymous author of the year 1433, which have been

Libel of English Policie. preserved by Hackluyt, termed *The Prologue of the processe of the Libel of English policie, exhorting all England to keepe the sea, and namely, the narrowe sea, showing what profite commeth thereof, and also what worship and saluation to England, and to all Englishmen.*

"And if I should conclude all by the king
Henrie the Fift, what was his purposing,
Whan at Hampton he made the great dromons,
Which passed other great ships of all the commons;
The Trinitie, the Grace de Dieu, Holy Ghost,
And other moe, which as nowe bee lost.
What hope ye was the king's great intent
Of thoo shippes, and what in minde hee meant:
It was not ellis; but that hee cast to be
Lorde round about environ of the sea."

The term dromond is the corruption of a Levantine term, dromones, imported probably by the crusaders. The dromonds were long row-galleys, but the adopted term dromond was applied generally to all large ships.

Henry's fleet. There is a list of Henry's vessels in the fourth year of his reign preserved in the proceedings of the privy council. His navy then consisted of three "large ships," or "grands niefs," three "carracks," eight barges, and ten balingers. In 1417 it was augmented to three "large ships," eight "carracks," six other ships, one barge, and nine balingers.

Early tonnage. Again, in a letter preserved among the Cottonian manuscripts, and printed in Ellis's collection, it is stated that the Spaniards offered Henry V. two carracks for sale, one of which is described as of a tonnage equal to 1400, and the other to 1000 butts. So energetical was Henry V. in all things relating to his navy, and the consequent increase in the number of the royal ships during his reign was so great, as to have led to the error that before his time the sovereigns of England were not possessed of vessels, but relied wholly upon the aid to be gathered from the different ports of England, or to be hired from foreigners. This is evidently incorrect.

Neglect of the navy. On the death of Henry V. a different line of policy appears to have been adopted; for in May 1423 the king's ships were all sold at Southampton, under a restriction that no foreigner could be a purchaser of them. But it appears that a long period did not elapse before the depressed state of the naval resources of the kingdom, consequent on this injudicious measure, attracted the attention of parliament. The following interesting quotation from the preface of the fifth volume of the *Proceedings of the Privy Council*, printed by the Record Commission, refers to this event:—"In 1443 the attention of parliament was directed to this important part of the national defence (the naval force), and a highly curious ordinance was made for the safeguard of the sea. From February to November eight ships with forestages, or, as they were sometimes called then, as now, forecastles, armed with 150 men each, were to be constantly at sea. Every large ship was to be attended by a barge of 80 men, and a balinger of 40 men. There were also to be 'awaiting and attendant upon them' four 'spynes' or 'spinaces,' with 25 men each. The whole number of men in these 24 ships was 2240."

There is also in the same preface an account of the various kinds of ships which formed the navies of this period, a part of which we shall quote, and by the addition of some further information of the same nature, derived from Froissart, Monstrelet, and other sources, the reader will be enabled to form a tolerably correct opinion as to the state of naval architecture in England previous to and during the fifteenth century.

Ships. *Ships.* "The burthen of the largest ships at that period probably did not exceed 600 tons, though some of them were certainly very large," as, for instance, the vessel built at Bayonne for Henry V., already mentioned. "One which belonged to Hull was released from arrest" (she having been pressed into the king's service), "because she drew so much water that she could not approach within two miles of the coast of Guienne, where the Duke of Somerset's army intended to disembark;" and several notices occur of ships of 300 and 400 tons and upwards. Some had three and others only two masts, with short topmasts, and a "forestage" or "forecastle," consisting of a raised platform or stage, which obtained the name of castle from its containing soldiers, and probably from its having bulwarks. In this part of the ship it appears business was transacted; and in the reign of Edward III., if not afterwards, ships had sometimes one of these stages at each end, as ships "*ove chastiel devant et derere*" are then spoken of. Lydgate, describing the fleet with which King Henry V. went to France after the battle of Agincourt, says,

"Fifteen hundred ships ready there be found,
With rich sails and high topcastle."

This is a confusion of terms. The "topcastles" were not the forecastles, but were castellated enclosures at the mastheads, in which the pages to the officers were stationed during an engagement, in order to annoy the enemy with darts and other missiles; as is frequently mentioned in Froissart, and is represented in the illuminations to his work.

Carracks. *Carracks* "were vessels of considerable burthen, and were next in size to great ships, in which class they indeed were sometimes included. Their tonnage may be estimated by their being in some instances capable of carrying 1400 butts; and the sail of one afforded Chaucer a strange simile expressive of magnitude,

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'And now hath Sathanas, saith he, a tayl
Broder than of a carrike is the sayl.'

Though occasionally armed and employed against the enemy, they were more generally used in foreign trade."

Charnock says that the first carrack which was built in England was built for a merchant, John Tavenier of Hull, who was consequently honoured by Henry VI. with distinguished favour; and she was licensed in 1449 with particular privileges to trade through the Straits of Morocco. The king also ordered her to be called the "Grace Dieu Carrack." The license states her to have been built "by the help of God and some of the king's subjects."

Barges. *Barges* "were a smaller kind of vessel and of different construction from ships, though, like them, they sometimes had forecastles. Those appointed to protect the seas in 1415 were of 100 tons burthen, and contained forty mariners, ten men-at-arms, and ten archers; whilst the ships employed on the same occasion were of 120 tons, and had forty-eight mariners, twenty-six men at arms, and twenty-six archers each. Four large barges and two balingers were capable of holding 120 men-at-arms and 480 archers and sailors."

Balingers. *Balingers* "were still smaller than barges, had no forecastle, and sometimes contained about forty sailors, ten men-at-arms, and ten archers." Froissart makes frequent mention of "balniers," "balleniers," which he describes "as drawing little water, and being sent in advance to seek adventures, in the same manner as knights and squires, mounted on the fleetest horses, are ordered to scour in front of an enemy, to see if there be any ambuscades." Monstrelet speaks of one vessel that was employed by Louis XI. to abduct the Count de Charolais, by the two names ballenier and balayer. It is not improbable that the name is derived from the French word *baleine*, and that its origin was similar to that of our English name whaler. The whale-fishery in Biscay was of a very early date.

Galleys. *Galleys* "are frequently mentioned at a very early period; and in the 5th Rich. II., 1381, the Commons complained that no measures had been taken to resist the enemy, who had attacked the English at sea with their barges, galleys, and other vessels. In 1405 Henry IV. directed his council to apply to the King of Portugal to lend him his galleys to assist the English navy against the French."

In Sir Grenville Temple's Travels in Greece and Turkey the following description of a Maltese galley, or, more correctly, galleas, made from an old model preserved there, will be found:—"These galleys measured 169 feet 1 inch in length, and 39 feet 6 inches in breadth. They had three masts with latine sails, and were propelled by forty-nine oars, each 44 feet 5 inches long. Their armament consisted of 1 thirty-six pounder, 2 of twenty-four, and 4 of six, all on the forecastle, which in those days had in reality some appearance of a castle. On each side of the vessel, aft of the forecastle, were 4 six-pounders." The total crew, including galley-slaves, consisted of 549 persons.

Galleas. The *Galleas* and the *Galleon* appear to have been successive improvements on the original galley, rendered necessary by the introduction of cannon into naval warfare. The artillery introduced on board the early galleys was placed either before or abaft the rowers, and to fire in the direction of the length. In the galleas, a description of vessel first used at the battle of Lepanto, guns were also placed between the rowers, to fire from the broadside. Evelyn describes the galleases he saw at Venice (1645) as being "vessels to rowe of almost 150 foote long and 30 wide, not counting prow or poop, and contain twenty-eight banks of oares, each seven men, and to carry 1300 men, with three masts." In the galleon the oars ceased to be the principal means of propulsion, and if used at all, were only so as occasional aids. The galley and galleas had overhanging topsides for the accommodation of the oars. In the galleon, on the contrary, the topsides "tumbled home" to so extraordinary an extent, that the breadth at the water was twice that at the topside, a fashion which has continued, but in a much less degree, to the present time.

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Spynes or spynaces. *Spynes* or *spynaces*, "now called pinnaces, seem to have been large boats, capable of holding twenty-five men, and were probably used for swiftness. To these must be added crayers, hulks, gabarres or gabbars, a kind of flat-bottomed boat, used in shallow rivers." The French still continue to apply the term "gabarre" to store-ships.

Playtes and smaller vessels. "Playtes, cogships, whence perhaps cogs and coggles are derived; farecrofts, passagers, which were perhaps boats used between England and France; and cock-boats, a small boat which attended upon all kinds of ships. The whole of these vessels were employed in conveying goods or passengers, and most of them on rivers or in the coasting trade. The ships, carracks, barges, balingers, and galleys, were employed equally for commerce or for war. When sent against the enemy, soldiers were put on board of them; and it is most likely they were at all times partly manned by soldiers. In foreign voyages they usually sailed in convoys; and it was a very ancient custom for the masters and sailors to elect their own admiral."

Foists or foysts. In Burchett's account of the unfortunate action in the Bay of Conquet, in 1513, in which the Lord High Admiral, Sir Edward Howard, lost his life, four *foists* are mentioned as forming a part of the French force. They were probably vessels of a similar character with the galley, but smaller in size. About the beginning of the seventeenth century, "carracks," "galleons," and "tall shippes," appear to have become synonymous terms.

Hulks. The term hulk originally was applied in a different sense from that which is stated in the part of the foregoing remarks which we have quoted from the preface to the proceedings of the privy council. Frequent allusion is made to hulks in documents of the fifteenth and sixteenth centuries. In a letter from Sir Thomas Seymour to the privy council, dated the 13th of November 1544, when in command of the "shipes whyche was a poyntede to kepe the Narrow Sees," vindicating himself for putting back on account of a storm, there is the following passage, from which it might almost be inferred that hulk was a general name synonymous with ships:—"Thre holkes that come after me colde nott gett syght thereof (the 'Eylle of Wyght') tyll they warre in a bay on the est syde of the Eylle, of the whyche Mr Strowd, Bramston, and Battersebe of the garde, God rest their sowles, was in on of them, whyche holke brake all her ankeres and cabelles, and she brake all to peses on the shorr, and but 41 of 300 saved a lyve. The other two rode out the storme; whyche lasted all that nyght and the next day. My brother (Sir Hy Seymour) and John Roberds of the garde, tryde the sees all the furst nyght, and the next day cam into Dartemouth haven, wharre my brothers holke strake on a roke and brest all to peses; but God be praysede, all the men warre savede, savying thre; and a nother new holke that tryde the sees that nyght brake thre of her bemes, and with moche ado came into the Wyght."

Again, in a letter from Lord Viscount Lisle, Baron Malpas, the Lord High Admiral of England, to Henry VIII., there is an announcement, that "their is cum into the Downes 30 sayle of hulkses, whereof sum be tall shipes." And again, in a letter from the same to the Lord Chamberlain, Lord St John, he speaks of having detained "3 grate hulkes bound, as they say, for Lusshborne, the leste of y^m 500 tunnes." And again, from the same to the same, he speaks of his former letter and the "goodly hulkes," and says, "sithens that tyme I have stayed other too, which in beautye and well appoynting are beyond the others. That I have last stayed ys a shipe of 600 at the least, and hath

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5 toppes, and she ys of the town of Dansick, and ladon in Flanders for Lusshbourne."

State mercantile shipping. William Canynge.

The importance of the mercantile shipping of England during the fifteenth century must have been considerable. About the middle of it flourished the celebrated William Canynge, a merchant of Bristol, who built the church of St Mary's, Redcliff, in that city, in which church he was buried in 1474. This man appears to have been much in advance of the rude times in which he lived. His mercantile transactions were on so extensive a scale, and carried on in vessels of such large size, that they must have had an important influence in improving the navies of the period. The information which has descended to us respecting him is therefore not only a fact of much historical interest, but is one which is intimately connected with, and most materially affects, our subject. He was a great patron of the arts, a friend and protector of genius, and eminent for his virtue and piety. From an inscription upon his tomb, a tradition has become current, that Edward IV. took 2470 tons of shipping from him, he having "forfeited the king's peace;" and for the obtaining of which again, it is stated that Edward accepted these ships instead of a fine of 3000 marks. The *Itinerary* of William of Worcester, preserved in the library of Bennett College, Cambridge, gives the names of Canynge's vessels, among which are the Mary and John of 900 tons, Mary Redcliff of 500 tons, and Mary Canynge of 400 tons. The same authority gives the names and tonnage of other large ships belonging to Bristol merchants, among which are the John of 511 tons, and the Mary Grace of 300 tons. If there be any truth in the tradition of the confiscation of the shipping, it is probable that the inscription on the tomb may refer to some act of Canynge's in favour of the house of Lancaster, as he appears to have enjoyed the favourable opinion of Henry VI. Another account, which, it is said, is authenticated by the original instrument in the Exchequer, states that this Canynge assisted Edward IV. with a loan, and received in return a license to have 2470 tons of shipping free of imposts. In Corry's *History of Bristol* it is said, "the commerce and manufactures of Bristol appear to have made considerable progress during the fifteenth century, about the middle of which flourished the celebrated Canynge. This extraordinary man employed 2853 tons of shipping, and 800 mariners, during eight years. Two recommendatory letters were written by Henry VI. in 1449, one to the master-general of Prussia, and the other to the magistrates of Dantzic, in which the king styles Canynge his beloved eminent merchant of Bristol."

Doubts as to accuracy in estimating size of ships.

Some doubt must always remain as to the actual size of the shipping of this remote period, as we cannot ascertain the bulk that was then considered as equivalent to a ton. It is probable that the tonnage was estimated according to the number of butts of wine that a vessel could carry. For we find references to ships sometimes by tonnage, and sometimes by the "portage" of so many butts.

This, however, is only a question as to exactness of size. In whatever way measured, Canynge's ships must have been of very considerable dimensions. It is rather extraordinary, that at the unsettled period in question Bristol should have enjoyed such a state of commercial prosperity as the ownership of such shipping as that enumerated by William of Worcester necessarily involves. Bristol, for many centuries, was only second in mercantile importance to London; but the civil wars which distracted the kingdom during a great part of the fifteenth century must have much retarded the increase both of the military and the mercantile navy of England; and only when order was again re-established by the accession of Henry VII. to the throne, in 1485, could men's minds revert from the internal excitement of party strife to external affairs.

Henry VII.

In this interval, in which England was torn by the wars of the houses of York and Lancaster, naval science had made more rapid strides than in any previous period of similar duration. The compass was not only known but was generally adopted. Navigators could take observations by the use of an instrument called the astrolabe, invented by the Portuguese. The Spaniards and Portuguese were sufficiently advanced in the art of navigation to sail on a wind, and their smaller vessels, at least, were adapted for this manœuvre. New maritime states had started into existence. The Netherlands, until then scarcely known, was, under the Duke of Burgundy, the most formidable naval power in the north of Europe. "His navy," says Philip de Commines, "was so mighty and strong, that no man durst stir in those narrow seas for fear of it, making war upon the king of France's subjects, and threatening them everywhere; his navy being stronger than that of France and the Earl of Warwick joined together." Venice, in 1420, according to Denina, in his *Revolutions of Italy*, supported 3000 merchant-ships, on board of which were 17,000 seamen. They employed 300 sail of superior force, manned by 8000 seamen; had forty-five carracks, with 11,000 men to navigate them; and her arsenals employed 16,000 carpenters. Portugal had pushed her discoveries round the Cape, and Spain had added America to the world.

Progress of naval improvement. Compass. Astrolabe. Netherlands. Venice.

The progress of discovery by the Portuguese to the south and east, and by the Spaniards to the west, in the voyages of Columbus, with the consequent rapid increase in the importance of these two powers, and the influence of their discoveries on the state of Europe, renders the fifteenth century probably the most important of modern history. In it was given the death-blow to the increase of the Saracenic power, and to that of the Mediterranean states. The Turk, the Venetian, and the Genoese, had hitherto been the monopolizers of the commerce of the east. The discovery of the passage round the Cape of Good Hope opened this trade to all nations. The commercial sceptre, and consequently the military sceptre, hitherto shared by the Turk, passed wholly from the infidel to the believer. The crescent sank before the cross.

Portugal. Spain. Passage round the Cape of Good Hope.

There can be no doubt, also, that the "*tormentas*" of the "*grão Cabo de boa Esperāça*," were a means of great improvement in naval architecture; for, in consequence of the representations of Bartholomew Diaz, John II. of Portugal ordered ships to be constructed for the especial purpose of contending with the stormy seas of the Cape of Good Hope. The ships were built to form the squadron of Vasco de Gama, and were of small tonnage, from the very proper idea that small vessels were more adapted to prosecute researches in unknown seas than those of a large size, and consequent increased draught of water.

Its influence on naval architecture.

The squadron of Vasco de Gama consisted of three ships and a caravella. One of the ships was of the burthen of 200 tons, another 120, and the third 100; the caravella was of 50 tons. The largest of the ships was a victualler; the smallest was intended to prosecute discovery up creeks and shallows; and the other was for a display of force. As it is evident that it was not increase of dimensions which was to be the object in designing new vessels, the direction of improvement must have been towards perfecting their forms, strengthening their frames, and adding to the efficiency of their *materiel*. Portugal by these means became the most advanced state of Europe in knowledge of the art of ship-building; for it was long supposed that the passage to India required ships such as the Portuguese alone could build. Spain, in her career of discovery, conquest, and colonization across the mighty waters of the Atlantic, as if to assimilate the means to the vastness of her achievements, rapidly acquired the art of constructing ships of very large dimensions; and as long as she possessed a marine, her ships maintained this superiority.

Squadron of Vasco de Gama.

History.

State of naval affairs in England.

There is a curious instance of the light in which naval enterprises were considered in England at this time, notwithstanding the earnest desire of the monarch to re-establish his navy, which had necessarily suffered from the long civil wars. A letter from Henry VII. to the Pope is preserved in the Cottonian Library, excusing himself from sending succour against the Turk, from which the following is a quotation:—"The Galees commying from Vennest o England be commonly vij. monethes sailying, and sometimes more;" and again, "it should be May or they should be ready to saill, and it shall be the last end of September or the said shippes shuld passe the Streits of Marrok; and grete difficultie to fynde any Maryners hable to take the rule and governance of the said shippes sailying into so jeopardous and ferre parties."

Henri Grace à Dieu.

There is a drawing extant in the Pepysian Library in Magdalen College, Cambridge, of the Henri Grace à Dieu, built by the order of Henry VII., which Charnock has engraved in his *History of Marine Architecture*, and argues as to the general authenticity of the representation. He says, "this vessel may be termed the parent of the British navy. This celebrated structure, the existence of which is recorded in many of the ancient chronicles, cost the king, by report, nearly 14,000 pounds."

Early origin of naval terms.

From this drawing may be traced the derivation of one or two names which have been preserved even to the present hour; as, for instance, the "yard-arm," no doubt from the ends of the yards being armed with an iron hook. The castellated work from which has arisen the term "forecastle" is earlier than this; and the buckler-ports are most probably derived from a yet earlier period, when the bucklers of the knights were ranged along the sides of the ship, as they are represented in the illustrations of Froissart, and of the early chroniclers, and even in the Bayeux Tapestry.

"The masts were five in number, inclusive of the bowsprit, an usage which continued in the first-rates without alteration till nearly the end of the reign of King Charles I.; they were without division, in conformity with those which had been in unimproved use from the earliest ages. This inconvenience it was very soon found indispensably necessary to remedy, by the introduction of separate joints, or top-masts, which could be lowered in case of need."

The drawing shows two tiers of ports. The introduction of port-holes is said to be an improvement due to a French ship-builder of Brest, named Descharges, in the reign of Louis XII., and about the year 1500. If the drawing be authentic, the correctness of this appropriation of the merit of the introduction of port-holes may be questionable.

Again, if the drawing be a correct representation of the vessel, she would have been in danger of upsetting, excepting in calm weather, and when her course was with the wind. In fact, as yet the large ships of war of England were not at all adapted to sail on a wind, and were very ill provided with such sails as would enable them to do so; they had therefore nothing to fear from the result of a measure which could not be put into execution. The fleets of war seldom ventured out of port excepting in the summer months, and then only when the wind was favourable to their intended course. But very shortly after the date of the building of the Henri Grace à Dieu, great improvement took place, and in the reign of Henry VIII. there is evidence to prove that sailing on a wind formed one of the qualities of the vessels composing his fleets. This fact appears to throw some doubt upon the correctness of the drawing, for it must have required ships widely different from any of which that would at all give an idea, to have performed the evolution of tacking or wearing; and as the Henri Grace à Dieu was in all probability the same ship that on the accession of Henry VIII. was called the Regent, she must have formed one in fleets which were capable of performing these manœuvres. It is true that she may have been altered to adapt her to these new requirements of an improved system of seamanship; and it must also be said, that she was burned in an action with the French fleet, which occurred as early as the fourth year of the reign of Henry VIII.

History.

Henry VIII. Sailing on a wind.

Though it is out of the question that ships with the enormous top-hamper which, on the evidence of all the drawings extant, still continued to be the fashion, could have made much progress in sailing on a wind, the letters of the time extant corroborate the statement made; for they begin to contain references to this improvement in navigation. In a letter from Sir Edward Howard, "Lord Admiral," to King Henry VIII., upon the state of the fleet, A.D. 1513, preserved in the Cottonian Library, and published in Ellis's collection, the following passage occurs:—"Ye commanded me to send your grace word how every shipp dyd sail; and this same was the best tryal that cowd be, for we went both slakyng and by a bowlyn, and a cool acros and abouet in such wyse that few shippes lakkyd no water in over the lee wales." The Lord High Admiral Lisle, in one of his letters (1545), says the small vessels of his fleet could "lye best by a wynde;" and in 1567 we have conclusive proof that there were "fore and aft," indeed "cutter-rigged" vessels on the British seas; as in a map of Ireland of that date, published in the state-papers, two such vessels are represented, for the purpose, apparently, of indicating regular packets from England to Ireland.

It has been very generally supposed, on the authority of Sir Walter Raleigh, that the "knowledge of the bowline" was a discovery in navigation made shortly before his time; but is is probable that there were, even from the time of the Northmen, craft so rigged as to be capable of sailing on a wind. Froissart mentions, in several instances, "a vessel called a Lin, which sails with all winds, and without danger;" and again, "a vessel called a Lin, which keeps nearer the wind than any other." Boats with a rig adapted for this manœuvre are also represented in engravings of a very early date. In the plates of Breydenbach's *Voyage to Palestine*, which was published in 1483, boats and small vessels are represented with lateen sails; and in Braun's *Civitates Orbis Terrarum*, published in 1572, sprit-sails are met with. It is quite certain, however, that sailing on a wind was by no means a general quality possessed by the ships of war, or to any extent even by the greater portion of the larger shipping, until about the reign of Henry VIII. One other instance may be adduced in the account of the loss of the Mari Rose, a ship of the "portage of 500 tons," not so much to corroborate the fact of sailing on, a wind as to show that the two innovations, the introduction of port-holes and the "knowledge of the bowline," were in advance of the qualities of the large ships of war of the time. Sir Walter Raleigh says that, "in King Henry VIII.'s time, at Portsmouth, the Mari Rose, by a little sway of the ship in casting about, her ports being within sixteen inches of the water, was overset and lost."

Loss of the Mari Rose.

The loss of this ship has been the means of giving another interesting insight into the comparatively low state of nautical skill in England at this period, namely, the middle of the sixteenth century. In a letter among the state-papers published under the direction of the Record Commission, addressed by the Duke of Suffolk to Sir William Pagett, "chief secretary to the kinge's highnes," dated the 23d of July 1545, and containing a schedule of things necessary to be had for the raising of the Mari Rose, one item is "fifty Venyzian maryners and one Venyzian carpenter;" the next item is "sixty Englisshe maryners to attende upon them." It would also appear that the attempt was to be made under the direction of an Italian, as the conclusion of the schedule is, "Item, Symond, petrone and master in the Foyst, doth aggrie that all thyngs must be

had for the purpose aforesaid." The attempts, however, all failed; the wreck of the Mari Rose remains to this day at Spithead, and so lately as August 1836, several of her brass cannon, of most exquisite workmanship, were recovered from the sea by the enterprise and ability of an Englishman of the name of Deane.

Minutiæ of ship-building at this period.

Some idea of the detail of ship-building rather before this period may be obtained from an account of a vessel built by James IV. of Scotland, at the close of the fifteenth or the beginning of the sixteenth century. The extract is from Charnock, but he has not mentioned his authority. "The king of Scotland rigged a great ship, called the Great Michael, which was the largest and of superior strength to any that had sailed from England or France; for this ship was of so great stature, and took so much timber, that, except Falkland, she wasted all the woods in Fife which were oakwood, with all timber that was gotten out of Norway; for she was so strong, and of so great length and breadth, all the wrights of Scotland, yea, and many other strangers, were at her device by the king's command, who wrought very busily in her; but it was a year and a day ere she was completed. To wit, she was twelve score feet of length, and thirty-six foot within the sides; she was ten foot thick in the wall and boards, on every side so slack and so thick that no cannon could go through her. This great ship cumbered Scotland to get her to sea. From that time that she was afloat, and her masts and sails complete, with anchors offering thereto, she was counted to the king to be thirty thousand pounds expense, by her artillery, which was very great and costly to the king, by all the rest of her orders. To wit, she bare many cannon, six on every side, with three great bassils, two behind in her dock and one before, with three hundred shot of small artillery, that is to say, myand and batterd falcon, and quarter falcon, flings, pestilent serpentens, and double dogs, with hagtor and culvering, corsbows and handbows. She had three hundred mariners to sail her, she had six score of gunners to use her artillery, and had a thousand men of war, by her captains, shippers, and quarter-masters."

Large Swedish ship.

Several of the writers of this period mention the fact of a Swedish ship of extraordinary dimensions being built in the middle of the sixteenth century, and which was burned in an action between the Swedes and Danes in 1564. Chapman has given an estimate of the dimensions of this vessel. She was called the Makalos (by Charnock, Megala). According to Chapman, she was 168 English feet in length and 43 English feet in breadth, an immense vessel for that period. Her armament was 173 guns, 67 only of which could be considered as cannon, the remainder being merely swivels.

Royal dockyards.

Henry VIII. was deeply sensible of the necessity of a permanent and powerful naval force, and established the navy office, and also several dockyards for building and repairing the ships of the royal navy. Among these were Woolwich, Deptford, and Chatham. He also greatly added to and improved the dockyard at Portsmouth. He invited from foreign countries, particularly from Italy, the commercial cities of which were still in advance of the rest of Europe in the maritime arts, as many skilful foreigners as he could allure, either by the hope of gain or by the honours and distinguished countenance he paid to them. The following extract is from a report made to James I. in the year 1618, and published in the *Archæologia*. It was made in answer to a commission issued by that monarch to the several master-builders.

Edward VI.

The minority of Edward VI., and the civil and religious strife which distracted the kingdom during the reign of Mary, depressed the resources of the state, and evidently much checked the progress of its maritime strength. The report says, "In former times our kings have enlarged their dominions rather by land than sea forces, whereat even strangers have marvelled, considering the many advantages of a navy; but since the change of weapons and fight, Henry VIII., making use of Italian shipwrights, and encouraging his own people to build strong ships of war, to carry great ordnance, by that means established a puissant navy, which in the end of his reign consisted of 70 vessels, whereof 30 were ships of burthen, and contained in all 10,550 tons, and 2 galleys. The rest were small barques and row-barges, from 80 tons downwards to 15 tons, which served in rivers and for landing of men. Edward VI., in the sixth year of his reign, had but 53 ships, containing in all 11,005 tons, with 7995 men, whereof only 28 vessels were above 80 tons each. Queen Mary had but 46 of all sorts."

Defects of the ships of this period.

There is one peculiarity about the fleets of this time, which exemplifies the defects of their design in a very remarkable feature. It is, that the ships built for the royal navy appear only to have been adapted for the lodgment of the soldiers and mariners, with their implements of war, and the necessary stores for navigation. The provisions were carried in an attendant vessel, called a "victualler," of which there was one attached to each of the large ships of war in the fleet, or to several of the smaller size. The hold appears to have been principally occupied by the "cook-room," the inconvenience of which arrangement, though much complained of, was general when Sir Walter Raleigh, in his *Discourse on the Royal Navy and Sea Service*, recommended that it should be removed to the forecastle; and even so lately as 1715, several men of war had "cook-rooms" in their holds. There is also no doubt that the enormous quantity of ballast which was rendered necessary by the immense top-hamper of these ships, and the space which it occupied, from being shingle, left but little room for the stowage of any quantity of provisions. In the ships built for commerce, this defect does not appear to have existed, as in fleets composed of the king's and of private shipping, those ships only which belonged to the royal navy had these attendant victuallers. The cook-rooms in the merchant shipping were under the forecastle; and they had less top-hamper, as less accommodation was required for officers.

Epoch in naval architecture.

Although the comparative inefficiency of the vessels may be commented on, it will be apparent that that period in the history of naval architecture and of navigation has now been entered on in which, though still in their infancy, these arts may be considered as perfect in all but the maturity to be acquired by the experience of years. The mariner's compass was known; the theory of taking observations was understood, and the practice of it in the course of being perfected; and therefore the longest voyages could be undertaken with comparative certainty and safety. Besides this, the ships, though still imperfect, were becoming gradually manageable machines, and had ceased to be the cumbrous masses of the preceding ages, which, with few exceptions, were capable of little more than of being driven before the wind.

Three epochs in the maritime history of England.

If the contents of the foregoing pages be considered, there will appear to be three epochs in the maritime history of England; the first commencing with the introduction of galleys by Alfred, and ending with the reign of Edward III., before whose time these galleys and vessels, propelled by oars, were the chief instruments of navigation; the second ending with the reign of Henry VII., during which period, though sailing vessels were used for the purposes both of war and commerce, they were comparatively at the mercy of the winds, and, speaking generally, could sail only when they blew both fairly and gently; the third epoch has been already noticed.

From the extract of the report of the builders, the state of the navy during the reigns of Edward VI. and of Mary

History. Elizabeth. Action with Spanish Armada.

will be seen. It is known, therefore, that when Elizabeth ascended the throne, the marine of England, both military and mercantile, was in a very depressed state. The successful enterprise of Drake, and the fear of the Spanish Armada, aroused the energies of the country, and the force collected to resist the invasion amounted to 197 vessels of various descriptions, of the aggregate burthen of nearly 30,000 tons, 34 of which, measuring together 12,600 tons, composed the royal navy. It is true, that by far the larger portion were of small force. One only, the Triumph, was of 1100 tons; another, the White Bear, was of 1000 tons; two were of 800 tons, 3 of 600, six of 500, and five of 400; sixty-six were under 100 tons; and fifteen were victuallers, of which the tonnage is not mentioned. There are also seven other vessels included in the 197 which have no tonnage assigned them; but they must have been of small size, the number of mariners on board the whole seven being only 474. We have very conclusive means of comparing the Spanish with the English ships, and also of judging how very little naval arrangements were then understood, from their imperfect state even on board a fleet which had occupied the whole attention of the Spanish authorities for a space of three years, exemplified in the following anecdote. Burchett, in his account of the action of the 23d of July 1588, says, "The great guns on both sides thundered with extraordinary fury, but the shot from the high-built Spanish ships flew over the heads of the English without doing any execution; one Mr Cock being the only Englishman who fell, while he was bravely fighting against the enemy in a small vessel of his own."

Three-decked ships.

The Spaniards appear to have been the first to introduce a third tier of guns, the earliest mention of a three-decker being the Philip, a Spanish ship engaged in the action off the Azores in 1591, with the Revenge, commanded by Sir Richard Greenvil. The following armament of the Philip is extracted from a most spirit-stirring account of this tremendous action, which was written by Sir Walter Raleigh, and has been preserved by Hackluyt. "The Philip carried three tire of ordnance on a side, and eleven pieces in euerie tire. She shot eight forth right out of her chase, besides those of her stern portes."

The English do not appear to have followed the example set by the Spaniards; for, during the long reign of Elizabeth, the ships of the royal navy were not much, if at all, increased in their dimensions, which was probably owing to the triumphant successes of her fleets, though they were composed of ships generally much smaller in size than those opposed to them. From the list of the royal navy at the time of her death, in 1603, given by Sir William Monson in his tracts, of 42 ships composing the navy, there were then only two ships of 1000 tons, three of 900, three of 800, two of 700, four of 600, four of 500, and there were eight under 100 tons burthen. Two of these ships, the Triumph and the White Bear, are rated in this list each at 100 tons less burthen than in the list of the fleet in the year 1588, already noticed.

The mercantile marine was also greatly improved and increased during the reign of Elizabeth. This wise monarch did all in her power to encourage foreign trade; and she honoured Drake by knighting him on board his own vessel at Deptford, after his return from circumnavigating the globe. The celebrated Sir Walter Raleigh, under a charter granted by her in 1584, commenced trading with America, and his successes, with those of others, in trade, as well as in the capture of richly laden Spanish merchantmen, prove the superiority of the English ships of this period. In 1600 the East India Company obtained their charter from Elizabeth, and merchant-ships, which proved the precursors of a fleet of the finest merchantmen, were immediately built by them for this distant traffic.

Shortly after the accession of James to the throne, several commissions were appointed to inquire into the state of the navy. From that of the year 1618 a very voluminous report emanated, of which the following is an extract, that affords an example of the state of knowledge on naval architecture at that time:—"The next consideration is the manner of building, which in shipps of warr is of greatest importance, because therein consists both their sayling and force. The shipps that can saile best can take or leave (as they say), and use all advantages the winds and seas does afford; and their mould, in the judgment of men of best skill, both dead and alive, should have the length treble to the breadth, and breadth in like proportion to the depth, but not to draw above 16 foote water, because deeper shipps are seldom good saylers, and ever unsafe for our rivers, and for the shallow harbours, and all coasts of ours, or other seas. Besides, they must bee somewhat snugg built, without double gallarys, and too lofty upper workes, which overcharge many shipps, and make them coeme faire, but not worke well at sea.

History. James I. Report of commission.

"And for the strengthening the shipps, wee subscribe to the manner of building approved by the late worthy prince, the lord admll., and the officers of the navy (as wee are informed), on those points.

"1. In makeing 3 orlopes, whereof the lowest being placed 2 foote under water, both strengtheneth the shipp, and though her sides bee shott through, keepeth it from bildgeing by shott, and giveth easier meanes to finde and stopp the leakes.

"2. In carrying their orlopes whole floored throughout from end to end, without fall or cutting off ye wast, which only to make faire cabbins, hath decayed many shipps.

"3. In laying the second orlope at such convenient height that the portes may beare out the whole fire of ordinance in all seas and weathers.

"4. In placeing the cooke roomes in the forecastle, as otherr war shipps doe, because being in the midshipps, and in the holds, the smoake and heate soe search every corner and seame, that they make the okam spew out, and the shipps leaky, and soone decay; besides, the best roome for stowage of victualling is thereby soe taken up, that transporters must be hyred for every voyage of any time; and, which is worst, when all the weight must bee cast before and abaft, and the shipps are left empty and light in the midst, it makes them apt to sway in the back, as the Guardland and divers others have done."

This commission was followed by several others during this and the succeeding reign, and from their reports arose many regulations tending much to the improvement of the navy, although the expenses incurred were, ostensibly at least, in part the means of causing the subsequent revolution.

Mercantile shipping of this period.

In the early part of the reign of James I. the mercantile navy of England was reduced to a very low state, most of the commerce being carried on in foreign bottoms. The incitement offered by the advantageous trade which the Dutch had long engaged in to India at length aroused the nation, and the formation of the East India Company, which was the act of James, was followed by the building of the largest ship that had yet been constructed for the purposes of commerce, at least in England. The king dined on board of her, and gave her the name of the Trade's Increase. She is reported to have been of the burthen of 1200 tons. The impetus once given, before the end of the reign of James an important mercantile navy was owned by British merchants.

Trade's Increase.

Shipwrights' Company.

Another interesting fact connected with this reign is the founding of the Shipwrights' Company, in the year 1605, and which was incorporated by a charter granted to the "Master, Warden, and Commonality of the Art or Mystery of Shipwrights," in May 1612. Mr Phineas Pett was the first master. The draughts for the ships of the royal

navy were subsequently ordered to be submitted to this company for approval previously to being built from. They also had jurisdiction over all builders, whether of the royal navy or of merchant-shipping.

Draughts of ships of royal navy.

Royal Prince.

In 1610 the Royal Prince was launched; she was the largest ship which at that time had been built in England, and was also a most decided improvement in naval architecture. The great projection of the prow, a remnant of the old galley, was for the first time discontinued, and the stern and quarters assimilated more to those of a modern ship than to any which had preceded her. She is thus described in Stow's *Chronicles*:—"A most goodly ship for warre, the keel whereof was 114 feet in length, and the cross-beam was 44 feet in length; she will carry 64 pieces of ordnance, and is of the burthen of 1400 tons. The great workmaster in building this ship was Master Phineas Pett, Gentleman, some time master of arts at Emanuel College, Cambridge."

Phineas Pett.

The same gentleman, Mr Phineas Pett, continued the principal engineer of the navy during the reign of Charles. The family of the Petts were the great instruments in the improvement of the navy, and, if the term may be allowed, of modernizing it, by divesting the ships of much of the cumbrous top-hamper entailed on them from the castellated defences which had been necessary in, and which yet remained from, the hand-to-hand encounters of the middle ages; and it is probable that, but for the taste for gorgeous decoration which prevailed during the seventeenth century, this ingenious family would have been able to effect much more; as it was, they decidedly rendered England pre-eminently the school for naval architecture during the time they constructed its fleets. This family can be traced as principal engineers for the navy from about the middle of the fifteenth century to the end of the reign of William III.

The Petts.

First frigate.

Evelyn, in his *Diary*, relating a conversation, says, "Sir Anthony Deane mentioned what exceeding advantage we of this nation had by being the first who built frigates, the first of which ever built was that vessell which was afterwards called the Constant Warwick (built in 1646), and was the work of Pet of Chatham, for a trial of making a vessell that would sail swiftly. It was built with low decks, the guns lying near the water, and was so light and swift of sailing, that in a short time she had, ere the Dutch war was ended, taken as much money from privateers as would have laden her." The dimensions of this vessel are given in Pepys's *Miscellanies* as follows: length of the keel 85 feet, breadth 26 feet 5 inches, depth 13 feet 2 inches, and 315 tons burthen; her highest number of guns" 32, and of crew 140.

Peter Pett.

Peter Pett, who built the Constant Warwick, was the son of Phineas Pett. He caused the fact of his being the inventor of the frigate to be recorded on his tomb. He was also the builder of the Sovereign of the Seas, in 1637, which was the first three-decker built in England. Her length over all is stated to have been 232 feet, her length of keel 128 feet, her main breadth 48 feet, and her tonnage 1637. Heywood describes her in the following terms:—"She hath three flush deckes and a forecastle, an halfe decke, a quarter decke, and a round-house. Her lower tyre hath thirty ports, which are to be furnished with demi-cannon and whole cannon throughout, being able to beare them. Her middle tyre hath also thirty ports for demi-culverin and whole culverin. Her third tyre hath twentie-sixe ports for other ordnance. Her forecastle hath twelve ports, and her halfe decke hath fourteene ports. She hath thirteene or foureteene ports more within board for murdering peeces, besides a great many loope-holes out of the cabins for musket shot. She carrieth, moreover, ten peeces of chase ordnance in her right forward, and ten right aff; that is, according to land service, in the front and the reare. She carrieth eleaven anchors, one of them weighing foure thousand foure hundred, &c.; and according to these are her cables, mastes, sayles, cordage, which, considered together, seeing Majesty is at this infinite charge, both for the honour of his nation, and the security of his kingdome, it should bee a spur and encouragement to all his faithful and loving subjects to bee liberall and willing contributaries towards the ship money."

First three-decker.

Of this ship, Fuller, in his *Worthies*, says, "The Great Sovereign, built at Woolwich, a leiger ship for state, is the greatest ship our island ever saw; but great medals are made for some grand solemnity, while lesser coin are more current and passable in payment." She was afterwards cut down one deck, and remained in the service, with the character of the best man-of-war in the world, until the year 1696, when she was accidentally burnt at Chatham.

Sir Walter Raleigh's works: *Invention of Shipping; Concerning the Royal Navy and Sea-Service.*

About this time, 1650, appeared the first work connected with naval improvement ever written in this country, and by no less celebrated an author than Sir Walter Raleigh. It is very probable that his two discourses, the one on the *Invention of Shipping*, the other *Concerning the Royal Navy and Sea-Service*, had great influence in creating the interest which was evidently taken about this period in the improvement of the navy. Sir Walter says, "Whosoever were the inventors, we find that every age had added somewhat to ships and to all things else. And in my owne time the shape of our English ships hath been greatly bettered. It is not long since the striking of the top-mast (a wonderfully great ease to great ships both at sea and harbour) hath been devised. Together with the chaine-pumpe, which takes up twice as much water as the ordinary did, we have lately added the bonnett and the drabler. To the courses we have devised studding-sayles, top-gallant-sayles, sprit-sayles, top-sayles. The weighing of anchors by the capstane is also new. We have fallen into consideration of the length of cables, and by it we resist the malice of the greatest winds that can blow; witnesse our small Milbroke men of Cornewall, that ride it out at anchor half seas over betweene England and Ireland all the winter quarter; and witnesse the Hollanders that were wont to ride before Dunkirke with the wind at north-west, making a lee-shore in all weathers; for true it is that the length of the cable is the life of the ship in all extremities; and the reason is, because it makes so many bendings and waves as the ship riding at that length is not able to stretch it, and nothing breaks that is not stretched. In extremity, we carry our ordnance better than we were wont, because our nether-overloops are raised commonly from the water, to wit, betweene the lower part of the port and the sea. We have also raised our second decks, and given more vent thereby to our ordnance, tying in our nether-overloope.

"We have added crosse pillars in our royall ships to strengthen them, which being fastened from the kelson to the beames of the second decke, keep them from settling or from giving away in all distresses.

"We have given longer floares to our ships than in elder times, and better bearing under water, whereby they never fall into the sea after the head, and shake the whole body, nor sinck sterne, nor stoope upon a wind, by which the breaking loose of our ordnance, or the not use of them, with many other discommodities, are avoided. And to say the truth, a miserable shame and dishonour it were for our shipwrights, if they did not exceed all other in the setting up of our royall ships, the errors of other nations being farre more excusable than ours. For the kings of England have for many years been at the charge to build and furnish a navy of powerfull ships for their owne defence, and for the wars only; whereas the French, the Spainards, the Portugalls, and the Hollanders (till of late), have had no proper fleete belonging to their princes or states.

"Only the Venetians for a long time have maintained their arsenal of gallyes, and the kings of Denmark and

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Sweden have had good ships for these last fifty years. I say that the forenamed kings, especially the Spainards and Portugalls, have ships of great bulke, but fitter for the merchant than the man of warre, for burthen then for battaile. . . . . Although we have not at this time 135 ships belonging to the subjects of 500 tuns each ship, as it is said we had in the 24th yeare of Queen Elizabeth, at which time also, upon a generall view and muster, there were found in England, of all men fit to beare arms, eleaven hundred and seventy-two thousand; yet are our merchants' ships now farre more warlike and better appointed than they were, and the royal navy double as strong as then it was. . . . . We have not, therefore, lesse force than we had, the fashion and furnishing of our ships considered; for there are in England at this time 400 saile of merchants fit for the wars, which the Spainards would call gallions; to which we may add 200 saile of crumsters or hoyes, of Newcastle, which each of them will beare six demi-culverins, and four sakers, needing no other addition of building than a slight spar-decke fore and afte, as the seamen call it, which is a slight decke throughout. The 200 which may be chosen out of 400, by reason of their ready staying and turning, by reason of their windwardnesse, and by reason of their drawing of little water, and they are of extreame vantage neere the shoare, and in all bayes and rivers to turn in and out; these, I say, alone, well manned and well conducted, would trouble the greatest prince in Europe to encounter in our seas; for they stay and turn so readily as, ordering them into small squadrons, three of them at once may give their broad-sides upon any one great ship, or upon any angle or side of an enemy's fleet. They shall be able to continue a perpetuall volley of demi-culverins without intermission, and either sink or slaughter the men, or utterly disorder any fleete of crosse sailes with which they encounter.

"I say, then, if a vanguard be ordained of these hoyes, who will easily recover the wind of any other ships, with a battaile of 400 other warlike ships, and a reare of thirty of his majestie's ships to sustaine, relieve, and countenance the rest (if God beat them not), I know not what strength can be gathered in all Europe to beat them. And if it be objected that the states can furnish a farre greater number, I answer, that his majestie's forty ships, added to 600 before named, are of incomparable greater force than all that Holland and Zeeland can furnish for wars."

Ships of royal navy inferior to merchant-ships.

In the foregoing extract there is strong evidence that the ships of the royal navy were generally inferior to those employed by the merchant-service, in the essential qualifications of being weatherly. This is exactly the conclusion that might be arrived at from the consideration, that a private individual would dispense with all that superabundance of top-hamper which was entailed on the ships of the royal navy, by the accommodation required for the numerous officers and gentlemen generally embarked on board them, and also by the mania for gorgeous decorations. This mania is well exemplified by the fact, that of the Sovereign of the Seas it is stated, "She beareth five lanthornes, the biggest of which will hold ten persons to stand upright, and without shouldering one another."

Sir Walter Raleigh, in his *Discourse on the Royal Navy and Sea-Service*, adverts to the same subject. He says, "We find by experience, that the greatest ships are lesse serviceable, goe very deep to water, and of marvellous charge and fearefull cumber, our channells decaying every yeare. Besides, they are lesse nimble, lesse maineable, and very seldome imployed. *Grande navio, grande fatica*, saith the Spainard; a ship of 600 tons will carry as good ordnance as a ship of 1200 tons; and though the greater have double the number, the lesser will turn her broad-sides twice before the greater can wend once; and so no advantage in that overplus of ordnance. And in the building of all ships, these six things are principally required:—1. First, that she be strong built; 2. Secondly, that she be swift; 3. Thirdly, that she be stout sided; 4. Fourthly, that she carry out her guns all weather; 5. Fifthly, that she hull and try well, which we call a good sea ship; 6. Sixthly, that she stay well when bourding and turning on a wind is required.

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"1. To make her strong, consisteth in the truth of the workeman and the care of the officers.

"2. To make her sayle well, is to give a long run forward, and so afterward done by art and just proportion. For, as in laying out of her bows before, and quarters behind, she neither sinck into nor hang in the water, but lye cleare off and above it; and that the shipwrights be not deceived herein (as for the most part they have ever been), they must be sure that the ship sinck no deeper into the water than they promise, for otherwise the bow and quarter will utterly spoile her sayling.

"3. That she be stout, the same is provided and performed by a long bearing floore, and by sharing off above water even from the lower edge of the ports.

"4. To carry out her ordnance all weather, this long bearing floore, and sharing off from above the ports, is a chiefe cause, provided alwayes that your lowest tyre of ordnance must lye foure foot cleare above water when all loading is in, or else those your best pieces will be of small use at the same in any growne weather that makes the billoe to rise, for then you shall be enforced to take in all your lower ports, or else hazard the ship.

"5. To make her a good sea ship, that is to hull and trye well, there are two things specially to be observed; the one that she have a good draught of water, the other that she be not overcharged, which commonly the king's ships are, and therefore in them we are forced to lye at trye with our maine course and missen, which, with a deep keel and standing streake, she will performe.

"6. The hinderance to stay well is the extreame length of a ship, especially if she be floaty and want sharpnesse of way forwards; and it is most true, that those over-long ships are fitter for our seas than for the ocean; but one hundred foot long, and five and thirty foot broad, is a good proportion for a great ship. It is a speciall observation, that all ships sharpe before, that want a long floore, will fall roughly into the sea, and take in water over head and ears.

"So will all narrow quartered ships sinck after the tayle. The high charging of ships is it that brings them all ill qualities, makes them extreame leeward, makes them sinck deep into the water, makes them labour, and makes them overset. Men may not expect the ease of many cabbins, and safety at once, in sea-service. Two decks and a half is sufficient to yield shelter and lodging for men and mariners, aud no more charging at all higher, but only one low cabbin for the master. But our marriners will say, that a ship will beare more charging aloft for cabbins, and that is true, if none but ordinary marryners were to serve in them, who are able to endure, and are used to, the tumbling and rowling of ships from side to side when the sea is never so little growne; but men of better sort and better breeding would be glad to find more steadinesse and lesse tottering cadge-work. And albeit, the marriners doe covet store of cabbins, yet indeed they are but sluttish dens, that bread sicknesse in peace, serving to cover stealths, and in fight are dangerous to teare men with their splinters."

Fuller's Worthies.

In Fuller's *Worthies*, there is also a short summary of the comparative qualities of the ships of different nations in the middle of the seventeenth century. It is as follows: "First, for the Portugal, his cavils and carracts, whereof few now remain (the charges of maintaining them far exceeding the profit they bring in); they were the veriest drones on the sea, the rather because formerly their seeling was dam'd up with a certain kind of mortar to dead the shot, a fashion now by them disused.

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"The French, however dexterous in land-battles, are left-handed in sea-fights, whose best ships are of Dutch building. The Dutch build their ships so floaty and buoyant, they have little hold in the water in comparison to ours, which keep the better winde, and so outsail them.

"The Spanish pride hath infected their ships with loftiness, which makes them but the fairer markes to our shot. Besides the winde hath so much power of them in bad weather, so that it drives them two leagues for one of ours to the leeward, which is very dangerous upon a lee-shore.

"Indeed the Turkish frigots, especially some thirty-six of Algier, formed and built much nearer the English mode, and manned by renegadoes, many of them English, being already too nimble heel'd for the Dutch, may hereafter prove mischievous to us, if not seasonably prevented."

Rise of Dutch naval power.

During the early part of the seventeenth century, the Dutch navy rapidly increased in importance. Their success in having wrested from the Portuguese a share of the commerce of the east, emboldened them, in the then depressed state of the Spanish marine, to make a similar attempt on the west, and endeavour to establish settlements in South America.

The wars with Spain, in which they were consequently engaged, had such an important effect in establishing their maritime power, that in 1650 their navy consisted of 120 vessels fitted for war, seventy of which had two tiers of guns; and their fleet was in all respects the most efficient in Europe.

Evelyn's *Navigation and Commerce.*

Evelyn, in his tract on Navigation and Commerce, speaking of the fisheries, says "Holland and Zeeland alone should, from a few despicable boats, be able to set forth above 20,000 vessels of all sorts, fit for the rude seas, of which more than 7000 are yearly employed upon this occasion. 'Tis evident that by this particular trade they are able to breed above 40,000 fishermen and 116,000 mariners, as the census (1639) has been accurately calculated."

The tremendous struggle in which they were enabled by these means to engage with us shortly after this period, in consequence of the injurious operation of the navigation act on their commerce, had a most influential effect on the improvement of our navy, which at the commencement of the contest was very unequal to that of the Dutch; and it is probable that this war was the means of enabling us to contend triumphantly against the immense and unexpected attempts of Louis XIV. to wrest the sceptre of the seas from our grasp.

Charles I.

The sovereigns of the house of Stuart, without exception, appear to have devoted much attention to the improvement of the navy. Charles I. may be almost said to have lost both crown and life in consequence of these efforts; nor would it be doing justice to Cromwell to omit mention of the energy with which he took advantage of the all but despotic power which he possessed to increase his naval force. For this purpose not only many ships were built during the protectorate, but numbers of merchant-vessels were bought for the service of the state.

Charles II. His personal attention to ship-building and naval affairs.

After the Restoration, Charles II. paid great personal attention even to the minutiæ of his navy, as shown by the following curious extract from a letter of his to Prince Rupert, preserved in the state-papers, and also by continual references to his naval predilections in Evelyn's and Pepys's memoirs and writings. The letter is dated 4th August 1673. It says, "I am very glad the Charles does so well; a gerdeling this winter when she comes in will make her the best ship in England; next summer, I believe, if you try the two sloops that were builte at Woolidge that have my invention in them, they will outsail any of the French sloops. Sir Samuel Mooreland has now another fancy about weighing anchors; and the resident of Venice has made a model also to the same purpose. We have not yet consulted them with Mr Tippet nor Mr Deane; but hope when they are well considered, we may find one out of them that will be good."

Sir Anthony Deane.

In Pepys's *Diary*, 19th May 1666, there is the following notice relating to one of the gentlemen mentioned in the above letter:—"Mr Deane and I did discourse about his ship the Rupert, which succeeds so well, as he has got great honor by it, and I some by recommending him. The king, duke, and everybody, say it is the best ship that was ever built. And then he fell to explain to me his manner of casting the draught of water which a ship will draw beforehand, which is a secret the king and all admire in him; and he is the first that hath come to any certainty beforehand of foretelling the draught of water of a ship before she be launched." This gentleman appears therefore to have been the first who applied mathematical science to naval architecture in this country. Pepys also says, "another great step and improvement to our navy, put in practice by Sir Anthony Deane," was effected in the Warspight and Defiance, which were "to carry six months' provisions, and their guns to lie $4\frac{1}{2}$ feet from the water." This was in 1665.

First application of mathematical calculation to naval architecture.

The foregoing extract probably indicates the date of the first practical application to a useful purpose in this country of the famous discovery of Archimedes. It is well known that he was called upon by his king to test the purity or the adulteration of the gold of the royal crown, and the displacement of the water of his bath by his own immersion therein suggested to his mind the means of solving the problem. He saw that a body immersed in water displaced its own bulk of water, and after this the knowledge followed that a body floating in a fluid displaced its own weight of that fluid. If the weight of the body, therefore, was known, the quantity of water which it would displace could immediately be calculated, and the depth to which it would sink be found.

Sir Robert Slingeby.

In this historical sketch the probability that the merchant-shipping of England were superior in their sea-going qualities to those composing the royal navy, has been adverted to in a *Discourse touching the Past and Present State of the Navy*, by Sir Robert Slingeby, knight-baronet, and comptroller of the navy, dated 1669, there is the following interesting statement, which points to a reason why this superiority of the merchant-shipping may have existed. "But since these late distractions began at home" (the Commonwealth), "forraigne trade decayed, and merchants so discouraged from building, that there hath been scarce one good merchant-ship built these twenty years past, and of what were then in being, either by decayes or accident, there are very few or none remaining. The merchants have found their private conveniences in being convoyed att the publick charge; they take noe care of making defence for themselves if a warr should happen." Yet he says, in the time of Charles I., "the merchants continued their trade during the wars with France and Spain, if there could but two or three consort together, not caring who they met," they being little inferior in strength or burthen to the ships of the royal navy.

Decay of mercantile navy during the Commonwealth.

Its subsequent improvement.

Sir Richard Haddock.

First analysis of the royal navy.

About 1684 Sir Richard Haddock, comptroller of the navy, adopted the recommendation of Mr, afterwards Sir Anthony Deane, at that time surveyor of the navy, and directed an inquiry to be made as to "the number of cube feet that are contained in the bodyes of several draughts to their main water-line, when all materialls are on board fitt for saileing." The result of this inquiry was a very voluminous statement of the weights which made up the whole displacement of the fourth, fifth, and sixth rate ships, including minute details of their masts, yards, armament, &c., accompanied by perfect drawings of each ship. The following table contains the dimensions and displacements, &c., of each class:—

Table of Dimensions, from a Manuscript dated 1684.

	A First Fourth-rate near the largest dimensions.	A Second Fourth-rate near the dimensions of the Adventure.	A Fifth-rate of the largest dimensions.	A First Sixth-rate.	A Second Sixth-rate.	A Sixth-rate of the largest dimensions.	A Sixth-rate of the old fashion.
	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.
Length on the gun-deck from the rabbitt of the stem to the rabbitt of the post	124 6	116 6	103 9	87 8	70 0	92 6	93 0
Maine breadth to the outside of the outboard planke	35 0	32 9	28 8	23 6	21 6	23 6	22 9
Depth in hold from the seeling to the upper side of the beame	14 0	13 2	11 4	10 9	9 10	11 9	10 0
Breadth at the afte side of the maine transome	21 0	18 4	18 0	14 0	13 0	14 0	15 0
Height on the gun-deck from planke to planke — afore	5 9	6 0	5 9	5 7	5 6	...	...
— midships	6 0	6 0	6 0	...	...	...	...
— abafte	6 6	6 3	6 7	6 3	6 2	...	...
The center of the fore mast from the rabbitt of the stern	13 6	12 9	9 10	7 6	6 6	10 0	9 6
— maine	69 0	62 0	54 6	45 0	36 0	50 0	49 6
— mizion	102 0	96 9	84 0	71 0	57 0	73 0	74 0
Draft of water — afore	14 6	13 6	12 0	9 8	8 6	10 0	8 0
— abaft	15 10	15 0	13 0	10 8	9 6	11 0	9 0
Number of tuns, tunage	885	580	362	...	...	230	220
Number of men (in warr)	260	180	135	85	70	90	29
Number of guns	50	44	34	24	18	22	24
Cube feet in the several draughts to their main water line	29,814	22,346	13,195	8906	6790	...	...
	Ts. cwt. qr. lb.	Ts. cwt. qr. lb.	Ts. cwt. qr. lb.	Ts. cwt. qr. lb.	Ts. cwt. qr. lb.	Ts.	Ts.
Weight of each ship's hull, and all manner of materials on board	851 16 2 8	638 9 0 16	377 0 0 3	254 9 0 16	194 0 0 0	...	...
Each ship's hull at first launching	418 0 0 0	314 0 0 0	160 0 0 0	120 0 0 0	98 0 0 0	...	...
Burthen in tuns, what she will really carry	433 16 2 8	324 9 0 16	216 0 0 0	134 9 0 16	...	135	130
No. of months' provisions and water	4	3	3	2	2	...	...

James II.

James II., from having so long and so gloriously filled the office of Lord High Admiral while Duke of York, was perfectly aware of the requirements of the navy; and during his short reign he paid great attention to increasing its efficiency. He also especially directed inquiries into the question of the durability of timber for the construction of it, and carefully accumulated both materials and stores for its maintenance. It is not a little curious that it was probably the attention which the monarchs of the line of Stuart had bestowed on the naval service, which enabled it so triumphantly to resist the persevering attempts of Louis XIV. to recover for them the throne of their ancestors.

The Revolution.

Though England was at the Revolution possessed of an efficient fleet, manned by experienced seamen, who had all the confidence arising from a series of naval triumphs, it must be remembered that for a long period no opposition to her naval superiority had been anticipated from any other power than Holland; and consequently the fleets of England were composed of ships which had many of them been built to adapt them to this service, for which small dimensions and light draughts of water were essential qualifications, on account of the shoalness of the Dutch coast.

William III.

William was too cautious a monarch to have neglected so important a means of national defence as was the navy, when engaged with such an ambitious and energetic opponent as Louis XIV.; and we find that the naval force was considerably increased, both numerically and in dimensions, during his reign. But the triumphs of our armies under Marlborough having for a time diverted the attention of the nation from naval affairs, it fell into decay during the reign of his successor.

Louis XIV.

When Louis XIV. determined to dispute with England the sovereignty of the seas, he was not only without a navy, but without the means of forming one. The military and commercial marine of France had ceased to exist. The sanguine temperament of the monarch, and the wisdom of his minister Colbert, removed all obstacles; commerce began to flourish on the quays, merchant-vessels to crowd the ports; dockyards, harbours, and shipping appeared simultaneously to start into existence; and the nation, which almost for centuries had been essentially military, felt constrained to turn its energies to commerce and to the sea. A navy which, in 1661, consisted of some four or five small vessels, in little more than ten years bearded and baffled the combined fleets of Holland and of Spain, and asserted the sovereignty of the Mediterranean. In 1681 her fleets consisted of 115 line-of-battle ships, manned by 36,440 men, with 179 smaller ships, the crews of which amounted to 3037 men; and in 1690 a fleet of eighty-four vessels of war, out of which three were of a hundred guns and upwards, and ten others were above eighty-four guns, with twenty-two fire ships, was cruising in the British seas. It is true that these mighty armaments failed in fulfilling the ambitious designs of Louis. But the severity of the struggle, which at length ended in the annihilation of his hopes, and in our triumphant assertion of our naval superiority, must always serve as an example of the danger we may incur by too great confidence in that superiority.

Rise of French naval power.

Comparison between English and French ships.

The following comparison between the French and British ships of about this period, is from an official contemporary paper, by a gentleman of the name of Gibson:—"Our guns being for the most part shorter, are made to carry more shott than a French gunn of like weight, therefore the French guns reach further, and ours make a bigger hole. By this the French has the advantage to fight at a distance and wee yard-arm to yard-arm. The like advantage wee have over them in shipping; although they are broader and carry a better saile, our sides are thicker, and better able to receive their shott; by this they are more subject to be sunk by gunn shott than wee."

Injudicious management of royal navy.

The paper also complains much of the injudicious management of our shipping, by which it says, "many a fast sayling shipp have come to loose that property, by being over-masted, over-rigged, over-gunned (as the Constant Warwick, from twenty-six gunns, and an incomparable sayler, to forty-six gunns and a slugg), over-manned (vide all the old shipps built in the parliament time now left),

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over-built (*vide* the Ruby and Assurance), and haveing great tafferills, gallarys, &c., to the making many formerly a stiff, now a tender-sided shipp, bringing thereby their head and tuck to lye too low in the water, and by it takeing away their former good property, in steering, sayling, &c. The French by this defect of ours make war with the sword (by sending no small shipps of warr to sea, but clean), and wee, by cruseing in fleetes, or single shipps foule, with bare threates."

Lord Rodney.

In a letter from Sir George (afterwards Lord) Rodney, dated the 31st May 1780, to Mr Stephens, the secretary of the Admiralty, is a passage which goes to prove the truth of the above statement. "Nothing could induce them (the French fleet) to risk a general action, though it was in their power daily. They made, at different times, motions which indicated a desire of engaging, but their resolution failed them when they drew near; and as they sailed far better than his majesty's fleet, they with ease could gain what distance they pleased to windward."

Cause of inferiority of English ships.

One great cause of the inferiority of our ships arose from the practice which prevailed during the first half of the eighteenth century, through a mistaken idea of economy, of "rebuilding" old ships, without reference to the opinions of practical men, so that the forms and dimensions of the previous century passed down, in many instances, into the succeeding one, and justice was not done to the ship-building knowledge of the surveyors.

French system followed by Spain.

The French system of improvement was followed by the Spaniards, and the capture of the Princessa, in 1740, of 70 guns, 165 feet in length, and 49 feet 8 inches in breadth, when our ships of the same force then building were only 151 feet long and 43 feet 6 inches broad, caused an appeal to be made by the Admiralty to Admiral Sir John Norris. The surveyors of the navy of that date who had succeeded Sir A. Deane were men of no note, because no opportunity of showing their powers had been allowed them. In consequence of the inquiries then made, the several master-shipwrights of the dockyards were directed to send in proposals for the future established dimensions of the navy; and, in 1745, Sir Jacob Attwood being surveyor of the navy, the Admiralty issued a new establishment for the dimensions of the several ratings of ships. The following table, taken from Derrick's *Memoirs of the Royal Navy*, contains the various established alterations from time to time, from the reign of Charles II. to this of 1745, which was the last:—

Improvements attempted by the Admiralty.

An Account showing the Dimensions established, or proposed to be established, at different times, for Building of Ships. Extracted from Derrick's Memoirs of the Royal Navy.

	Establishment of				Proposed in		Establishment of 1745.
	1677.	1691.	1706.	1719.	1733.	1741.	
Ships of 100 Guns.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
Length on the gun-deck	165 0	...	...	174 0	174 0	175 0	178 0
Length of the keel, for tonnage	137 8	...	...	140 7	140 7	142 4	144 6½
Breadth, extreme	46 0	...	...	50 0	50 0	50 0	51 0
Depth in hold	19 2	...	...	20 0	20 6	21 0	21 6
Burthen in tons	1550	...	...	1869	1869	1892	2000
90.							
Length on the gun-deck	158 0	...	162 0	164 0	166 0	168 0	170 0
Length of the keel, for tonnage	...	...	132 0	132 5	134 1	137 0	138 4
Breadth, extreme	44 0	...	47 0	47 2	47 9	48 0	48 6
Depth in hold	18 2	...	18 6	18 10	19 6	20 2	20 6
Burthen in tons	1307	...	1551	1566	1623	1679	1730
80.							
Length on the gun-deck	...	156 0	156 0	158 0	158 0	161 0	165 0
Length of the keel, for tonnage	...	...	127 6	128 2	127 8	130 10	134 10½
Breadth, extreme	...	41 0	43 6	44 6	45 5	46 0	47 0
Depth in hold	...	17 4	17 8	18 2	18 7	19 4	20 0
Burthen in tons	...	1100	1283	1350	1400	1472	1585
70.							
Length on the gun-deck	150 0	...	150 0	151 0	151 0	154 0	160 0
Length of the keel, for tonnage	...	...	122 0	123 2	122 0	125 5	131 4
Breadth, extreme	39 8	...	41 0	41 6	43 5	44 0	45 0
Depth in hold	17 0	...	17 4	17 4	17 9	18 11	19 4
Burthen in tons	1013	...	1069	1128	1224	1291	1414
60.							
Length on the gun-deck	...	144 0	144 0	144 0	144 0	147 0	150 0
Length of the keel, for tonnage	...	...	119 0	117 7	116 4	119 9	123 0½
Breadth, extreme	...	37 6	38 0	39 0	41 5	42 0	42 8
Depth in hold	...	15 8	15 8	16 5	16 11	18 1	18 6
Burthen in tons	...	900	914	951	1068	1123	1191
50.							
Length on the gun-deck	...	...	130 0	134 0	134 0	140 0	144 0
Length of the keel, for tonnage	...	...	108 0	109 8	108 3	113 9	117 8½
Breadth, extreme	...	...	35 0	36 0	38 6	40 0	41 0
Depth in hold	...	...	14 0	15 2	15 9	17 2½	17 8
Burthen in tons	...	...	704	755	853	968	1052
40.							
Length on the gun-deck	...	...	118 0	124 0	124 0	126 0	133 0
Length of the keel, for tonnage	...	...	97 6	101 8	100 3	102 6	108 10
Breadth, extreme	...	...	32 0	33 2	35 8	36 0	37 6
Depth in hold	...	...	13 6	14 0	14 6	15 5½	16 0
Burthen in tons	...	...	531	594	678	706	814
20.							
Length on the gun-deck	...	...	...	106 0	106 0	112 0	113 0
Length of the keel, for tonnage	...	...	...	87 9	85 8	91 6	93 4
Breadth, extreme	...	...	...	28 4	30 6	32 0	32 0
Depth in hold	...	...	...	9 2	9 5	11 0	11 0
Burthen in tons	...	...	...	374	429	498	508

History.

The ships built after the establishment of 1745 are reported to have been stiff, and to have carried their guns well, but were still inferior to those of the French; and, consequently, about ten years afterwards an alteration was made in the draughts for the several ratings, and the dimensions were also slightly increased. It may not be uninteresting to remark, that the proportional breadths in the establishment of 1745 considerably exceeded those of more modern ships. Their length varied from 3·49 to 3·85 of their breadth; while the lengths of most of our line-of-battle ships, built shortly afterwards, are within the limits of 3·61 and 3·83 of their breadths.

Royal George.

The Royal George was the first ship built on the increased dimensions, which were the result of the before-mentioned inquiry. She was laid down in 1746, and launched in 1756; and rather more than ten years afterwards, that is, in 1758, Thomas Slade and William Bateley being the surveyors of the navy, the Triumph and Valiant of 74 guns were built on the lines of the Invincible, a French 74 gun-ship, captured in 1747.

Triumph and Valiant.

The dimensions of these ships are given below, as they were manifestations of an improved system, which, however, was not persevered in; for, with the exception of occasionally building after a French or Spanish model, the English ships were scarcely altered from those built at the commencement of the century.

	Royal George.	Triumph and Valiant.
	Feet. In.	Feet. In.
Length on the gun-deck	178 0	171 3
Length of the keel, for tonnage	143 5½	138 8
Breadth, extreme	51 9½	49 9
Depth in hold	21 6	21 3
Burthen in tons	2047	1826

History

There was still a very essential distinction between the navy of England and of either France or Spain, which was this, that until after 1763 neither of these nations had any three-deckers in their fleets. Their largest armament appears to have been eighty-four guns on two decks, while we had third-rates which were three-deckers, as the Cambridge and Princess Amelia, launched in 1754 and 1757, and carrying only eighty-four guns, our naval officers of that period having advocated a high battery, and the naval architects having designed some very fine ships of this new class. The capture of the Foudroyant, a French eighty-four on two decks, in 1758, caused a change in this respect, by furnishing the English with a model for a very superior class of men-of-war, which was adopted. Derrick, in his *Memoirs of the Royal Navy*, says, that "no eighty-gun ship with three decks was built after the year 1757, no seventy-gun ship after 1766, nor any sixty-gun ship after 1759."

Grand distinction between English and foreign navies.

During the peace that preceded the war with America, which commenced in the year 1768, the French had introduced three-deckers into their fleets, having found their eighty-fours on two decks to be no match for the more powerful of our three-deckers. Their first-rates were at this time generally of 110 guns on three decks. The Bretagne, one of these ships, was, according to Charnock, 196 feet 3 inches long on the water-line; and her moulded breadth was 53 feet 4 inches. Her displacement, it is stated in Sewell's *Collection of Papers on Naval Architecture*, was 4640 English tons.

French-built three-deckers.

In 1786 the establishment of the French fleet was fixed by an ordinance of the government, as according to the following table, which is extracted from Charnock, and some very fine vessels of each class were built upon these dimensions:—

Establishment of French fleets.

	Ships of 120 Guns.	Ships of 110 Guns.	Ships of 80 Guns.	Ships of 74 Guns.	Ships of 64 Guns.	Frigates carrying 18 Pounders.	Frigates carrying 12 Pounders.	Corvettes of 20 Guns.	Advice-boats, carrying four 4 Pounders.
	Feet. In.	Feet.	Feet.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.
Length from head to stern	196 6	186—185	184—180	170 0	156 0	144 0	136 0	112 0	80 0
Breadth from outside to outside of the frame	50 0	49 6 in.	48 0 in.	44 6	41 0	36 6	34 6	28 4	24 0
Depth in hold	25 0	24 6	23 9	22 0	20 0	18 0	17 6	14 4	12 0
Draught of water abaft when light	17 6	17 4	17 0	15 8	14 6	12 6	11 3	9 6	8 4
Draught of water forward when light	14 0	13 8	12 0	10 10	11 1	8 7	8 6	8 5	8 0
Draught of water abaft when laden	25 0	24 8	22 6	21 6	19 9	16 0	15 4	13 3	11 6
Draught of water forward when laden	22 8	22 2	21 0	19 10	18 9	15 2	13 9	11 9	10 0
Total weight of the ship and stores when victualled and furnished for a six months' cruise	Tons. 5246	Tons. 4910	Tons. 3825	Tons. 3548½	Tons. 2300	Tons. 1479	Tons. 1162	Tons. 546	Tons. 266
Weight of the hull and masts	2500	2400	1804	1437	1120	665	583	266	141

George III. and George IV.

The ships of England continued throughout the wars of the reign of George III. inferior to those of France and Spain. The skill of our commanders, and the indomitable courage of our seamen, eventually succeeded in these, as in all former contests, in annihilating opposition, and in triumphantly asserting our naval supremacy. It cannot be denied that their task would have been comparatively easy, accompanied with less loss of life and expenditure of treasure, had their ships been more upon a par with those of their opponents. The French officers, however, after the war, to save their vanity, attributed our successes at sea to the superiority of our ships, and they commenced building after our models.

Although so much attention appears to have been directed at various times to the improvement of the navy, not only by the servants of the crown officially connected with it, but by the sovereigns themselves, we have seen that an inferiority of our ships in sailing to those of our opponents has been repeatedly asserted on undoubted testimony. The reason that all the attention thus bestowed failed in producing a corresponding beneficial effect appears to have been that in England the speculative ideas of men, undoubtedly of sense and judgment, as may be seen from the quotations of their opinions which have been given, but men uninformed as to principles, were taken as the rules for guidance. In France, on the contrary, the aid of science was called in, and some of the greatest mathematicians of the time turned their attention to the improvement of the shipping of that country, and worked harmoniously with the naval officers who were to use the ships, as

Reasons for the continued inferiority of British shipping.

History.

well as with the practical men who were to construct them, modifying their theories by the practice and experience of the others. Colbert employed an engineer of the name of Rénau d'Elisagary, a protégé of the Count de Vermandois, whose first essay was in the adaptation of ships to carry bombs, to be used in the then projected armament against the piratical states of the Mediterranean. Under the enlightened direction of Colbert, the French ships which, by the ordinance of 1688, were much restricted in dimensions, were increased nearly one-fourth in size, and every means taken which the then state of knowledge could suggest to insure a proportionate improvement in their qualities; while a corresponding increase in size was not made in English ships till the commencement of the energetic surveyorship of Sir William Symonds in 1830. Rénau was, we believe, the first French author who wrote on the theory of ships. He was followed by the Bernoullis, by Père La Hoste, by Bouguer, Euler, Don Jorje Juan, Romme, and a host of others, the effects of whose writings may be traced in the progress of the improvements introduced into the navies of France and Spain, and which the navy of England was forced to imitate. The only English treatise of that period on ship-building that can lay any claim to a scientific character was published by Mungo Murray in 1754; and he, though his conduct was irreproachable, lived and died a working shipwright in Deptford dock-yard.

Instance of ignorance.

A palpable instance of the ignorance or neglect of all the principles of naval architecture among the authorities who were charged with designing our royal navy, even up to the close of the last century, may be quoted from an article in the Papers on Naval Architecture, as given by Mr Wilson then of the Admiralty.

Razee of the Anson.

Mr Wilson, speaking of the cutting down of the Anson, a sixty-four-gun ship, to a frigate of thirty-eight guns, says, "she was cut down in the year 1794; and although in all other maritime states the science of naval construction was well understood, yet so culpably ignorant were the English constructors, that this operation, so well calculated, when properly conducted, to produce a good ship, was a complete failure. Seven feet of the upper part of the top sides, together with a deck and guns, making about 160 tons, were removed, by which her stability was greatly increased; but, by a complete absurdity, the sails were reduced one-sixth in area. In her first voyage the rolling was so excessive that she sprung several sets of top-masts. To mitigate this evil, in 1795, her masts and yards were increased to their original size; but as there were no decrease of ballast, she was still a very uneasy ship, and, as a necessary result, her wear and tear were excessive.

"Other sixty-fours were cut down, masted, and ballasted in exactly the same manner, and, it need scarcely be added, experienced similar misfortunes; and although they were improved by enlarging their masts and yards, they were still bad ships. Had their transformations been scientifically conducted, a class of frigates would have been continued in the navy, capable, from their size, of coping with the large American frigates; and thus the disasters we experienced in the late war, from the superior force of that nation, would, without doubt, have been not merely avoided, but turned into occurrences of a quite opposite character."

Improvements in naval architecture in this country.

The subject, however, of the improvement of ship-building was by no means lost sight of in this country at that period. The investigations and experiments which were made were, as usual in England in comparison with France and other continental nations, more of a practical than of a theoretical nature. Attwood's papers, read before the Royal Society in 1796 and 1798, form almost a solitary exception to this remark. In 1785, and subsequent years, Mr Miller of Dalswinton, in Dumfriesshire, made many experiments, expending as much as L.30,000 of his own private fortune for the advancement of naval architecture. In 1788 he was induced, by a Mr Taylor, to allow Symington, a working-engineer, to place a steam-engine on board a pleasure-boat on his lake at Dalswinton, for the purpose of propelling it by a paddle-wheel, and he thus became the originator of steam-navigation.[1]

Beaufoy's experiments.

In 1791, "a Society for the Improvement of Naval Architecture" was instituted, mainly by the exertions of Colonel Beaufoy. This society numbered amongst its members the then Duke of Clarence, afterwards William IV., and many noblemen and gentlemen of great influence. They conducted a most valuable series of experiments between 1793 and 1798, but a first report only of the results was ever published by the society. The funds at their disposal became exhausted, and the experiments were thus terminated, the interest of the public having flagged on account of the necessarily tedious nature of the proceedings. A detailed account of the whole of the experiments was subsequently published, in a most patriotic spirit, by Mr Henry Beaufoy, at his own private expense, and presented gratuitously to scientific societies and parties connected with naval architecture. Some valuable practical results were deduced from them, and these will be discussed hereafter, when treating of the resistances and other qualities of differently formed vessels.

Increase of merchant-shipping.

At the commencement of the present century the merchant-shipping of this country had increased to such an extent as to be of great importance. From the returns prepared by the Registrar-General of the Board of Trade, the total number of British merchant-vessels in the year 1801 was 19,711, with an aggregate registered tonnage of 2,038,253 tons, employing 149,766 men. In 1811 the total number of merchant-vessels was 24,106, with an aggregate registered tonnage of 2,474,784 tons, employing 162,547 men.

East India Company's shipping.

In the Honourable East India Company's service there were at this period 67 ships, each carrying 30 to 38 guns, 31 ships of 20 to 28 guns, and 52 ships of 10 to 19 guns, thus forming a powerful addition to the warlike resources of the country. Additional attention was also attracted to the subject of ship-building in the early part of this century by the institution of the Royal Yacht Club. It was joined by many influential and wealthy noblemen and gentlemen, and they gave much encouragement to the production of superior fast-sailing yachts.

School of Naval Architecture at Portsmouth.

Another important effort to improve the scientific knowledge of naval architecture, was the establishment, in 1811, of a school for naval architecture in Her Majesty's Dockyard at Portsmouth. This school was the result of the statements and recommendations contained in the report of a commission of naval revision, appointed in 1806, to examine into the management of the dockyards. The commissioners found that the practice of permitting the master shipwrights and their assistants to take private apprentices, receiving high fees with them, had been at that time disallowed and discontinued. By this system young men of superior early education, and of superior standing to the ordinary shipwright apprentices, had been trained in the higher branches of the profession, and their further scientific and theoretical education had been attended to, while at the same time they had acquired a knowledge of practical shipbuilding by being employed amongst the workmen. The commissioners therefore considered it expedient that some means should be adopted to supply the future demand for such men to fill those higher civil situations in which scientific knowledge is indispensable for the due performance of the duties. The school was accordingly instituted, but upon

[1] *Sketch of the Origin and Progress of Steam Navigation*, Bennet Woodcroft, 1848.

so large a scale, and with so little consideration of the real requirements of the service, that in a very few years 42 students were educated there, while the whole number of places in the Admiralty service, requiring such education and training, did not exceed 25 or 26. The necessary result of this was, that they were put into inferior positions for which their previous standing and training had not adapted them, and the school was considered to have been a failure. Much increase, however, of sound scientific knowledge resulted from the labours of the principal of the school, the late Dr Inman, though it may be remarked that he confined his labours to too limited a sphere, and did not follow out the investigations of the French mathematicians. Many valuable papers on naval architecture have also been published by different members of the school, and the article Ship-building, in the previous edition of this work, and from which much of the present article is taken, was written by the late Mr Creuze, one of its most talented and distinguished members.

The following table, taken from the navy list of 1813, will show the force of the royal navy at that period, distinguishing the number of ships in each class:—

Extent and Disposition of the British Naval Force in 1813.

Stations.	Line.	50–44	Frigates.	Sloops and Yachts.	Bombs, Fire-ships.	Brigs.	Cutters.	Schooners, Gun-ves., Lug., &c.	Total.
Downs	4	0	1	4	0	20	5	6	40
North Sea and Baltic	12	2	8	5	3	50	11	9	100
English Channel and coast of France	15	0	16	15	0	23	7	13	89
Irish station	0	0	5	3	0	5	1	7	21
Jersey, Guernsey, &c.	0	0	1	0	0	2	2	2	7
Spain, Portugal, and Gibraltar	15	0	11	6	2	14	4	1	53
Mediterranean and on passage	27	5	33	10	2	26	1	2	106
Coast of Africa	0	0	0	1	0	0	0	0	1
Halifax, Newfoundland, &c.	9	2	23	13	0	23	1	6	77
West Indies { Leeward Islands	2	1	10	8	0	6	2	4	33
West Indies { Jamaica and on passage	5	1	11	7	0	8	0	0	32
South America	4	1	8	7	0	4	0	2	24
Cape of Good Hope and southward	1	0	3	3	0	2	0	0	9
East Indies and on passage	4	0	16	3	0	4	0	0	27
Total at sea	98	12	146	85	7	187	34	52	619
In port and fitting	24	9	24	21	0	25	9	9	121
Guard-ships	5	1	4	5	0	0	0	0	15
Hospital ships, prison ships, &c.	32	1	3	2	0	0	0	0	38
Total in commission	159	23	177	111	7	212	43	61	793
Ordinary, and repairing for service	72	11	80	37	4	12	1	3	220
Building	28	4	25	9	0	7	0	0	73
Totals	259	38	282	157	11	231	44	64	1086

In 1832 the Navy Board was abolished, and it was determined to place the construction of ships under one head, continuing the name of surveyor of the navy, but altering the nature of the office by the appointment of a naval officer instead of a naval architect and ship-builder. Captain (afterwards Rear-Admiral Sir) William Symonds was the officer selected. He had early distinguished himself amongst his brother-officers by the attention he had paid to the sailing properties of boats and vessels. It was said of him that he could take any one of the boats in turn, of the vessel to which he was attached, and make her beat any of the others. His habit of observing the peculiarities of the different ships, whose properties he had an opportunity of witnessing, led him to draw certain conclusions respecting the forms of vessels; and, while holding a civil appointment in Malta, he built a yacht called the Nancy Dawson, in accordance with these preconceived views. The great speed of this yacht gained him notoriety, and procured for him the patronage and support of several influential and patriotic noblemen. Through their influence he obtained the sanction of the Board of Admiralty to build a corvette, the Columbine, and as this vessel was very favourably reported of, his character as a designer was proportionally raised. These successes led to his appointment as surveyor of the navy. It is not proposed here to discuss the propriety or otherwise of this office being filled by a naval officer, though in Sir William Symonds' case it led to important changes in the construction of the ships of the royal navy, and to much acrimony of feeling on the part of the shipwright officers of the service. One point is quite certain, that no man can be qualified to control the different forms of the various classes of ships, more especially of new classes that may be required in the navy, without long and careful study of the subject of naval architecture, both practically and theoretically. It is equally certain that a naval officer of experience is the most competent judge of the general proportions and qualities of the ships that will be most useful in the service, and that he is best able to point out the faults at sea of any ships that have been tested, so as to lead to the correction of these faults, and the improvement of future ships.

Sir William Symonds was the first constructor of the English navy who was left unrestricted as to dimensions, and he was consequently enabled to introduce into the service ships which undoubtedly bear very high characters as men-of-war. He also practically demonstrated the possibility of ships of war obtaining sufficient stability without the aid of ballast—a very important advantage, and one which has been productive of much benefit. He was in error, however, as to the true principles on which the stability of floating bodies is dependent, in order to secure as great freedom from rolling and as great ease of motion as possible. His ships had great statical stability, and therefore great power of carrying sail, and hence were generally very successful in trials of speed in sailing. But this advantage was not obtained without, in many instances, incurring a compensating disadvantage from uneasiness of motion. This appears to have been a very general fault in ships of his construction, some of them being marked examples of the uneasiness attendant on a stability which depends almost wholly on breadth at the load-water section and above it, to the neglect of the form of the solids of

immersion and emersion. His ships, however, were very general favourites in the service amongst the officers in command of them, who in their reports made light of any faults, and bore any personal inconvenience and want of comfort cheerfully and willingly, on account of the speed of their ships and their success in the sailing matches. The country is much indebted to Sir William Symonds for many improvements which he introduced into the navy, especially at the commencement of his tenure of office. He failed, however, to keep pace with the improvements of his time, his want of scientific education and of enlarged views rendering him unable to go beyond or apply to steamers, or any new class of vessels, the ideas which he had imbibed in his earlier years, and to which he adhered with a pertinacity amounting to obstinacy.

The following table contains the dimensions of the various classes of ships which Sir William Symonds introduced into the British navy, as well as of one or two other English ships built to compete with those of his construction. The dimensions according to which the ships of the French navy were at that time built are also given:—

Dimensions of English Ships of War at the period when Sir W. Symonds was Surveyor of the Navy.

	Names of Ships and of their Designers.	Guns.	Length of Gun-Deck.		Length of Keel for Tonnage.		Extreme Breadth.		Depth in Hold.		Burden in Tons.
			Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	
	First Rate.										
Designs of Sir William Symonds.	Queen	110 on 3 decks	204	0	166	5	60	0	23	9	3099
	Second Rate.										
	Vanguard	80 on 2 decks.	190	0	155	3	56	9	23	4	2589
	Third Rate.										
	Boscawen	70 on 2 decks.	180	0	146	8	54	0	22	4	2212
	Fourth Rate.										
	Vernon	50	176	0	144	$6\frac{1}{2}$	52	$8\frac{1}{2}$	17	1	2082
	Fifth Rate.										
	Pique	36	160	0	131	0	48	8	14	6	1622
	Sixth Rate.										
	Vestal	26	130	0	105	9	40	$7\frac{1}{2}$	10	6	913
	Carysfort	26	130	0	106	10	40	0	10	6	911
	Corvettes.										
	Rover	18	113	0	90	$1\frac{3}{4}$	35	5	16	9	590
	Calypso	18	120	0	99	$5\frac{1}{2}$	37	6	18	0	731
	Brigs.										
	Columbine	16	105	$0\frac{1}{2}$	84	0	33	$6\frac{1}{4}$	7	11	492
	Serpent	16	102	5	79	10	32	3	15	0	434
	Racer	16	100	8	78	$9\frac{1}{2}$	32	$4\frac{3}{4}$	14	10	431
	Pantaloon	16	91	10	71	4	29	4	12	8	323
London	Sir Robert Seppings	92 on 2 decks.	205	6	170	4	54	4	23	2	2598
Castor	Sir Robert Seppings	36	159	0	133	7	43	0	13	6	1283
Inconstant, Admiral Hayes		36	166	6	133	$5\frac{5}{8}$	45	5	13	7	1422
Modeste, Admiral Hon. G. Elliot		18	120	0	98	7	32	9	7	11	562
Sapphire	Professor Inman	28	119	0	100	$7\frac{1}{2}$	33	8	8	0	605
Orestes	Professor Inman	18	109	11	92	$10\frac{1}{8}$	30	6	7	6	459

Dimensions of French Ships of War, as being built in 1837.

	Line-of-Battle.			Frigates.		Corvettes.	
Number of Guns	120	100	90	60	52	32	24
	Feet. Inch.	Feet. Inch.	Feet. Inch.	Feet. Inch.	Feet. Inch.	Feet. Inch.	Feet. Inch.
Length on gun-deck between rabbets	209 5	205 $0\frac{1}{2}$	198 6	178 $1\frac{1}{2}$	172 1	138 $7\frac{1}{2}$	125 4
Moulded breadth	55 $3\frac{3}{4}$	54 $11\frac{1}{2}$	53 $5\frac{3}{4}$	47 7	45 $2\frac{1}{2}$	36 $0\frac{1}{4}$	32 $7\frac{1}{4}$
Draught of water, forward	24 $11\frac{3}{4}$	23 $10\frac{3}{4}$	23 4	19 $11\frac{1}{2}$	...	14 9	13 $6\frac{1}{2}$
Draught of water, aft	26 $8\frac{3}{4}$	26 $0\frac{1}{2}$	25 4	21 $3\frac{1}{2}$	...	16 3	14 10
Draught of water, mean	25 $10\frac{1}{4}$	24 $11\frac{1}{2}$	24 4	20 $7\frac{1}{2}$	20 8	15 6	14 $2\frac{1}{4}$
Load, displacement in tons	4940	4393	4013	2542	2267	999	738

The introduction of vessels propelled by steam for practical purposes dates its origin in the year 1812, when Henry Bell started the Comet steam-vessel on the Clyde, for the conveyance of passengers. In 1815 there were 10 steamers in existence, with an aggregate registered tonnage of 1633 tons. In 1825 this number had increased to 168, with an aggregate tonnage of 20,287 tons, and in 1835 the number was 538, with an aggregate tonnage of 80,520. Some interesting and valuable experiments were made about 1832, by Mr Scott Russell, on the Forth and Clyde Canal, with a view to introduce steam on canals, and though not successful in their object, a peculiar class of very long and finely-formed boats for quick passenger traffic on canals resulted from them. These boats were drawn by two horses, and were expected to travel at the rate of 9 or 10 miles per hour, but it was found that if these were not at once put to this speed, but started sluggishly or gradually, a wave was formed in front of the boat and continued to precede it, washing over the banks of the canal and over the towing-path. Under these circumstances the horses were much distressed with the labour which they had to perform. If, on the other hand, they were urged into a speed of 9 or 10 miles an hour at once upon starting, no wave was formed, and the boat seemed to rise on the surface of the water and to be propelled with comparative ease so long as that speed was maintained; but if they flagged, and their rate of travelling fell to 6 or 7 miles an hour, the wave was formed, and it then became necessary to go slower, or walk

History. them till it disappeared, and then to start them again at once into the higher speed. This peculiar result was no doubt mainly caused by the confined space of the canal, but no scientific investigation to account for it has yet been given. The lines of these boats were called wave-lines by Mr Scott Russell, and for ease of propulsion in smooth water they are undoubtedly beneficial. Lines of a similar character were also used about the same time by Mr Fearnall in fast-passenger steamers on the Thames. Their advantage was made very apparent by the construction of the Vesper in 1837, a passenger-boat from London Bridge to Gravesend. This boat went through the water at a speed of about 12 miles an hour, with scarcely any wave or even a ripple at her bows, while her competitors were carrying a heavy wave and swell before them. Other vessels with lines of a similar character were built subsequently by Messrs Fletcher and Fearnall, by Mr Ditchburn, who had been in their employment, and also by others.

Up to 1836 the mercantile marine had laboured under the disadvantage of a tonnage law for the charging of dues, which, by the mode of measurement enacted, held out a premium for the construction of inferior ships. In this year a new act was passed, and a better system introduced. By this act the internal capacity of a ship became the measure of her tonnage, and the serious objections to the former law were obviated.

It was about this period that iron began to be used to any great extent as a material for ship-building. Its merits for this purpose will be discussed hereafter, when treating of the practical construction of ships. Mr Manby, Mr Laird of Liverpool, and Mr Fairbairn of Manchester, were the first constructors of vessels of any size of this material. Mr Fairbairn, in 1833 and 1834, built two passenger-steamers of iron to ply on the Humber, between Selby and Hull, and in 1836 he commenced business in company with others as an iron-ship-builder at Millwall, on the Thames. In 1837 Mr Laird built an iron steam-vessel, the Rainbow, for the General Steam Navigation Company at Deptford, and from that time the use of iron has rapidly increased.

The next important step in the history of ship-building was the introduction of the screw-propeller. Many proposals had been made, and patents taken out, for propellers of this nature; but a small vessel fitted with a propeller, patented by Ericsson, was the first brought into practical use. A small experimental vessel called the F. B. Ogdon, was built in 1837, and fitted by Ericsson with one of his propellers, and the Lords Commissioners of the Admiralty, attended by their secretary, Sir William Symonds, took a trip in her in that year. They, however, failed to see the advantage of such an invention to men-of-war, and refused to entertain any proposal for its introduction into the navy. Mr F. P. Smith also built a small experimental vessel during this year, and fitted her with a screw propeller. Ericsson, on receiving no encouragement from the British government, took steps to bring his invention before the Americans, and a small vessel, the Robert F. Stockton, was built by him in 1838, in this country, with this view, and made the voyage safely to America. Mr Smith, in the meantime, induced a number of influential men to form a company to carry out his invention, and in 1839 the Archimedes was built by them, to test and demonstrate its value. The success of this vessel was such, and the advantages likely to accrue to men-of-war from the introduction of the screw were so apparent, that the Rattler was then ordered to be built in one of the government yards. This vessel was on the same lines as one of the Admiralty paddle-wheel steamers, but its stern was lengthened to fit it to receive the screw propeller. Her success was undeniable, but the progress of the screw in the navy was very slow for many years, owing to the opposition of Sir William Symonds and to the frequent changes of the Board of Admiralty. Some progress, however, was made in the introduction of screw-ships into the navy, several small vessels being built to the designs of Mr Fincham, the master shipwright of Portsmouth yard. This officer was in favour of its introduction, as were all the officers of the engineering department under the Board of Admiralty, and they were supported by the Hon. Mr Corry, the secretary of the Admiralty at that time. The Arrogant and Dauntless, two screw-frigates, were afterwards built by Mr Fincham; and, at the same time, the Termagant, also a screw-frigate, was built by Mr White of Cowes. After this, the growing dissatisfaction with the excessive rolling of Sir William Symonds' ships, his obstinate adherence to his own forms of construction, together with his unwillingness to co-operate in the introduction of screw-steam ships into the navy, led the Board of Admiralty, of that date, to order that a committee of reference should be constituted, to whom all designs for ships should be submitted before they were laid down. This led to Sir William Symonds resigning his office, and Sir Baldwin Walker, the present surveyor, was appointed as his successor. It was understood that Sir Baldwin Walker had not given his attention to the study of naval architecture in all its branches, and the Board of Admiralty announced that they should not expect him to originate the lines of the vessels to be built, but that these should be designed by naval architects attached to his office. The construction of the ships of the royal navy was thus placed on a proper footing, and if this arrangement be carried out, and the naval architects have full power given to them, and be at the same time competent men, the country ought to reap the benefit of so judicious an arrangement. History.

With respect to the class of ships ordered to be built at this period in the dockyards no change in accordance with the advancing state of screw propulsion took place. The naval members of the Board of Admiralty were men who had long looked upon the noble line of battle-ships of the navy as not to be surpassed, and they could not apparently make up their minds to desecrate them, as they seemed to consider it, by the introduction of steam-power. The result of this somewhat romantic feeling was, that early in Sir Baldwin Walker's administration a number of sailing three-deckers were laid down in opposition to the expressed opinion of the leading civil professional officers attached to the admiralty. Not one of these vessels has been launched, or will be launched, as a sailing vessel. They have all been converted, or are under conversion, to screw-ships, by being lengthened in midships, at the bows and also at the sterns. The greater proportion of the other sailing three-deckers are also being razéed and converted into two-decked screw-ships, their sterns only being altered. These important changes on the last-mentioned vessels are being carried out, while two of the members of the late school of naval architecture are the assistant-surveyors; and a repetition of the errors committed at the end of the last century, on the occasion of a similar operation upon several ships, will no doubt be avoided. The errors committed at that time have been described by Mr Wilson, as previously quoted, and are ascribed by him to a want of sufficient scientific knowledge; but as this is not the case at the present time, the country may now expect a very fine class of vessels to be the result.

It may also be remarked, that the introduction of the system of distilling the necessary supply of fresh-water on board the ships, and thus obviating the necessity of carrying so great a weight of fresh-water, has materially facilitated the arrangements for these alterations.

The history of ship-building in the royal navy up to the present time (1859), cannot be closed without reference to the class of small gun-boats and of iron-cased floating batteries recently introduced into the service. The gun-

History.

boats are of three classes, varying slightly in size and horse-power. The greater proportion of them are 106 ft. long between the perpendiculars, 22 ft. beam and 8 ft. deep, and are fitted with high-pressure engines of sixty horse-power. They are of 233 tons burden, and their draught of water, when ready for sea, is about 6 ft. The importance of this class of vessels as a protection against invasion cannot be overrated. The introduction of steam as a mechanical agent for the propulsion of vessels, independent of wind and tide, brings back almost the same state of things as existed when hostile fleets were composed of rowing galleys. The supremacy on the ocean which this country has so long held by means of the experience of such a large proportion of her population as seamen, must now depend on other sources of strength, and it behoves the nation to make preparations suitable to meet the altered circumstances. If our fleet were to suffer any reverse, and thus leave the sea free to an enemy; or if an enemy came to a determination to try and evade our fleet, and land an army on our shores, that army might be embarked at many different points; and with steam as an agent, the different portions of it might, with almost perfect certainty, meet at any appointed time at any spot. When once upon our coasts, they could move along them with a rapidity far beyond that at which any troops on shore could follow them. The importance, then, of keeping up a large and effective force of steam gun-boats, to lie, in the time of an expected invasion, in every bay and creek of our indented shores, is evident. For the construction of a fleet of such vessels, iron is fortunately the most valuable material, as the evils attending its use in large men-of-war will not militate against its use in these vessels. If they should be struck by shot, the men will be above the splinters, and by building these vessels with their frames very far apart, and with a strong inner and outer sheathing, both water-tight on every frame, they may be made almost unsinkable. The chief advantage, however, of iron for such vessels is its durability, if moderate care be taken to construct them in such a manner, that all the parts may be kept painted, and then that they be periodically cleaned and painted. Iron vessels so constructed and hauled up on shore, and so treated, might be considered as almost free from decay.

The floating batteries, coated with iron-plates 4 inches thick, appear at first sight to be most formidable vessels. Some of these have been built without any reference to speed, but with merely as much steam power as will give them the power of locomotion. Two others are now being built with great steam-power, and with finely-formed bodies, and these are therefore intended to have great speed. They are not protected at the bow and at the stern, but only in midships, and this part is separated from the ends by strong iron bulkheads, so that the centre portion is, as it were, a citadel into which the men may retire when attacked. Their cost is estimated at about L.250,000 each; and this very large expenditure will necessarily prevent their number being greatly increased. It may be expected, therefore, that the nation which has the command of the sea, will send small vessels of superior speed, and armed with guns capable of penetrating the plates of these batteries, to watch them and prevent their being brought against the ordinary vessels composing the fleet. Whatever speed these batteries may attain, it cannot be doubted but that light vessels, unencumbered with such weight, may be built to surpass them as soon as their speed is known.

Table of the British Navy, extracted from the Navy List, October 1859.

Class.	Propelling power.	Guns.	In commission.	In ordinary, and repairing for service.	Harbour vessels, hulks, &c.	Building.	Totals.
Three-decked ships	Screw	110 to 131	2	4	...	2	8
Do. do.	Sails	110 to 120	9	1	1	...	11
Two-decked ships	Screw	60 to 100	34	12	...	10	56
Do. do.	Sails	72 to 84	12	23	...	...	35
Frigates	Screw	36 to 50	19	18	...	5	42
Do.	Sails	40 to 50	12	70	...	...	82
Corvettes and sloops	Screw	4 to 21	29	11	...	10	50
Do. do.	Sails	14 to 26	20	45	...	...	65
Frigates and sloops	Paddle	3 to 22	46	18	...	...	64
Transports	Screw	...	7	3	...	...	10
Despatch vessels	Screw	2 to 4	16	4	...	2	22
Gun and other vessels	Screw	2 to 4	8	3	...	1	12
Yachts, tugs, &c.	Paddle	...	37	16	...	...	53
Do., and other vessels	Sails	...	12	17	...	...	29
Floating batteries	Screw	16	...	8	...	...	8
Grand total	...	...	...	...	...	...	547
Gun-boats	Screw	2	...	...	...	...	160
Frigates, iron-cased, not yet in Navy-list—building	...	...	...	...	...	...	4

By a return published during this year, it appears that the total number of ships of all classes belonging to the navies of other kingdoms is as follows:—

France	448	Austria	135
Russia	164	Portugal	37
Sweden—principally small vessels	311	Sardinia	28
		Prussia	55
Norway	143	Greece	26
Denmark	120	Turkey	49
United States	79	Brazil	27
Holland	139	Peru	15
Belgium	7	Chili	5
Spain	82	Mexico	9
The Two Sicilies	121		

In the merchant-service the screw for some time made but little progress. A company trading to Rotterdam, Messrs Laming and Company, were amongst the first to adopt it; and the mercantile marine owes much to their enterprising spirit in this respect. Their vessels were very successful, and attracted much attention from the time of their first introduction; and doubtless much of their immediate success may be attributed to men of high stand-

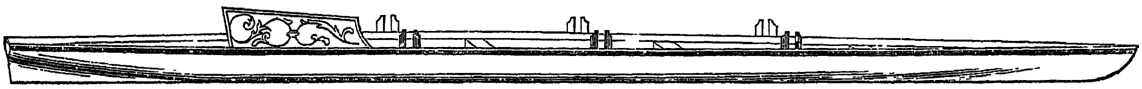
Extract from Return of British Merchant-Shipping by the Registrar-General of the Board of Trade.

Year.	Number and Tonnage of New Vessels Built and Registered in the British Empire in each Year.				Total Number of Registered Merchant-Vessels belonging to the British Empire in each Year.						
	Sailing Vessels.		Steamers.		Sailing Vessels.		Steamers.		Total.		Men.
	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.	
1840	1904	285,289	77	10,639	28,138	3,215,731	824	95,807	28,962	3,311,538	201,340
1845	1183	154,783	73	11,950	30,805	3,582,859	1012	131,202	31,817	3,714,061	224,900
1850	1381	229,603	81	15,527	32,938	4,045,331	1350	187,631	34,288	4,232,962	239,283
1855	1319	305,113	263	84,862	33,782	4,842,263	1910	408,290	35,692	5,250,553	261,194

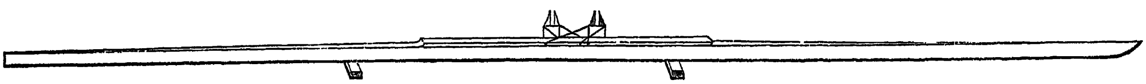
ing in their respective professions of ship-builders and engineers being employed in their construction, and being left unfettered to work out the end that was desired. From that time screw-vessels, constructed of iron, began rapidly to supersede paddle-wheel steamers and sailing vessels, especially for the conveyance of perishable merchandize, such as fruit and provisions; and the great capability of combining sailing and steaming which the screw affords, will no doubt tend to the continued increase of auxiliary steamers. The preceding table of the merchant-shipping of the country shows the extent to which the substitution of steamers for sailing vessels is taking place.

Reference has been previously made to the beneficial influence of the yacht clubs throughout the country. The English yachts were supposed to be unrivalled in speed; and in 1851 a challenge cup was given, open to the whole world for competition. A yacht from America, however, came over to this country, and carried off the prize. She soon showed such great superiority that the favourite English yachts at once gave up the contest, and it appeared likely that she would be allowed to walk over the course. To prevent this the late Mr Robert Stephenson entered his yacht, the Titania, built by Mr Scott Russell, to compete with her, and thus give her an opportunity of showing the extent of her superiority, and on what points that superiority was greatest. Representations of these two yachts are given in Plates V. and VI., and their relative performances and qualities will be examined hereafter. Though the introduction of steam has done much to lessen the interest taken in yachting, yet it is to be hoped that the valuable encouragement given to naval architects, and to the maritime predilections of the country by yachting clubs will be continued, and that many will follow the example already set by a few spirited men, of placing a small amount of auxiliary steam-power in their yachts with screw-propellers. This is done without impairing their beauty, and renders them certain in their movements when desired.

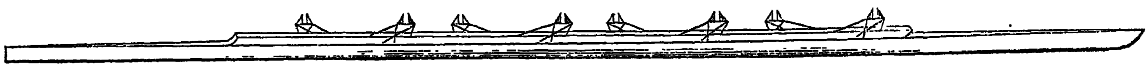
In connection with this subject, and as a means of forming a taste for it, the rowing and racing boats of the youths at public schools, and of the young men at the universities and elsewhere, may be mentioned. The following may be taken as the average performances of such boats at the present day. The drawings and the dimensions are from boats built by Messrs Searle and Sons of Lambeth, London:—



Randan Gig, 28 Feet Long.
A Pleasure Boat for three Pairs of Sculls; or for a Pair of Sculls in the middle, and with a single Oar or Scull forward and aft in addition when desired.



A Sculling Outrigger, 30 Feet Long.
New Style for Racing in Smooth Water.



Eight-Oared Outrigger, 60 Feet Long.
New Style for Racing in Smooth Water.

Eight-Oared Cutter, 60 Feet Long.
The Old Style of Racing Boat, or for Water for which the Outrigger is considered of too slight a Build.

Description of Boat.	Length.	Breadth.	Depth.	Weight.	Maximum speed per hour in still water.
Outrigger Racing Boats—	Feet.	Ft. In. Ft. In.		lb.	Miles.
Outrigger sculling boat	32	0 10 to 1 2	8½ in.	30 to 40	6
„ pair-oared	34	1 3 to 1 6	9 to 11 in.	45 to 55	6½ to 7
„ four-oared	42 to 45	1 10 to 2 3	1 foot.	100 to 112	8½ to 9
„ six-oared	50 to 54	2 0 to 2 4	1 „	150 to 190	9 to 9½
„ eight-oared	57 to 65	2 2 to 2 4	1 „	280 to 330	9½ to 10
Racing Boats of the old style—			Ft. In. Ft. In.		
Sculling boat	30	3 4 to 3 6	1 0 to 1 2	55 to 60	5½
Randan wherry	32	3 4 to 3 6	1 0 to 1 3	100 to 140	6
Four-oared cutter	40 to 42	3 6 to 3 8	1 1 to 1 3	224 to 280	7½ to 8
Six-oared cutter	45 to 50	3 6 to 3 8	1 1 to 1 3	336 to 376	8
Eight-oared cutter	54 to 58	3 6 to 3 8	1 1 to 1 3	520 to 600	8½ to 9
The lighter kind of Pleasure Boats—					
Pair-oared gig	23 to 25	3 6 to 3 8	1 foot 4 in.	180 to 200	4 to 4½
Randan gig	27 to 30	3 6 to 3 8	1 „ 4 „	200 to 224	5
Four-oared gig	40 to 42	3 4 to 3 6	1 „ 3 „	250 to 300	6½ to 7
Six-oared gig	55 to 48	3 4 to 3 6	1 „ 3 „	350 to 400	7
Eight-oared gig	54 to 58	3 2 to 3 4	1 „ 2 „	560 to 620	7½

To pass from these diminutive but beautiful specimens of naval architecture, the last great work which requires to be noticed in this brief outline of the history of the rise and progress of ship-building is the construction of the Great Eastern, Plate VIII. The dimensions of this vessel, as given on the plate, are so far beyond those of ordinary vessels, that it is necessary to draw particular attention to them. At the period of writing this article she has not been to sea except for one or two trial trips. Her performances will be discussed hereafter, but the results predicted by science as to her speed, with a given amount of steam-power, appear to have been realized. How far mercantile enterprise will be benefited by the construction of vessels of her magnitude remains to be proved.

Calculations incidental to designing a Ship.

DESCRIPTION OF THE MANNER OF PERFORMING THE CALCULATIONS INCIDENTAL TO DESIGNING A SHIP, WITH INVESTIGATIONS OF SOME OF THE PRINCIPAL ELEMENTS OF THE DESIGN.

Theory.

The labours of the numerous men of science who have devoted either the whole or a portion of their attention to the various problems embraced in the theory of ships, have left but few of its abstract principles uninvestigated; most of the proportions of a ship have been examined, and the laws on which they depend clearly defined, either by the aid of mathematical demonstration, or by experimental induction. There are, however, some questions which, though sound in theory, still depend on the results of physical experiments for perfecting their practical application.

Many of the elements of naval construction are dependent on the known laws of nature; and it may now be said that the principal difficulties of these are surmounted, and are familiar to the instructed naval architect. These are of themselves sufficient to insure the attainment of a certain and considerable degree of excellency in a ship, to give it a preponderance of any given quality, to discover the causes of any bad quality, and to point out the means of providing a remedy for the faults discovered.

The forces which act upon a ship in motion, in a fluid, even though the fluid be at rest, are as yet but imperfectly defined by mathematicians; and the elements of naval construction dependent on the laws regulating them are, therefore, less known and less certain in their application. The form of a ship's body need not, however, remain imperfect, because the curve of the solid of least resistance is uncertain, since enough has resulted from the consideration of the nature of that solid to prove its inapplicability to vessels in general; and theoretic perfection of the science in this particular would, therefore, be of no practical utility.

A very unphilosophic mode of reasoning is frequently applied to the question of the application of the exact sciences to naval architecture. It has been argued, that because men without any great amount of scientific knowledge have produced good ships, therefore the exact sciences are not necessary for the advancement of naval architecture. In such instances the success has resulted in some cases from chance, in others from induction after a succession of failures, but more frequently from the results of observations on other good ships; and in all these cases, wherever the changes from a foregoing example have been of any moment, the result has been a matter of doubt until tested by trial after completion. It is true that the scientific naval architect cannot effect, by any mathematical process, the synthetical composition of a perfect ship, but he may, by the application of the principles fully established and known to him, produce one with a full confidence of its possessing a preponderance of those qualities which he has considered it desirable that it should possess. The mistake is in the assumption that men of science consider that the theory of naval architecture is already perfected, and is a definite science, whereas this is far from being the case; and it can only be advanced gradually to a greater degree of perfection by an analysis of the actual performances of ships at sea, collected and registered, and the abstract sciences then brought to bear upon them. In every science a perfect theory is the result of the perfection of the science. The time is gone by, when a theory was first formed, and facts were then warped or twisted to suit the pre-conceived theory.

It is now proposed to proceed to show, in as concise a manner as possible, the method of performing the calculations necessary to determine the essential elements of the design of a ship's body, and which are required in the course of preparing the original draught or drawing. The rules to find the areas of plane figures, bounded by straight lines and curves, will first be given; and afterwards those for finding the volumes of solids, bounded by planes and curvilinear spaces.

To find the area of a plane area, bounded by straight lines and a curve.

Simpson's rules for finding the areas of plane surfaces.

ART. 1. If the area is symmetrical in regard to the line $A_1\ A_n$, that is, if a line $A_1 A$ can be found to divide the area into two equal parts, as $A_1\ a_n$ and $A_1\ b_n$; –

Divide this line (or axis) into a convenient number of equal parts, taking care to have an *even* number of such parts, then draw the lines $A_1 a_1$, $A_2 a_2$, $A_3 a_3$, &c., $A_n a_n$ at right angles to the line $A_1 A_n$, through the points A_1, A_2, A_3, &c., A_n, and meeting the curve in the points a_1, a_2, a_3, &c., a_n, these lines being called ordinates;

The second, $A_2 a_2$, fourth, $A_4 a_4$, &c., are called the EVEN ordinates. The *third* $A_3 a_3$, fifth $A_5 a_5$, &c., are called the ODD ordinates (the first and last being omitted).

Then, if these ordinates be measured on the same scale as the equal distances $A_1 A_2$, $A_2 A_3$, &c., the following rules will give the area of the figure :—

RULE I.—*To the sum of the first and last ordinates add four times the sum of all the* EVEN *ordinates, and twice the sum of all the* ODD *ordinates (omitting the first and last); multiply this final sum by the common distance between the ordinates, divide by* 3, *and the result will be the area (nearly).*

Note 1.—The following is the usual demonstration given to this rule, which is due to Thomas Simpson, who was Professor of Mathematics at Woolwich, about the middle of the last century :—

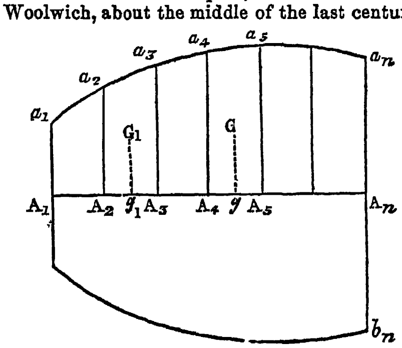


Fig. 3.

Referring to fig. 3,

$$\text{Put } A_1\, a_1 = \alpha_1,\ A_2\, a_2 = \alpha_2,\ A_3\, a_3 = \alpha_3, \text{ \&c., } A_n\ a^n = \alpha_n,$$
$$A_1 A_2 = A_2 A_3 = A_3 A_4, \text{ \&c., } A_{n-1} A_n = h$$

We suppose a parabolic curve, the equation to which is

$$y = A + B x + C x^2 \quad \ldots\ldots\ldots\ldots \quad (1)$$

to pass through the *three* points a_1, a_2, a_3; for since (1) contains three arbitrary constants A, B, C, we can, as is well known, make the curve (1) pass through three given points. Now, since (1) passes through a_1, we know (if A_1 be taken as origin) that $y = \alpha_1$ when $x = o$; when $x = h$, $y = \alpha_2 = A_2\ a_2$, and $y = \alpha_3 = A_3\ a_3$ when $x = 2\ h$; hence we have the following equations :—

$\alpha_1 = A$ . . (2) $\alpha_2 = \alpha_1 + B\,h + C\,h^2$ . . (3) $\alpha_3 = \alpha_1 + 2\,B\,h + 4\,C\,h^2$ . . (4) between (3) and (4) we readily determine B and C, viz. :—

$$B = \frac{4\,\alpha_2 - \alpha_3 - 3\,\alpha_1}{2\,h} \quad \ldots\ldots \quad (5)$$

$$C = \frac{\alpha_3 - 2\alpha_2 + \alpha_1}{2\,h^2} \quad \ldots\ldots \quad (6)$$

Introducing these values into (1), we obtain

$$y = \alpha_1 + \frac{4\,\alpha_2 - \alpha_3 - 3\,\alpha_1}{2\,h}x + \frac{\alpha_3 - 2\,\alpha_2 + \alpha_1}{2\,h^2}x^2.$$

But by the Integral Calculus we know that the area of a curve is represented by

$\int y\,dx$, taken between proper limits. In the present case these limits are o and $2h$.

$$\therefore \text{ area of } A_1\ a_3, \text{ or} \int_0^{2h} y\,dx = 2\alpha_1\,h + \left(\frac{4\alpha_2 - \alpha_3 - 3\alpha_1}{4h}\right)h^2$$

Calculations incidental to designing a Ship.

$+\left(\frac{\alpha_3-2\alpha_2+\alpha_1}{6h^2}\right)h^3$, or area of $A_1\,\alpha_3=\frac{h}{3}\left(\alpha_1+\alpha_3+4\alpha_2\right)$, after a little reduction.

Again, by making a parabola of the same form as (1) pass through the three points α_3, α_4, α_5, we obtain a result precisely similar to the above, that is,

$$\text{area } A_3\;\alpha_5=\frac{h}{3}(\alpha_3+\alpha_5+4\alpha_4, \text{ and}$$

$$\text{area } A_5\;\alpha_7=\frac{h}{3}(\alpha_5+\alpha_7+4\alpha_6),$$

$$\text{area } A^{n}{}_{-2}\,\alpha_n=\frac{h}{3}(\alpha_n{}_{-1}+\alpha_n+4\alpha^{n}{}_{-2}).$$

Adding these areas we find

$$\text{(I.) Area } A_1\,\alpha_n=\frac{h}{3}\left\{\alpha_1+\alpha_n+4\,(\alpha_2+\alpha_4+\alpha_6+\&c., \alpha_{n-2}) + 2\,(\alpha_3+\alpha_5, \&c., \alpha_{n-1})\right\}$$

It ought to be observed that in the application of this, and the following rules, an *odd* number of ordinates are always to be taken, and the nearer the ordinates are taken, that is, the less the common interval, the more nearly will the final result approach the *true* area of the figure.

For those who are not familiar with the Integral Calculus, another demonstration may be obtained, as follows:—

Through the point α_2, draw a tangent to the parabola which passes through α_1, α_2, α_3, and produce $A_1\,\alpha_1$, $A_3\,\alpha_3$, to meet this tangent in the points c and d; join $\alpha_1\,\alpha_3$; intersecting $A_2\;\alpha_2$ in b; through α_1 and c draw $c\,e$ and $\alpha_1\,f$ parallel to $A_1\,A_3$, then it is shown in all works on Conic Sections that $\alpha_1\,\alpha_3$ is parallel to $c\,d$. Hence by Euc. I. 35—

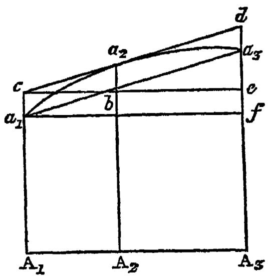


Fig. 4.

Paral^m $\alpha_1\,d$ = paral^m cf, because they are on the same base and between the same parallels $A_1\,c_1$, $A_3\,d$.

$$\text{Now, } A_2\,b=\frac{A_1\,\alpha_1+A_3\,\alpha_3}{2} \text{ and } A_2\,\alpha_2=\alpha_2$$

$$\therefore \text{ area of parabola } \alpha_1\,b\alpha_3\,\alpha_2\,\alpha_1=\frac{2}{3}\text{paral}^{m}\,\alpha_1\,d=\frac{2}{3}\text{paral}^{m}\,cf\text{ [1]}$$

$$=\frac{2}{3}\left(\alpha_2-\frac{\alpha_1+\alpha_3}{2}\right)\times 2h, \text{ since } A_1\,A_3=\alpha f=2h.$$

$$\text{Also area of trapezoid } A_1\,\alpha_1\,\alpha_3\,A_3=\left(\frac{A\alpha_1+A_3\,\alpha_3}{2}\right)A_1\,A_3 = h\,(\alpha_1+\alpha_3).$$

Adding these two areas, we obtain that of the whole figure

$$A_1\,\alpha_1\,\alpha_2\,\alpha_3\,A_3=\frac{h}{3}\left\{3\alpha_1+3\alpha_3+4\alpha_2-2\alpha_1-2\alpha_3\right\}$$

$$=\frac{h}{3}\left\{\alpha_1+4\alpha_2+\alpha_3.\right\}$$

By repeating this process for the area of the figures $A_3\,\alpha_3\,\alpha_4\,\alpha_5\,A_5$, &c., &c., and adding the results, we obtain for the whole area $A_1\,\alpha_n$ the same result as before.

If α_2 were less than α_1, the parabola would be convex towards $A_1\,A_3$; but the same rule would still apply, for A_2b would then be equal to $\frac{\alpha_1+\alpha_3}{2}-\alpha_2$, and this introduced into the form for finding the area of the parabola, leads to the same result as that already obtained.

Another demonstration, on different principles, will be given in Note (3.)

RULE II.—*To the sum of the first and last ordinates, add* THREE TIMES *the sum of the second, third, fifth, sixth, eighth, ninth, &c., ordinates, and* TWICE *the sum of the fourth, seventh, tenth, thirteenth, &c., ordinates (omitting the last ordinate); multiply this final sum by three times the common distance between the ordinates, divide the product by 8, and the result will give the area (nearly).*

Note 2.—To obtain what naval architects call the "Second Rule," we suppose a parabola, the equation to which is

$$y=A+Bx+Cx^2+Dx^3 \quad \ldots\ldots \quad (1)$$

to pass through the four points α_1, α_2, α_3 α_4 (fig. 1), the four constants being determined by these conditions; that is, when x takes the successive values o, h, $2h$, $3h$; y becomes α_1, α_2, α_3, and α_4; hence the following equations:

$$\alpha_1=A \ldots\ldots (2) \because \text{when } x=o \;\; y=\alpha_1$$

$$\alpha_2-\alpha_1=Bh+Ch^2+Dh^3 \ldots (3) \because \text{when } x=h_1\; y=\alpha_2$$

$$\alpha_3-\alpha_1=2Bh+4Ch^2+8Dh^3 \ldots (4) \because \text{when } x=2h_1\, y=\alpha_3$$

$$\alpha_4-\alpha_1=3Bh+9Ch^2+27Dh^3 \ldots (5) \because \text{when } x=3h_1\, y=\alpha_4$$

$$(4)-(3)\times 2 \text{ gives } \alpha_3-2\alpha_2+\alpha_1=2Ch^2+6Dh^3 \ldots (6)$$

$$(5)+(3)-(4)\times 2 \text{ gives } \alpha_4-2\alpha_3+\alpha_2=2Ch^2+12Dh^3 \ldots (7)$$

$$(7)-(6) \text{ gives } 6Dh^3=\alpha_4-3\alpha_3+3\alpha_2-\alpha_1 \ldots (8)$$

$$\text{From (6) and (8) } 2Ch^2=\alpha_4+4\alpha_3-5\alpha_2+2\alpha_1 \ldots (9)$$

$$\text{From (3), (8) and (9) } 6Bh=2\alpha_4-9\alpha_3+18\alpha_2-11\alpha_1 \ldots (10)$$

$$\text{But area, or} \int_o^{3h} y\,dx=\int_o^{3h}\left\{A+Bx+Cx^2+Dx^3\right\}dx$$

(we write the limits of x, o and $3h$, because at A_1, x is o, and at A_4, x is $3h$).

$$\therefore \text{ Area } A_1\,\alpha_4=\frac{3h}{8}\left\{8A+12Bh+24Ch^2+54Dh^3.\right\}$$

Introducing the values of A, B, C, and D, given by the above equations, we find, after some obvious reductions,

$$\text{Area } A_1\,\alpha_4=\frac{3h}{8}\left\{\alpha_1+\alpha_4+3\,\alpha_2+3\,\alpha_3\right\} \quad \ldots \quad (11.)$$

In like manner, by making a curve similar to (1) pass through the points α_4, α_5, α_6, α_7, we have

$$\text{Area } A_4\,\alpha_7=\frac{3h}{8}\left\{\alpha_4+\alpha_7+3\,\alpha_5+3\,\alpha_6\right\} \quad \ldots \quad (12.)$$

$$\text{Area } A_7\,\alpha_{10}=\frac{3h}{8}\left\{\alpha_7+\alpha_{10}+3\,\alpha_8+3\,\alpha_9\right\} \quad \ldots \quad (13.)$$

$$\vdots \qquad \vdots$$

$$\text{Area } A_{n-3}\alpha_n=\frac{3h}{8}\left\{\alpha_{n-3}+\alpha_n+3\,\alpha_{n-2}+3\,\alpha_{n-1}\right\} \quad \ldots \quad \text{(N.)}$$

Adding equations (11), (12), (13), &c., (N), we get

$$\text{(II.) Area } A_1\,\alpha_n=\frac{3h}{8}\left\{\alpha_1+\alpha_n+3\,(\alpha_2+\alpha_3+\alpha_5+\alpha_6+\&c., \alpha_{n-2}+\alpha_{n-1})+2\,(\alpha_4+\alpha_7+\alpha_{10}+\&c., \alpha^{n}{}_{-3})\right\}$$

It will be seen from the foregoing method that we may make a curve of the form

$$y=A+Bx+Cx^2+Dx^3+Ex^4+\&c., Nx_{n-1}$$

pass through n points, taking care that the equation shall contain n arbitrary constants, to be determined by the conditions that the curve may pass through α_1, α_2, α_3, α_4, &c., α_n (fig. 3, page 140), when x and y are respectively $x=o$, $x=h$, $x=2\,h$, &c., $x=(n-1)\,h$,

$$y=\alpha_1,\; y=\alpha_2,\; y=\alpha_3, \;\&c.,\; y=\alpha_n,$$

α_1, α_2, α_3, &c., and h, having the same interpretation as before; the ordinates being taken at equal distances apart, as on this hypothesis the calculation of the area is much simplified.

Rules obtained after this manner for any given number of ordinates will, in general, give us the area of the figure more correctly than if we employed the preceding rules, because in the latter case we suppose a continuous curve to pass through the given points, whereas, in the former cases, we have a *series of curves* passing through the given points, and the curvilinear boundary is itself supposed to be a continuous curve. Such rules (for many ordinates) give rise to a great deal of labour in obtaining them, and entail almost as much labour in their application. In the latter case, moreover, logarithms will assist us to some extent, and in the former,

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[1] The equation to a parabola being $y^2=4\,m\,x$, or $y=2\,m^{\frac{1}{2}}\,x^{\frac{1}{2}}$ . . . . . . (1)

$$\text{Area, or} \int_o^x y\,dx=2m^{\frac{1}{2}}\int_o^x x^{\frac{1}{2}}\,dx=\frac{4a^{\frac{1}{2}}\,x^{\frac{3}{2}}}{3}=\frac{2\,xy}{3} \text{ by (1)}$$

$$=\frac{2}{3} \text{ circumscribed parallelogram.}$$

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there are some remarkable properties of the natural numbers connected with the determination of the arbitrary constants, and on which perhaps more light may hereafter be thrown. We have remarked some curious properties of the squares, cubes, &c., of numbers connected with the eliminations. There can be no doubt that many other rules of a very simple kind may be obtained on the condition that any number of the constants may disappear from the general equation, which is equivalent to as many conditions.

Emerson, in his *Arithmetic of Infinites*, published by Nourse in the year 1767, gives the following formulæ, obtained by the foregoing processes—from one up to nine ordinates.

Area $= h\alpha_1$ . . . . for one ordinate.

$= \frac{h}{2}(\alpha_1+\alpha_2)$ . . . . for two ordinates.

(1) $= \frac{h}{3}(\alpha_1+\alpha_3+4\alpha_2)$ . . . . for three ordinates.

(2) $= \frac{3h}{8}\left\{\alpha_1+\alpha_4+3(\alpha_2+\alpha_3)\right\}$ . . . . for four ordinates.

(3) $= \frac{h}{25}\left\{7(\alpha_1+\alpha_5)+32(\alpha_2+\alpha_4)+12\alpha_3\right\}$ for five ordinates.

(4) $= \frac{5h}{288}\left\{19(\alpha_1+\alpha_6)+75(\alpha_2+\alpha_5)+50(\alpha_3+\alpha_4)\right\}$ six do.

(5) $= \frac{h}{140}\left\{41(\alpha_1+\alpha_7)+216(\alpha_2+\alpha_6)+27(\alpha_3+\alpha_5)+272\alpha_4\right\}$ for seven ordinates.

(6) $= \frac{7h}{17280}\left\{751(\alpha_1+\alpha_8)+3577(\alpha_2+\alpha_7)+1323(\alpha_3+\alpha_6)+2989(\alpha_3+\alpha_4)\right\}$ for eight ordinates.

(7) $= \frac{4h}{14175}\left\{989(\alpha_1+\alpha_9)+5888(\alpha_2+\alpha_8)-928(\alpha_3+\alpha_7)+10496(\alpha_4+\alpha_6)-4540\alpha_5\right\}$ for nine ordinates.

Where extreme accuracy is required, these may be combined such a way as to give the area. For instance, if there were fifteen ordinates in a figure, (5) and (7) may be combined, remembering that the last ordinate of (5) becomes the first in (7), &c., &c.

When seven ordinates are considered sufficient, the following elegant rule, due to the late Mr Thomas Weddle, of the Military College, Sandhurst, may be employed :—

RULE III.—*When* SEVEN *ordinates are employed.*[1] *To five times the sum of the* EVEN *ordinates, add the fourth, or middle ordinate, and all the odd ordinates ; multiply this sum by* THREE TIMES *the common distance between the ordinates, divide by* 10, *and the result will give the area* (nearly).[2]

Note 3.—The Calculus of Finite Differences may be advantageously employed to approximate to the areas of surfaces, lengths of curves, volumes of solids, centres of gravity, moments of inertia, &c. For triple integrals may generally be reduced to integrals of the form

$$\int_{x_1}^{x_2} u\,dx$$

where u represents a function of x, or $f(x)$, as it is usually written, and x_1, x_2 represent the limits of the integral.

Now, if we suppose x to vary by the constant difference Δx, we may suppose $z = \frac{x}{\Delta x}$, and if $\alpha_1, \alpha_2, \alpha_3$, &c., α_n be the values of u when $z = o, 1, 2, 3$, &c., n, we have, by Taylor's theorem,

$$u = \alpha_1 + z\Delta\alpha_1 + z(z-1)\frac{\Delta^2\alpha_1}{1\cdot2}, + z(z-1)(z-2)\frac{\Delta^3\alpha}{1\cdot2\cdot3} + \text{\&c., ...} \quad (1.)$$

But by hypothesis Δx is constant, and according to the notation we have previously employed, we may suppose it $= h \therefore \frac{x}{h} = z$, and $\frac{dx}{h} = dz$. Multiplying each side of (1) by these differentials, and integrating, we have

$$\frac{1}{h}\int u\,dx = z\alpha_1 + \frac{z^2}{2}\Delta\alpha_1 + \left(\frac{z^3}{3}-\frac{z^2}{2}\right)\frac{\Delta^2\alpha_1}{1\cdot2} + \left(\frac{z^4}{4}-\frac{3z^3}{3}+\frac{2z^2}{2}\right)\frac{\Delta^3\alpha}{1\cdot2\cdot3}$$

$$+\left(\frac{z^5}{5}-\frac{6z^4}{4}+\frac{11z^3}{3}-\frac{6z^2}{2}\right)\frac{\Delta^4\alpha_1}{1\cdot2\cdot3\cdot4} + \left(\frac{z^6}{6}-\frac{10z^5}{5}+\frac{35z^4}{4}-\frac{50z^3}{3}+\frac{24z^2}{2}\right)\frac{\Delta^5\alpha_1}{\lfloor 5}$$

$$+\left(\frac{z^7}{7}-\frac{15z^6}{6}+\frac{85z^5}{5}-\frac{225z^4}{4}+\frac{274z^3}{3}-\frac{120z^2}{2}\right)\frac{\Delta^6\alpha_1}{\lfloor 6}$$

$$+\left(\frac{z^8}{8}-\frac{21z^7}{7}+\frac{175z^6}{6}-\frac{735z^5}{5}+\frac{1624z^4}{4}-\frac{1764z^3}{3}+\frac{720z^2}{2}\right)\frac{\Delta^7\alpha_1}{\lfloor 7}$$

$$+\left(\frac{z^9}{9}-\frac{28z^8}{8}+\frac{322z^7}{7}-\frac{1960z^6}{6}+\frac{6769z^5}{5}-\frac{13132z^4}{4}+\frac{13068z^3}{3}-\frac{5040z^2}{2}\right)\frac{\Delta^8\alpha_1}{\lfloor 8}$$

$$+\left(\frac{z^{10}}{10}-\frac{36z^9}{9}+\frac{546z^8}{8}-\frac{4536z^7}{7}+\frac{22449z^6}{6}-\frac{67284z^5}{5}+\frac{118124z^4}{4}-\frac{109584z^3}{3}+\frac{40320z^2}{2}\right)\frac{\Delta^9\alpha_1}{\lfloor 9}$$

$$+\left(\frac{z^{11}}{11}-\frac{45z^{10}}{10}+\frac{870z^9}{9}-\frac{9450z^8}{8}+\frac{63273z^7}{7}-\frac{269325z^6}{6}+\frac{723680z^5}{5}-\frac{1172700z^4}{4}+\frac{1026576z^3}{3}-\frac{362880z^2}{2}\right)\frac{\Delta^{10}\alpha_1}{\lfloor 10}$$

$$+\left(\frac{z^{12}}{12}-\frac{55z^{11}}{11}+\frac{1320z^{10}}{10}-\frac{18150z^9}{9}+\frac{157773z^8}{8}-\frac{902055z^7}{7}+\frac{3416930z^6}{6}-\frac{8409500z^5}{5}+\frac{12753576z^4}{4}-\frac{10628640z^3}{3}+\frac{3628800z^2}{2}\right)\frac{\Delta^{11}\alpha_1}{\lfloor 11}$$

$$+\left(\frac{z^{13}}{13}-\frac{66z^{12}}{12}+\frac{1925z^{11}}{11}-\frac{32670z^{10}}{10}+\frac{357423z^9}{9}-\frac{2637558z^8}{8}+\frac{13339545z^7}{7}-\frac{45995730z^6}{6}+\frac{105258876z^5}{5}-\frac{150917976z^4}{4}+\frac{120543840z^3}{3}-\frac{35916800z^2}{2}\right)\frac{\Delta^{12}\alpha_1}{\lfloor 12}$$

$$+ \text{\&c.,} + \text{\&c.,} \quad \ldots \quad (2.)$$

The coefficients in each of these terms are readily obtained by multiplying $(p-1)(p-2)(p-3)(p-4)(p-5)$, &c. $(p-n)$ together.

If we take this integral between the limits $z = 0$ and $z = 2$, which correspond to $x = 0$ and $x = 2h$, after multiplying by h.

$$\int_0^{2h} u\,dx = h\left\{2\alpha_1 + 2\Delta\alpha_1 + \frac{1}{3}\Delta^2\alpha_1 - \frac{1}{90}\Delta^4\alpha_1 + \frac{1}{90}\Delta^5\alpha_1 - \frac{37}{3780}\Delta^6\alpha_1 + \text{\&c.}\right\}$$

But by the principles of the Calculus of Finite Differences :

$$\Delta\alpha_1 = \alpha_2 - \alpha_1$$
$$\Delta^2\alpha_1 = \alpha_3 - 2\alpha_2 + \alpha_1$$

$$\therefore \int_0^{2h} u\,dx = \frac{h}{3}\left\{\alpha_1 + 4\alpha_2 + 2\alpha_3 - \frac{1}{30}\Delta^4\alpha_1 + \frac{1}{30}\Delta^5\alpha_1 - \frac{37}{1260}\Delta^6\alpha_1 + \text{\&c.}\right\}$$

Now, if we add similar expressions for the area included between $x = 2h$ and $x = 4h$; $x = 4h$ and $x = 6h$, &c. $x = (n-2)$ and $x = nh$ (n being an even number).

[1] Seven, thirteen, nineteen, &c., ordinates, may be employed on the same hypothesis, as is mentioned hereafter.
[2] The fourth ordinate is considered among the *even* ordinates.

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$$\int_0^{nh} u\,dx = \frac{h}{3}\Big\{\alpha_1 + \alpha_{n+1} + 4(\alpha_2 + \alpha_4 + \alpha_6 + \&c. + \alpha_{n-2})$$
$$+ 2(\alpha_3 + \alpha_5 + \alpha_7 + \&c. + \alpha_{n-1}\}.$$
$$- \frac{1}{30}(\Delta^4\alpha_1 + \Delta^4\alpha_2 + \Delta^4\alpha_4 + \&c. \quad \Delta^4\alpha_{n-1}).$$
$$+ \frac{1}{30}(\Delta^5\alpha_1 + \Delta^5\alpha^2 + \Delta^5\alpha_4 + \&c. \quad \Delta^5\alpha_{n-1}).$$
$$- \frac{37}{1260}(\Delta^6\alpha_1 + \Delta^6\alpha_2 + \&c. \quad \&c. \qquad).$$
$$+ \quad \&c. \quad \&c. \quad \&c. \qquad \Big\} \ldots . (3.)$$

The first line corresponds to the Rule we have already obtained (I.) by supposing a parabola to pass through the extremities of the ordinates α_1, α_2, α_3; and another through α_3, α_4, α_5, &c.

The following terms are the correction of the first line; hence, when great accuracy is required, the following results may be taken into account.

To obtain Rule (III.), we only have to suppose the integral (1) taken between the limits $z = 0$ and $z = 6$, or $x = 0$ and $x = 6h$, as was done by Mr Weddle in his demonstration, given in the *Dublin and Cambridge Mathematical Journal* for February 1856, which is similar to this:

$$\therefore \int_0^{6h} u\,dx = h\Big\{6\alpha_1 + 18\,\Delta\alpha_1 + 27\,\Delta^2\alpha_1 + 24\,\Delta^3\alpha_1 + \frac{123}{10}\Delta^4\alpha_1$$
$$+ \frac{33}{10}\Delta^5\alpha_1 + \frac{41}{140}\Delta^6\alpha_1 + \&c.\Big\} \ldots\ldots\ldots\ldots\ldots . (4.)$$

And we may suppose *sixth* differences *constant*, and then all the terms after $\Delta^6\alpha_1$ in (4) will vanish; but $\frac{41}{140}$ differs from $\frac{42}{140}$ by the small fraction $\frac{1}{140}$; hence, instead of $\frac{41}{140}$ we may write $\frac{42}{140}$ or $\frac{3}{10}$ without material error. Replacing $\Delta\alpha_1$ by $\alpha_2 - \alpha_1$, $\Delta^2\alpha_1$ by $\alpha_3 - 2\alpha_2 + \alpha_1$, $\Delta^3\alpha_1$ by $\alpha_4 - 3\alpha_3 + 3\alpha_2 - \alpha_1$ &c., after some obvious reductions (4) becomes

$$\int_0^{6h} u\,dx = \frac{3h}{10}\Big\{\alpha_1 + \alpha_3 + \alpha_5 + \alpha_7 + 5(\alpha_2 + \alpha_6) + 6\alpha_4\Big\}$$
$$= \frac{3h}{10}\Big\{\alpha_1 + \alpha_3 + \alpha_4 + \alpha_5 + \alpha_7 + 5(\alpha_2 + \alpha_4 + \alpha_6)\Big\} \ldots\ldots\ldots . (5.)$$

"From the foregoing investigation, it is clear, that formula (5.) gives the *exact* area, when fifth differences are constant, while it differs (in excess) from the true value by $\frac{1}{140}\Delta^6\beta$ when *sixth*, or even *seventh*, differences are constant. In other cases it will give the area very nearly, providing the differences, beginning at the sixth, are small."[1]

As many rules as we please may be obtained by integrating (1.) from $z = 0$ to $z = 1$, $z = 0$ to $z = 2$, $z = 0$ to $z = 3$, $z = 0$ to $z = 4$, &c.: from $z = 0$ to $z = n$, and, neglecting small quantities, as has been done by Mr Weddle, and by supposing the $(n-1)^{th}$ order of differences constant.[2]

Rule (II.) may be obtained by integrating equations (1.) from $z = 0$ to $z = 3$, which will be the same as supposing a series of parabolas to pass through the extremities of $\alpha_1, \alpha_2, \alpha_3, \alpha_4$; $\alpha_4, \alpha_5, \alpha_6, \alpha_7$, &c., as was the case in formula (3).

In these rules, if the curve passes through A_1 or A_n, the first or last ordinate must be considered 0.

Some examples will now be given on the application of the preceding rules.

(1.) Find the area of a figure, bounded by right lines and a curve, the ordinates of which are taken at 3 feet apart, and measure 1, 2, 3, 4, 5, 4, 3, 2, and 1 feet respectively.

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By Rule (I.)

Ordinates.	Even Ordinates.	Odd Ordinates.
1 1st ord.	2	3
1 last do.	4	5
–	4	3
2 sum of 1st and last ord.	2	—
48 four times sum of even do.	—	11 sum of odd ord.
22 twice sum of odd do.	12 sum of even ord.	2
—	4	—
72	—	22 twice sum of do.
1 = ⅓ common distance.	48 — four times do.	
—		
72 = area.		

By Rule (II.)

Ordinates.	Ordinates.	Ordinates.
1 first ord.	2 second ord.	4 fourth ord.
1 last do.	3 third do.	3 seventh do.
–	5 fifth do.	–
2 sum of 1st and last ord.	4 sixth do.	7 sum of do.
48 { – thrice sum of 2d, 3d, 5th, 6th, &c.	2 eight do.	2
	—	—
14 twice sum of 4th, 7th.	16 sum of do.	14 twice sum of do.
—	3	
64	—	
9 = 3 times com. dist.	48 three times sum of do.	
—		
8)576		
—		

72 = area, which agrees exactly with the area obtained by Rule (I.)

(2.) Find the area of a figure where the ordinates are 10, 12, 13, 14, 13, 12, and 10 feet, respectively, and the common distance 2 feet.

By Rule (I.) $\quad$ Area $= \frac{2}{3}\{10 + 10 + 4(12 + 14 + 12) + 2(13 + 13)\} = 149\frac{1}{3}$ feet.

By Rule (II.) $\quad$ Area $= \frac{3 \times 2}{8}\{10 + 10 + 3(12 + 13 + 13 + 12) + 2 \times 14\} = 148\frac{2}{3}$ feet.

By Rule (III.) $\quad$ Area $= \frac{3 \times 2}{10}\{10 + 13 + 14 + 13 + 10 + 5(12 + 14 + 12)\} = 150$ feet.

(3.) Find the area where the ordinates are 20·75, 21·78, 22·56, 23·79, 22·64, 21·51; and 21·51, the common distance being 6 feet.

By Rule (I.) $\quad$ Area $= \frac{6}{3}\{20{\cdot}75 + 21{\cdot}51 + 4(21{\cdot}78 + 23{\cdot}79 + 21{\cdot}51) + 2(22{\cdot}56 + 22{\cdot}64)\} = 801{\cdot}96$ feet.

By Rule (II.) $\quad$ Area $= \frac{6 \times 3}{8}\{20{\cdot}75 + 21{\cdot}51 + 3(21{\cdot}78 + 22{\cdot}56 + 22{\cdot}64 + 21{\cdot}51) + 2 \times 23{\cdot}79\} = 799{\cdot}4475.$

By Rule (III.) $\quad$ Area $= \frac{6 \times 3}{10}\{20{\cdot}75 + 22{\cdot}56 + 23{\cdot}79 + 22{\cdot}64 + 21{\cdot}51 + 5(21{\cdot}78 + 23{\cdot}79 + 21{\cdot}51)\} = 803{\cdot}97.$

As is stated in Note (3.), Rule (III.) can only be applied to obtain a very near approximation to the true area when the sixth and seventh ordinates are alike, or differ by a very small quantity.

By applying these rules to find the area of the quadrant $A_1\,a_7'$, the radius of which is 6 feet, it will be seen how much the results differ from the true area.

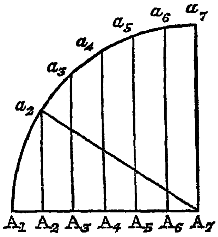

Fig. 5.

[1] The *Dub. and C. Math. Journal*, Feb. 1854.

[2] The coefficients of the various orders of differences have been extended, in order that the reader may obtain some of these rules for himself.

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Divide the radius $A_1 A_7$ into six equal parts (Fig. 5), and erect the ordinates $A_2 a_2$, $A_3 a_3$, &c. observing that $A_1 a_1 = 0$.

$$A_2 a_2 = \sqrt{(A_7 a_2)^2 - (A_7 A_2)^2} = \sqrt{6^2 - 5^2} = \sqrt{11} = 3{\cdot}3163$$
$$A_3 a_3 = \sqrt{(A_7 a_3)^2 - (A_7 A_3)^2} = \sqrt{6^2 - 4^2} = \sqrt{20} = 4{\cdot}4721$$
$$A_4 a_4 = \sqrt{6^2 - 3^2} = \sqrt{27} = 5{\cdot}1961$$
$$A_5 a_5 = \sqrt{6^2 - 2^2} = \sqrt{32} = 5{\cdot}6568$$
$$A_6 a_6 = \sqrt{6^2 - 1^2} = \sqrt{35} = 5{\cdot}9160$$
$$A_7 a_7 \qquad = 6$$

The area found by Rule (I.) $= 27{\cdot}9901$ feet.
" (II.) $= 27{\cdot}9285$ "
" (III.) $= 28{\cdot}0401$ "

Apply formula (5.) given at the end of Note (1.)

$$\text{Area} = \frac{h}{140}\Big\{41(\alpha_1 + \alpha_7) + 216(\alpha_2 + \alpha_6) + 27(\alpha_3 + \alpha_5) + 272\,\alpha_4\Big\}.$$

Where $h = 6$, $\alpha_1 = 0_1$ $\alpha_2 = 3{\cdot}3163$, $\alpha_3 = 4{\cdot}4721$, &c.
And area $= 28{\cdot}05$ feet.

But true area of quadrant $= \dfrac{6^2 \times 3{\cdot}1416}{4} = 28{\cdot}2744$, so that Rule (III.) and formula (5.), in the present case, give the area almost accurately.

(4.) The ordinates of a curve taken 6 feet apart are, 20, 22, 24, 25; 24, 23, and 21 feet, respectively: find the area of the figure.

By Rule (I.) $\text{Area} = \frac{6}{3}\Big\{20 + 21 + 4(22 + 25 + 23) + 2(24 + 24)\Big\} = 834$ feet.

By Rule (II.) $\text{Area} = \frac{3 \times 6}{8}\Big\{20 + 21 + 3(22 + 24 + 24 + 23) + 2 \times 25\Big\} = 832{\cdot}5$ feet.

By Rule (III.) $\text{Area} = \frac{3 \times 6}{10}\Big\{20 + 24 + 25 + 21 + 5(22 + 25 + 23\Big\} = 835{\cdot}2$ feet.

By formula (5.) $\text{Area} = \frac{6}{140}\Big\{20 + 21 + 216(22 + 23) + 27(24 + 24) + 272 \times 25\Big\} = 835{\cdot}5$ feet.

(5.) Find the area, when the ordinates, taken 4 feet apart measure 0, 2·275, 3·476, 4·567, 5·673, 6·451, 5·341, 4·236, 3·254, 3·065, 2·784, 1·876, and 0, respectively.

By Rule (I.) Area $= 174{\cdot}6293$.

(6.) Find the area by Rules (II.) and (III.) when the ordinates, taken 1 foot apart, measure, 0, 1·7684, 2·3457, 3·4567, 3·214, 2·97654, and 2·8543 feet, respectively.

By Rule (II.) Area $= 15{\cdot}2556$, &c.
By Rule (III.) Area $= 15{\cdot}86367$

Displacement.

Art. 2. Def.—By the *Displacement* of a ship is meant the volume of water which the ship displaces when floating on its surface.

Now, by the principles of hydrostatics, it is well known that the *weight* of a body floating in water, or any other fluid, is equal to the weight of the water or fluid displaced. Hence, after obtaining the displacement of a body, it is only necessary to multiply the volume (say in cubic feet) of the displaced fluid, by the weight of a cubic foot of the fluid, in order to obtain the weight of the floating body.

Def.—*By a plane of flotation is meant that section of the vessel, in any position, made by the surface of the water.*

Several general rules have been given to determine the displacement of ships, which can be but approximations to the true results, since the outlines of ships differ so widely, and it is therefore not considered necessary to give them.

In order to find the displacement, the ship is supposed to be divided by any number of equi-distant horizontal planes, that is, planes taken parallel to the load-water line, and also by any convenient number of equi-distant vertical planes, intersecting, of course, the former series of horizontal planes at right angles. These planes are generally projected by the draughtsman on the three plans of the vessel, viz., the body plan, the sheer plan, and half-breadth plan. (See Plate I.)

Calculations incidental to designing a Ship.

As is seen in the half-breadth plan, the ship is divided into two equal portions by a vertical plane, running from stem to stern; and the perpendicular distances measured on each horizontal plane, from their intersection with this plane to the ship's side, are considered as ordinates.

Thus, in the half-breadth plan (Plate I.), F 7 is the projection of the vertical plane which divides the ship into two equal parts, and F*f* E*e* are the ordinates in the horizontal plane, F, 7_n, any number of these horizontal planes may be taken, and for the purposes of calculation they may be numbered 1, 2, 3, 4, &c.; and A. B. C. &c.

The small portions, fore and aft, are usually calculated separately, the horizontal and vertical planes being taken much nearer to each other in consequence of the greater curvature of the vessel at these parts.

The calculation of the displacement may be proceeded with in two ways:—

1st, By finding the *areas* of all the horizontal sections, and employing these as ordinates in Rule (I.) or (II.)

2d, By finding the areas of all the vertical sections, and using these as ordinates in the same rules.

These two results ought to agree.

Or, the rule may be enunciated as follows, ordinates on the half-breadth plan being understood:—

Rule IV. *To the sum of the* first *and* last *horizontal sectional areas, add* four *times the sum of all the* even *horizontal areas, and* twice *the sum of all the* odd *horizontal areas; multiply this final sum by* one-third *the common distance between these horizontal planes, and this result gives one-half the displacement.*

We could not, from what has already been done, *à priori*, conclude that "Simpson's Rule" would enable us to find the volume of a solid, bounded by planes and a curvilinear surface. The following demonstration, however, proves that it holds true.

Note 4.—Let $A_1\, c_3$ represent a portion of such a body, bounded by the planes $A_1 C_3$, $C_3 a_3$, $A_1 a_3$, $C_1 a_1$, $C_1 c_3$, and by the surface $a_1 c_3$, we take the planes $A_1 a_3$, $A_1 c_1$, and $A_1 a_3$, as the three planes of reference, viz., $(x\,y)$, $(y\,z)$, and $(x\,z)$, respectively.

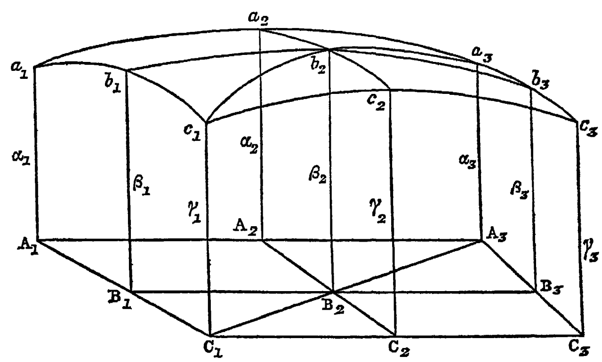

Fig. 6.

Bisect $A_1 A_3$, $A_1 C_1$, $C_1 C_3$, $A_3 C_3$, in the points A_2, B_1 C_2, and B_3, respectively; join $A_2 C_2$, and $B_1 B_3$; through these right lines let planes $A_2\, c_2$, $B_1\, b_3$, be drawn at right angles to the plane $A_1 C_3$, then

$$\text{Assume } A_1 A_2 = A_2 A_3 = B_1 B_2 = B_2 B_3 = C_1 C_2 = C_2 C_3 = h$$
$$A_1 B_1 = B_1 C_1 = A_2 B_2 = B_2 C_2 = A_3 B_3 = B_3 C_3 = k$$
$$A_1 a_1 = \alpha_1,\ B_1 b_1 = \beta_1,\ C_1 c_1 = \gamma_1$$
$$A_2 a_2 = \alpha_2,\ B_2 b_2 = \beta_2,\ C_2 c_2 = \gamma_2$$
$$A_3 a_3 = \alpha_3,\ B_3 b_3 = \beta_3,\ C_3 c_3 = \gamma_3$$

We may then imagine a surface of the form (1.) to pass through the nine points, $a_1, a_2, a_3, b_1, b_2, b_3, c_1, c_2, c_3$.

$$z = A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Exy^2 + Cx^2 y^2 \quad \ldots\ldots \quad \text{(I.)}$$

Calculations incidental to designing a Ship.

Since it contains *nine* arbitrary constants, A, B, C, B_1, C_1, &c., observing that the xs are measured along $A_1 A_3$, the ys along $A_1 C_1$, and the zs are $A_1 \alpha_1$, $A_2 \alpha_2$, $A_3 \alpha_3$, $B_1 b_1$, &c. Hence we have the following equations:—

(1.) $\alpha_1 = A$..............when $x=0,\ y=0, z=\alpha_1$...by (I.)

(2.) $\alpha_2-\alpha_1 = Bh + Ch^2$........ $x=h,\ y=0, z=A_2\alpha_2=\alpha_2$

(3.) $\alpha_3-\alpha_1 = 2Bh+4Ch^2$....... $x=2h, y=0, z=A_3\alpha_3=\alpha_3$

(4.) $\beta_1-\alpha_1 = B_1k + C_1k^2$....... $x=0,\ y=k, z=B_1 b_1=\beta_1$

(5.) $\gamma_1-\alpha_1 = 2B_1k+4C_1k^2$...... $x=0,\ y=2k, z=C_1 c_1=\gamma_1$

(6.) $\beta_2-\alpha_2-\beta_1+\alpha_1 = Dhk + Eh^2k + Ehk^2 + Gh^2k^2$...by (2.) and (4.)................................ $x=h,\ y=k,\ z=B_2b_2=\beta_2$

(7.) $\beta_3-\alpha_3-\beta_1+\alpha_1 = 2Dhk + 4Eh^2k + 2Ehk^2 + 4Gh^2k^2$...by (3.) and (4.)........ .... $x=2h, y=k,\ z=B_3 b_3=\beta_3$

(8.) $\gamma_2-\alpha_2-\gamma_1+\alpha_1 = 2Dhk + 2Eh^2k + 4Ehk^2 + 4Gh^2k^2$...by (2.) and (5.)......................... $x=h,\ y=2k, z=C_2 c_2=\gamma_2$

(9.) $\gamma_3-\alpha_3-\gamma_1+\alpha_1 = 4Dhk + 8Eh^2k + 8Ehk^2 + 16Gh^2k^2$...by (3.) and (5.)....................... $x=2h, y=2k, z=C_3c_3=\gamma_3$

Now, B, C, B_1 and C_1 are readily determined from equations (2), (3), (4), and (5), and D, E, F, and G, from equations (6), (7), (8), and (9); their values are—

$$A = \alpha_1$$

$$B = \frac{4\alpha_2-3\alpha_1-\alpha_3}{2h}.$$

$$C = \frac{\alpha_1-2\alpha_2+\alpha_3}{2h^2}.$$

$$B_1 = \frac{4\beta_1-3\alpha_1-\gamma_1}{2k}.$$

$$C_1 = \frac{\alpha_1-2\beta_1+\gamma_1}{2k^2}.$$

$$D = \frac{16\beta_2+9\alpha_1+3\alpha_3+3\gamma_1+\gamma_3-12\alpha_2-12\beta_1-4\beta_3-4\gamma_2}{4hk}.$$

$$E = \frac{6\alpha_2+4\beta_1+4\beta_3+2\gamma_2-3\alpha_1-3\alpha_3-8\beta_2-\gamma_1-\gamma_3}{4h^2k}.$$

$$F = \frac{4\alpha_2+6\beta_1+2\beta_3+4\gamma_2-3\alpha_1-\alpha_3-8\beta_2-3\gamma_1-\gamma_3}{4hk^2}.$$

$$G = \frac{\alpha_1+\alpha_3+4\beta_2+\gamma_1+\gamma_3-2\alpha_2-2\beta_1-2\gamma_2-2\beta_3}{4h^2k^2}.$$

In order to find the volume of a solid, we must integrate the equation $\iiint dx\,dy\,dz$, as shown in most works on the Differential and Integral Calculus, or, what amounts to the same thing, $\iint z\,dx\,dy$, where z is given by the equation to the surface, and the integrations in regard to x and y are to be determined by the conditions of the question. It is evident that, in the present case, the limiting values of x are 0 and $2h$, those of y being 0 and $2k$. Hence

$$\int_0^{2h}\int_0^{2k} z\,dxdy = \int_0^{2h}\int_0^{2k} dx\,dy\,(A + Bx + Cx^2 + B_1y + C_1y^2 + Dxy + Ex^2y + Exy^2 + Gx^2y^2) = \frac{hk}{9}\Big\{36A + 36Bh + 48Ch^2 + 36B_1h + 48C_1k^2 + 36Dhk + 48Eh^2k + 48Ehk^2 + 64Gh^2k^2\Big\}.$$

Introducing the values of A, B, C, &c. already found, we get, after obvious reductions, volume $A_1c_3 = \frac{hk}{9}\Big\{\alpha_1+4\alpha_2+\alpha_3 + 4(\beta_1+4\beta_2+\beta_3)+\gamma_1+4\gamma_2+\gamma_3\Big\}$ . . . . . (II.)

On examining the equations, we perceive that $\frac{h}{3}(\alpha_1+4\beta_2+\alpha_3)$ represents the area of the section $A_1\alpha_3$ (*Vide* Equation I., p. 141), and $\frac{h}{3}(\beta_1+4\beta_2+\beta_3)$ represents the area B_1b_3; also, $\frac{h}{3}(\gamma_1+4\gamma_2+\gamma_3)$ that of C_1c_3. Writing for the area of $A_1\alpha_3$, A_1; for that of B_1b_3, A_2; for C_1c_3, A_3 (Equation II.) becomes

$$\text{Volume } A_1c_3 = \frac{k}{3}(A_1+4A_2+A_3) \quad . \ . \ . \ . \ . \ . \ . \quad \text{(III.)}$$

By making similar paraboloidal surfaces pass through c_1, c_2, c_3, and six other points, &c. we have

$$\text{Volume } A_3c_5 \text{ next portion} = \frac{k}{3}(A_3+4A_4+A_5).$$

$$\text{"} \qquad \text{"} \qquad = \frac{k}{3}(A_5+4A_6+A_7).$$

$$\text{" last portion} = \frac{k}{3}(A_{n-2}+4A_{n-1}+A_n).$$

Adding these—

$$\text{Total volume} = \frac{k}{3}\Big\{A_1+A_n+4(A_2+A_4+A_6+\&c.+A_{n-1}+2(A_3+A_5+\&c.+A_{n-2})\Big\} \quad . \ . \ . \ . \ . \ . \quad \text{(IV.)}$$

We might have regarded $\frac{k}{3}(\alpha_1+4\beta_1+\gamma_1)$ as the area of the section A_1c_1, or B_1, as we shall denote it, $\frac{k}{3}(\alpha_2+4\beta_2+\gamma_2)$ that of A_2c_2, &c., or B_2, &c., and then

Volume $= \frac{h}{3}\Big\{B_1+B_n+4(B_2+B_4+\&c.+B_{n-1})+2(B_3+B_5+\&c.\ B_{n-2})\Big\}$. Multiplying these volumes by 2, we get the total displacement of the ship.

A Rule similar to that of (II.) Note (2) may be found by making a surface, the equation to which is of the form $z = A + Bx + Cx^2 + Dx^3 + B_1y + C_1y^2 + D_1y^3 + Exy + Ex^2y + Gxy^2 + Hx^2y^2 + Ix^3y + Kxy^3 + Lx^3y^2 + Mx^2y^3 + Nx^3y^3$ pass through sixteen points, since the equation contains this number of arbitrary constants, which are determined as before, and the integrations are taken from $x=0$ to $x=3h$, and $y=0$ to $y=3k$. We shall leave this work for the student, and proceed at once to

Observe that *vertical* areas may be employed in the place of *horizontal* areas, and care must be taken to omit the first and last areas from the *odd* ones in each case.

Rule (II.) might have been employed; but the following is the neatest, most concise, and at the same time sufficiently accurate, that has yet been given. It is by the Rev. Joseph Woolley, M.A., LL.D., Her Majesty's Inspector of Schools, to whom naval architects are under great obligations for the attention he has given to this branch of science:—

RULE V. (1.) *Add together all the* EVEN *ordinates in the* FIRST *and* LAST *horizontal planes.*

(2.) *Add together all the* EVEN *ordinates in the 3d, 5th, 7th, &c., sections, omitting the* FIRST *and* LAST, *and multiply the sum by 2.*

(3.) *Add together all the* FIRST *and* LAST *ordinates of all the* EVEN *horizontal planes.*

(4.). *Take* TWICE *the sum of all the ordinates, omitting the* FIRST *and* LAST *of all the* EVEN *horizontal planes.*

Then, *add together the results of (1), (2), (3), (4), and multiply this final sum by* TWO-THIRDS *of the product of the common distances between the horizontal and vertical planes, and this result gives the displacement.*

Note 5.—Not having seen the demonstration by Dr Woolley to this rule, the editors beg to offer the following, which must be somewhat similar in principle.

Dr Woolley supposes fig. 4 to be divided into two portions by a plane passing through $C_1 B_2 A_3 a_3 b_2 c_1$, and the equation to the surface passing through $a_1 b_1 c_1 b_2 a_2 a_3$ may be assumed as

$$z = A + Bx + Cx^2 + B_1y + C_1y^2 + Dxy \quad . \ . \ . \ . \quad \text{(I.)}$$

And the limits are $x=0$ and $x=2h$, and since, $A_1C_1 = 2k$, at any point y, we must have $y = \left(\frac{2h-x}{h}\right)k$.

$$\therefore \int_0^{2h}\int_0^{(2h-x)\frac{k}{h}} z\,dxdy = \int_0^{2h}\int_0^{(2h-x)\frac{k}{h}} dxdy(A + Bx + Cx^2 + B_1y + C_1y^2 + Dxy).$$

Calculations incidental to designing a Ship.

$$= \int_0^{2h} dx \left\{ A\left(\frac{2h-x}{h}\right)k + Bkx\left(\frac{2h-x}{h}\right) + Ckx^2\left(\frac{2h-x}{h}\right) + \frac{B_1k^2}{2}\left(\frac{4h^2-4hx+x^2}{h}\right) + \frac{C_1k^3}{3}\left(\frac{8h^3-12h^2x+6hx^2-x^3}{h^3}\right) + \frac{Dk^2x}{2}\left(\frac{4h^2-4hx+x^2}{h}\right)\right\}$$

$$= 2Ahk + \frac{4Bh^2k}{3} + \frac{4Ch^3k}{3} + \frac{4B_1hk^2}{3} + \frac{4C_1hk^3}{3} + \frac{2Dh^2k^2}{3} \quad \text{(II.)}$$

Now, since the surface (I.) passes through the six points already mentioned, we readily determine A, B, C_1, &c., as in the last note Their values are

$$\begin{aligned} A &= \alpha_1 \\ 2Bh &= 4\alpha_2 - \alpha_3 - 3\alpha_1 \\ 2Ch^2 &= \alpha_1 - 2\alpha_2 + \alpha_3 \\ 2B_1k &= 4\beta_1 - \gamma_1 - 3\alpha_1 \\ 2C_1k^2 &= \alpha_1 - 2\beta_1 + \gamma_1 \\ Dhk &= \alpha_1 + \beta_1 - \alpha_2 - \beta_1 \end{aligned}$$

Writing these values in (II.) it reduces to

$$\text{Volume} = \frac{2hk}{3}\left\{\alpha_2 + \beta_1 + \beta_2\right\}$$

In the same way, we find the volume of the figure $C_1\, c_1\, b_2\, a_3\, C_3$

$$= \frac{2hk}{3}\left\{\gamma_2 + \beta_3 + \beta_2\right\}$$

Adding these results, we find for the whole volume $A_1\, c_3$

$$\frac{2hk}{3}\left\{\alpha_2 + \beta_1 + 2\beta_2 + \beta_3 + \gamma_2\right\}$$

With similar expressions for the other portions of the ship.

$$\therefore \text{Whole volume} = \frac{2hk}{3}\left\{\beta_1 + \beta_n + 2(\beta_3 + \beta_5 + \beta_7 + \&c.) + (\alpha_2 + \gamma_2 + \alpha_4 + \gamma_4 + \&c.) + 2(\beta_2 + \beta_4 + \beta_6 + \beta_8 + \&c.\right\}$$

To find the Centres of Gravity of Bodies.

ART. 3. As a knowledge of the centres of gravity of bodies is of so much importance in the calculation of stability, it has been thought advisable to introduce the subject here at some length.

Various definitions have been given of the centre of gravity of a body. It is shown in almost every work on statics, that *there is a point in* (sometimes *without*) *every body such, that if the particles of the body be acted on by parallel forces, and the point already mentioned be fixed or supported, the body will remain in equilibrium, no matter in what position it is placed;*[1] and when the *forces* herein mentioned are replaced by the *weights* of the elementary portions of the body, or bodies, this point is known as the *centre of gravity* of the body or bodies.[2]

Gravity, or the force which attracts all bodies towards the earth's centre, is supposed to act on every particle of the body in parallel and vertical directions. This force is supposed to be constant at the earth's surface, and therefore attracts all bodies with an equal intensity. The reader will readily perceive that this hypothesis cannot differ materially from the truth when he compares the earth's radius with the dimensions of all bodies at its surface, and remembers that this attractive force varies inversely as the square of the distance. Under these circumstances, then, the centres of gravity of bodies are calculated. This point cannot be obtained, however, without the aid of the integral calculus, except in the case of a few plane surfaces and solids. We shall premise that when bodies are *homogeneous*, or of the same density throughout their parts,—that is, having equal weights, comprised under equal volumes,—we may then replace *weights* by *masses*, and conversely. Thus if M represent the mass of a body, d the density of a unit of the body, V the volume, W the weight, then

$$M = d \times V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$
$$W = g \times d \times V = gM \quad . \quad . \quad . \quad . \quad . \quad (2.)$$[3]

When a body is not homogeneous throughout its parts, the determination of the centre of gravity becomes somewhat more difficult.

To find the Centre of Gravity of an Area similar to fig. 1.

Centre of gravity.

ART. 4.—RULE VI. *Multiply the ordinates, beginning at the first by* 0, 1, 2, 3, 4, *&c., respectively, and employ these as ordinates in Rule (I.); multiply the result thus obtained by one-third of the common interval squared, divide by the area of the curve, and the result gives the distance we are to measure along* $A_1\,A_n$—*i.e.*, $A_1\,g$.[4]

Having obtained the distance A_1g, we may obtain the length of the perpendicular Gg (G being the centre of gravity of the figure, and g the point where the perpendicular drawn from G intersects A_1A^n.) by

RULE VII. *To the sum of the* SQUARES *of the* FIRST *and* LAST *ordinates, add* FOUR *times the sum of the squares of all the* EVEN *ordinates, twice the sum of the squares of all the* ODD *ordinates; multiply by one-third the common interval, and divide this result by twice the area, the quotient gives the perpendicular height of the centre of gravity above the axis* $A_1\,A_n$.[5]

Similar rules apply for finding the centres of gravity of the displacement of a ship.

ART. 5. *To find the centre of gravity of the displacement of a ship floating in the water, and in a state of equilibrium*—

The horizontal sections are taken at equal distances apart and parallel to the plane of flotation. The vertical sections are also taken at equal distances apart and parallel to the midship section. The ship is then cut into two equal portions by a plane running fore and aft, and at right angles to the two planes just mentioned. In the following rules, *half areas* and *half volumes* are to be understood.

RULE VIII. *Find the areas of all the horizontal sections (such as those shown in the half-breadth plan) and multiply these, beginning from the first, or plane of flotation, by the consecutive numbers* 0, 1, 2, 3, 4, *&c., respectively; introduce these products as ordinates into "Simpson's Rule;" multiply this result by one-third of the square of common distance between the sections, divide by the volume, and the quotient gives the distance of the centre of gravity below the plane of flotation.*[4]

RULE IX. *Find the areas of all the vertical sections, multiply these, beginning from the first*[6] *by the consecutive numbers* 0, 1, 2, 3, 4, *&c., respectively, and work as in the last rule; the result thus obtained gives the distance of the centre of gravity from the first vertical plane.*

[1] Pratt's *Mechanical Philosophy*, 2d edit., pp. 18 and 19.

[2] *The centre of gravity* has also been defined as that point within or without the body, from which, if the body be conceived to be suspended, it will remain in equilibrium in any position.

[3] "g, or 'the accelerating force of gravity,' is uniform, and is the same for all substances, and in the latitude of London = 32·18 feet." (Earnshaw's *Dynamics*, 3d edit., p. 42.)

[4] Care must be taken *not* to multiply by one-third of the common distance, as is mentioned in Rule I.

[5] The *last* ordinate must not be reckoned among the *odd* ordinates in these and the following rules.

[6] Either the first vertical section of the main body nearest the bow or stern may be taken as the first.

Calculations incidental to designing a Ship.

Centre of gravity.

These two distances fix the position of the centre of gravity of the main body. Since a ship is symmetrical in regard to the plane which divides it, fore and aft, into two equal parts, we know that the centre of gravity must lie in this plane.

No account is here taken of the small portions at the stem, stern, and that between the keel and last horizontal section. These are usually calculated separately, and in the same way as the main body. Having obtained the centres of gravity of all these portions, we readily obtain the centre of gravity of the total displacement by the rule which follows, observing, that if we consider the *first vertical plane* to be that nearest the bow, the volume of the small portion forward multiplied by the distance of its centre of gravity from the plane just mentioned must be *subtracted*. Or, in other words, if we consider all horizontal distances, measured in the *opposite* direction (from the first vertical plane) to the centre of gravity of the main body as *negative*, and all distances measured in the *same direction* as *positive*, we have then only to add the products *algebraically*, and this is to be understood in the following rule (one product being always *negative* in Rule XI.) All *results will be positive* in finding the distance of the centre of gravity *below the plane of flotation.*

RULE X. *Multiply each of the volumes by the perpendicular distance of its centre of gravity from the plane of flotation, and add the products; divide this result by the sum of all the volumes, and the quotient is the distance of the centre of gravity of the total displacement below the plane of flotation.* Also,

RULE XI. *Multiply each of the volumes by the perpendicular distance of its centre of gravity from the first vertical plane, and add algebraically (observing that one result will be negative), divide this result by the sum of all the volumes, and the quotient is the distance of the centre of gravity of the total displacement from the first vertical plane.*

One of the properties of Guldinus is also of great use in finding centres of gravity when the necessary data are supplied.

RULE XII. *Any solid of revolution is equal to the area of the surface which generates this solid, multiplied by the circumference, which is described by the centre of gravity of the latter.*

Without attempting to demonstrate formulæ (1.) of this article, since a demonstration may be found in almost every work on statics, we proceed to lay before the mathematical reader the principles on which the centres of gravity are calculated.

Note 6.—If we consider, in the first place, a system of material points having weight, and connected in an invariable manner, the weights of these points may be considered as so many vertical forces acting in parallel directions. If, moreover, we take three fixed planes, mutually at right angles to each other, their point of intersection being the origin (as is done in Geometry of three dimensions) let ω_1 be the weight of the first material point, and its co-ordinates x_1, y_1, z_1, measured along the three co-ordinate axes: ω_2, x_2, y_2, z_2, the weight and co-ordinates of the second point, &c. &c.; also, let $\bar{x}$, $\bar{y}$, $\bar{z}$ represent the co-ordinates of the centre of gravity of the system of weights measured along the same axes, then we have

$$\left.\begin{aligned}\bar{x} &= \frac{\Sigma(\omega_1 x_1 + \omega_2 x_2 + \omega_3 x_3 + \&c.)}{\Sigma(\omega_1 + \omega_2 + \omega_3 + \&c.\ \&c.)}\\ \bar{y} &= \frac{\Sigma(\omega_1 y_1 + \omega_2 y_2 + \omega_3 y_3 + \&c.)}{\Sigma(\omega_1 + \omega_2 + \omega_3 + \&c.)}\\ \bar{z} &= \frac{\Sigma(\omega_1 z_1 + \omega_2 z_2 + \omega_3 z_3 + \&c.)}{\Sigma(\omega_1 + \omega_2 + \omega_3 + \&c.)}\end{aligned}\right\} \quad . \; . \; . \; . \; . \quad (1.)$$

Remark.—These formulæ would be equally true if we suppose ω_1, ω_2, ω_3, &c. to represent the weights of any bodies whatever, and connected in an invariable manner, *providing we suppose these weights to act at their respective centres of gravity, and* x_1, y_1, z_1, *&c., to be the co-ordinates of these centres of gravity.* Next, if we suppose the density of the weights to be uniform throughout, we can replace the weights by their respective volumes v_1, v_2, v_3, &c. since $g \times d$ appears both in numerator and denominator. The proposition is also true for areas. Therefore, if A_1, A_2, A_3, &c. represent areas

$$\left.\begin{aligned}\bar{x} &= \frac{\Sigma(v_1 x_1 + v_2 x_2 + v_3 x_3 + \&c.)}{\Sigma(v_1 + v_2 + v_3 + \&c.)},\\ \text{or } \bar{x} &= \frac{\Sigma(A_1 x_1 + A_2 x_2 + A_3 x_3 + \&c.)}{\Sigma(A_1 + A_2 + A_3 + \&c.)}\\ \bar{y} &= \frac{\Sigma(v_1 y_1 + v_2 y_2 + v_3 y_3 + \&c.)}{\Sigma(v_1 + v_2 + v_3 + \&c.)},\\ \text{or } \bar{y} &= \frac{\Sigma(A_1 y_1 + A_2 y_2 + A_3 y_3 + \&c.)}{\Sigma(A_1 + A_2 + A_3 + \&c.)}\\ \bar{z} &= \frac{\Sigma(v_1 z_1 + v_2 z_2 + v_3 z_3 + \&c.)}{\Sigma(v_1 + v_2 + v_3 + \&c.)}\\ \text{or } \bar{z} &= \frac{\Sigma(A_1 z_1 + A_2 z_2 + A_3 z_3 + \&c.)}{\Sigma(A_1 + A_2 + A_3 + \&c.)}\end{aligned}\right\} \quad . \; . \; . \; . \quad (2.)$$

If the centres of gravity of the weights, volumes, or areas, as the case may be, range in a right line, the first equation gives the distance of their common centre of gravity from the origin. If the weights, or areas, &c., are in the same plane, the four former equations are all that are necessary to determine the centre of gravity.

Premising that the centre of gravity of a ball, or sphere, is at the centre of the body, we shall proceed to give two or three examples on these formulæ.

(1.) Four cannon-balls have their centres in the same right line at 2, 3, and 4 feet, respectively, apart, and weigh 68, 32, 12, and 8 lbs. respectively; that is, the "32" is 2 feet from the "68," the "12" is 3 feet from the "32," &c. Find the distance of the common centre of gravity from the centre of the "68" (supposing their centres to be in the same horizontal line).

Taking the origin at the centre of the "68," we have $x_1 = 0$, $x_2 = 2$, $x_3 = 2 + 3 = 5$, $x_4 = 2 + 3 + 4 = 9$ feet.

$$\therefore \text{ (1.) } \bar{x} = \frac{68 \times 0 + 32 \times 2 + 12 \times 5 + 8 \times 9}{68 + 32 + 12 + 8} = 1\cdot6\dot{3} \text{ feet.}$$

That is, if the balls were connected by an indefinitely fine rigid rod, without weight, passing through the centres of the balls, the whole might be suspended, and remain in equilibrium, at a point distant 1·63 feet from the centre of the "68."

(2.) Five cannon-balls, whose weights are 2, 8, 12, 32, and 68 lbs., lie on the floor of a room, at the respective perpendicular distances 3, 4, 5, 6, and 7 feet from the side, and 1, 2, 3, 4, and 5 feet from one end of the room; find their common centre of gravity from that corner of the room where the side and end (from which these distances are measured) intersect, supposing the centres of the balls to lie in the plane of the floor.

$$\text{Here } \bar{x} = \frac{2 \times 3 + 8 \times 4 + 12 \times 5 + 32 \times 6 + 68 \times 7}{2 + 8 + 12 + 32 + 68} =$$

6·28 feet nearly.

$$\bar{y} = \frac{2 \times 1 + 8 \times 2 + 12 \times 3 + 32 \times 4 \times 68 \times 5}{2 + 8 + 12 + 32 + 68} =$$

4·28 feet nearly.

$$\text{But distance from corner} = \sqrt{\bar{x}^2 + \bar{y}^2}$$

$$= \sqrt{(6\cdot28)^2 + (4\cdot28)^2} =$$

7·6 feet nearly.

(3.) Four cannon-balls, whose weights are 1, 8, 32, and 68 lbs., are suspended in a room (of the form of a parallelopipedon), their vertical heights from the floor being 2, 4, 6, and 5 feet, respectively, and their perpendicular distances, from an end and side of the room, are 2, 4, 5, 6 feet, and 3, 5, 6, 7 feet, respectively; find the distance of the centre of gravity of the balls, from that corner of the room where the side and end, herein mentioned, intersect.

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Here the side, end, and floor of the room are the planes of reference, and the origin at the corner, mentioned in the question, the line where the *side* intersects the floor may be taken as the axis of x, and the intersection of the *end* and floor as the axis of y, or, *vice versâ*, the intersections of the end and side being the axis of z.

$$\therefore \bar{x} = \frac{1 \times 2 + 8 \times 4 + 5 \times 32 + 6 \times 68}{1 + 8 + 32 + 68} = 5{\cdot}523 \text{ ft. nearly.}$$

$$\bar{y} = \frac{1 \times 3 + 8 \times 5 + 32 \times 6 + 68 \times 7}{1 + 8 + 32 + 68} = 6{\cdot}523 \quad ,,$$

$$\bar{z} = \frac{1 \times 2 + 8 \times 4 + 32 \times 6 + 68 \times 5}{1 + 8 + 32 + 68} = 5{\cdot}192 \quad ,,$$

Again, it is easily shown that the distance of a point $\bar{x}, \bar{y}, \bar{z}$, from the origin is—

$$d = \sqrt{\bar{x}^2 + \bar{y}^2 + \bar{z}^2} = \sqrt{(5{\cdot}523)^2 + (6{\cdot}523)^2 + (5{\cdot}192)^2} =$$
10 feet nearly.

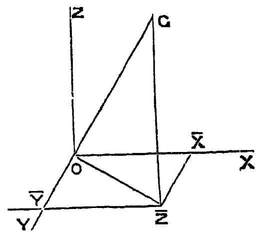

Fig. 5.

For if XOY be the plane of the floor, XOZ the side, and YOZ the end of the room, G the centre of gravity. Draw $G\bar{Z} \perp$ to the plane XOY; and from $\bar{Z}$ draw $\bar{Z}\bar{X}$ and $\bar{Z}\bar{Y}$ respectively, $\perp$ to OX and OY; then $O\bar{X} = \bar{x}$, $O\bar{Y} = \bar{y}$, $G\bar{Z} = \bar{z}$ in the above equations, and since the triangles $O\bar{X}\bar{Z}$, $O\bar{Z}G$ are right-angled,

$$OG^2 = O\bar{Z}^2 + G\bar{Z}^2 = O\bar{X}^2 + \bar{X}\bar{Z}^2 + G\bar{Z}^2, \text{ and } \bar{X}\bar{Z}^2 = O\bar{Y}^2.$$

$$\therefore OG = \sqrt{O\bar{X}^2 + O\bar{Y}^2 + G\bar{Z}^2}$$

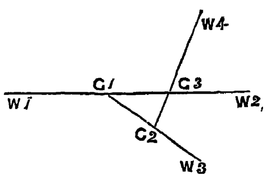

Fig. 6.

We might have determined the centre of gravity of any system of material points, or balls, not situated in the same line, or plane, and rigidly connected in the following manner: W_1, W_2, W_3, &c. representing these material points and their positions, join $W_1 W_2$, and let G_1 be their common centre of gravity, then these two points will act in the same manner as if their weights were collected at the point G_1. Join $G_1 W_3$, and let G_2 be the centre of gravity of W_1, W_2, acting at G_1, and of W_3; then W_1, W_2, W_3, may be conceived to act at G_2. Join $G_2 W_4$, &c. &c.

Note 7.—The principles made use of in equations (1.) may readily be extended to any body, or system of bodies; for, suppose the body referred to three co-ordinate planes mutually at right angles to each other, their common point of intersection being the origin, and x_1, y_1, z_1, the co-ordinates of any point in the body; then it is shown, in most works on the "Calculus," that the *volume* of an infinitesimal parallelopipedon, at that point, is represented by $\Delta x_1 \times \Delta y_1 \times \Delta z_1$.[1] Also, if δ_1 represents the density of a unit of volume at that point, the mass of the particle is $\delta_1 . \Delta x_1 . \Delta y_1 . \Delta z_1$, and its weight is $g\delta_1 \, \Delta x_1 \, \Delta y_1 \, \Delta z_1$. But as g is constant, it follows that we may either employ the weights or masses of the body in finding its centre of gravity, and

$$M = \Sigma\,(\delta_1 \, \Delta x_1 . \Delta y_1 . \Delta z_2 + \delta_2 + \Delta x_2 \, \Delta y_2 \, \Delta z_2 + \text{\&c. \&c.})$$

$$\bar{x} = \frac{\Sigma\,(x_1 \, \delta_1 \, \Delta x_1 \, \Delta y_1 \, \Delta z_2 + x_2 \, \delta_2 \, \Delta_2 x_2 \, \Delta y_2 \, \Delta z_2 + \text{\&c.})}{M}$$

$$\bar{y} = \frac{\Sigma\,(y_1 \, \delta_1 \, \Delta x_1 \, \Delta y_1 \, \Delta z_1 + y_2 \, \delta_2 \, \Delta x_2 \, \Delta y_2 \, \Delta z_2 + \text{\&c.})}{M}$$

$$\bar{z} = \frac{\Sigma\,(z_1 \, \delta_1 \, \Delta x_1 \, \Delta y_1 \, \Delta z_1 + z_2 \, \delta_2 \, \Delta x_2 \, \Delta y_2 \, \Delta z_2 + \text{\&c.})}{M}$$

But at the limit Δx_1, Δy_1, Δz_1 become dx_1, dy_1, dz_1, and dropping the suffixes, and extending the summation, or rather integration, to all the elements of the body, we obtain

$$(1.) \qquad M = \int\!\!\int\!\!\int dx \, dy \, dz \, . \, \delta.$$

Where δ is given by an equation of the form $\delta = f\,(x, y, z)$.

$$\text{Hence } \bar{x} = \frac{\int\!\!\int\!\!\int x \, dx \, dy \, dz \, . \, \delta}{M}, \; \bar{y} = \frac{\int\!\!\int\!\!\int y \, dx \, dy \, dz \; \delta}{M}, \; \bar{z} = \frac{\int\!\!\int\!\!\int z \, dx \, dy \, dz \; \delta}{M}.$$

These equations are to be taken between proper limits, and if the body is homogeneous, δ will appear in both numerators and denominators, and the equations may then be written:

$$(2.) \begin{cases} V = \int\!\!\int\!\!\int dx \, dy \, dz. \\ \bar{x} = \dfrac{\int\!\!\int\!\!\int x \, dx \, dy \, dz}{V}, \; \bar{y} = \dfrac{\int\!\!\int\!\!\int y \, dx \, dy \, dz}{V}, \; \bar{z} = \dfrac{\int\!\!\int\!\!\int z \, dx \, dy \, dz}{V}. \end{cases}$$

We may obtain a clearer idea of these integrals from the following considerations. Let us take the first of the latter set of equations, and integrate, first, in regard to z, and next in regard to y, observing that in these integrations x is constant, we may then write

$$\bar{x} = \int \left\{ \frac{x \int\!\!\int dy \, dz}{V} \right\} dx.$$

Where the quantity within the brackets represents the product of x by the *area*, A, of a plane section of the figure, perpendicular to the axis of x, and at a distance x from the plane of zy.

$\therefore \bar{x} = \dfrac{\int A \, x dx}{V}$, and similar expressions may be obtained for $\bar{y}$

If it be required to find the centre of gravity of *any* area, &c. we have only to suppose it to lie in the plane of xy and formulæ (2) reduce to

$$(3.) \begin{cases} A = \int\!\!\int dx \, dy = \int y \, dx \text{ (if we integrate in regard to } y) \\ \bar{x} = \dfrac{\int\!\!\int x \, dx \, dy}{A} = \dfrac{\int xy \, dx}{A}, \; \bar{y} = \dfrac{\int\!\!\int y \, dx \, dy}{A} = \frac{1}{2} \dfrac{\int y^2 \, dx}{A}. \end{cases}$$

Remark.—In many cases it is convenient to employ *polar co-ordinates* to find centres of gravity, and we have for the transformation

$$x = r \sin \theta \cos \phi, \; y = r \sin \theta \sin \phi, \; z = r \cos \theta,$$

Formulæ (2.) become

$$(4.) \begin{cases} \bar{x} = \dfrac{\int\!\!\int\!\!\int r^3 \sin{}^2\theta \cos \phi \, dr . d\theta . d\phi}{\int\!\!\int\!\!\int r^2 \sin \theta \, dr . d\theta . d\phi}, \\ \bar{y} = \dfrac{\int\!\!\int\!\!\int r^3 \sin{}^2\theta \sin \phi \, dr \, d\theta \, d\phi}{\int\!\!\int\!\!\int r^2 \sin \theta \, dr \, d\theta \, d\phi}, \\ \bar{z} = \dfrac{\int\!\!\int\!\!\int r^3 \sin \theta \cos \theta \, dr \, d\theta \, d\phi}{\int\!\!\int\!\!\int r^2 \sin \theta \, dr \, d\theta \, d\phi}, \end{cases}$$

where $\int\!\!\int\!\!\int r^2 \sin \theta \, dr \, d\theta \, d\phi$ between proper limits gives the volume.

We shall at once proceed to show by formulæ (3.) how to find the centre of gravity of an area, similar to the horizontal or vertical sections of a ship, premising that the notation is the same as that employed above (p. 140).

Note 8.—To find the centre of gravity of the portion $A_1 \alpha_3$, the equation to the parabola passing through α_1, α_2, α_3, being (h the common interval).

$$y = A + B\,x + Cx^2, \; x1 \text{ denoting } A_1 \, g_1 \text{ and } \bar{y}_1, \; G_1 \, g_1.$$

$$\bar{x}_1 = \frac{\int xy \, dx}{\int y \, dv} = \frac{\int_0^{2h} x\,(A + Bx + Cx^2)\,dx}{\int_0^{2h} (A + Bx + Cx^2)\,dx}$$

$$= \frac{\dfrac{h^2}{3}\left\{6A + 8Bh + 12Ch^2\right\}}{\dfrac{h}{3}\left\{6A + 6Bh + 8Ch^2\right\}} = h\left\{\frac{6A + 8Bh + 12Ch^2}{6A + 6Bh + 8Ch^2}\right\}.$$

But by Note (1), formulæ (2, 5, and 6) $A = \alpha_1$, $B = \dfrac{4\alpha_2 - \alpha_3 - 3\alpha_1}{2h}$, and $C = \dfrac{\alpha_3 - 2\alpha_2 + \alpha_1}{2h^2}$. Writing these in the above, we get

$$\bar{x}_1 = \frac{2h\,(2\alpha_2 + \alpha_3)}{\alpha_1 + \alpha_3 + 4\alpha_2}.$$

In the same way, the centre of gravity of $A_3 \, A_5$, along the line $A_1 \, A_n$ is found to be

$$A_3 g_2 = \frac{2h\,(2\alpha_4 + \alpha_5)}{\alpha_3 + \alpha_5 + 4\alpha_4}. \quad \therefore \; A_1 \, g_2 = A_1 \, A_3 + A_3 \, g_2 = 2h +$$

[1] Δx_1, Δy_1, Δz_1, represent the respective increments of x_1, y_1, z_1.

$\frac{2h(\alpha_4 + \alpha_5)}{\alpha_3 + \alpha_5 + 4\alpha_4}$, or if $\bar{x}_2 = A_1 g_2$, $\bar{x}_3 = A_2 g_3$, &c.

$$\bar{x}_2 = 2h + \frac{2h(2\alpha_4 + \alpha_5)}{\alpha_3 + \alpha_5 + 4\alpha_4} = \frac{2h(\alpha_3 + 6\alpha_4 + 2\alpha_5)}{\alpha_3 + \alpha_5 + 4\alpha_4}.$$

$$\bar{x}_3 = 4h + \frac{2h(2\alpha_6 + \alpha_7)}{\alpha_5 + \alpha_7 + 4\alpha_6} = \frac{2h(2\alpha_5 + 10\alpha_6 + 3\alpha_7)}{\alpha_5 + \alpha_7 + 4\alpha_6}.$$

And if g be the distance along the line $A_1 A_n$ of the centre of gravity of the whole figure, we have by formula (2), since the areas may be supposed to be collected at their respective centres of gravity, G_1, G_2, G_3, &c.

$$Ag \text{ or } \bar{x} = \frac{\text{Area } A_1 a_3 \times Ag_1 + \text{area } A_3 a_5 \times A_1 g_2 + \text{area } A_5 a_7 \times A_1 g_3 + \&\text{c. }\&\text{c.}}{\text{Area } A_1 a_3 + \text{area } A_3 a_5 + \text{area } A_5 a_7 + \&\text{c. }\&\text{c.}}$$

$$= \frac{A_1 \bar{x}_1 + A_2 \bar{x}_2 + A_3 \bar{x}_3 + \&\text{c.} + A_n \bar{x}_n}{A_1 + A_2 + A_3 + \&\text{c.} + A_n}.$$

Introducing the values of A_1, A_2, A_3, &c. $\bar{x}_1$, $\bar{x}_2$, $\bar{x}_3$, &c. already found, this reduces to

$$\text{(I.)}\ \bar{x} = h\,\frac{\{0 + (n-1)\alpha_n + 4(\alpha_2 + 3\alpha_4 + 5\alpha_6 + 7\alpha_8 + \&\text{c.}) + 2(2\alpha_3 + 4\alpha_5 + 6\alpha_7 + \&\text{c.})\}}{\alpha_1 + \alpha_n + 4(\alpha_2 + \alpha_4 + \alpha_6 + \alpha_8 + \&\text{c.}) + 2(\alpha_3 + \alpha_5 + \alpha_7 + \&\text{c.})}.$$

Next, to find Gg, or $\bar{y}$, we have

$$\bar{y}_1 = \tfrac{1}{2}\frac{\int_0^{2h} y^2\,dx}{\int_0^{2h} y\,dx},\quad \bar{y}_2 = \tfrac{1}{2}\frac{\int_0^{2h} y^2\,dx}{\int_0^{2h} y\,dx}, \text{ \&c. \&c.}$$

But $y^2 = (A + Bx + Cx^2)^2$; and this integration, added to the work connected with the substitution into the form

$$\bar{y} = \frac{A_1 \bar{y}_1 + A_2 \bar{y}_2 + \&\text{c.}}{A_1 + A_2 + \&\text{c.}}.$$

would lead to an immense amount of labour, which may be avoided by observing that the integral $\int y^2\,dx$ may be taken to represent the *area* of a curve, the ordinates of which are the squares of those at given points of the curve, as α_1, α_2, α_3, &c. With this understanding, we readily find, by employing "Simpson's Rule,"

$$\text{(II)}\ \bar{y} = \tfrac{1}{2} \text{ of } \frac{\alpha_1^2 + \alpha_n^2 + 4(\alpha_2^2 + \alpha_4^2 + \alpha_6^2 + \&\text{c.}) + 2(\alpha_3^2 + \alpha_5^2 + \alpha_7^2 + \&\text{c.})}{\alpha_1 + \alpha_2 + 4(\alpha_2 + \alpha_4 + \alpha_6 + \&\text{c.}) + 2(\alpha_3 + \alpha_5 + \alpha_7 + \&\text{c.})};$$

whence the centre of gravity of the curve is completely determined.

Note 9.—We next proceed to show how the centre of gravity of the volume of a figure similar to fig. 4, page 144, may be found, its equation being

$$z = A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Exy^2 + G_1 x^2 y^2.$$

By formulæ 2 if we integrate in regard to z,

$$\bar{x} = \frac{\int\int xz\,dxdy}{\int z\,dx\,dy} =$$

$$\frac{\int_0^{2h}\int_0^{2k} xdxdy\,(A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Exy^2 + Gx^2 y^2)}{\int_0^{2h}\int_0^{2k} dxdy\,(A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Exy^2 + Gx^2 y^2)}$$

$$= \frac{\frac{hk}{9}\{36Ah + 48Bh^2 + 72Ch^3 + 36B_1 hk + 48C_1 hk^2 + 48Dh^2k + 72Eh^3k + 64Fh^2k^2 + 96Gh^3k^2\}}{\frac{hk}{9}\{36A + 36Bh + 48Ch^2 + 36B_1 k + 48C_1 k^2 + 36Dhk + 48Eh^2k + 48Fhk^2 + 64Gh^2k^2\}}.$$

But $A = \alpha_1$, $B = \frac{4\alpha_2 - 3\alpha_1 - \alpha_3}{2h}$, $C = \frac{\alpha_1 - 2\alpha_2 + \alpha_3}{2h^2}$, &c. as was shown on page 140. Introducing these values, we find—

$$\bar{x} = h\,.\,\frac{2(2\alpha_2 + \alpha_3) + 8(2\beta_2 + \beta_3) + 2(2\gamma_2 + \gamma_3)}{\alpha_1 + 4\alpha_2 + \alpha_3 + 4(\beta_1 + 4\beta_2 + \beta_3) + \gamma_1 + 4\gamma_2 + \gamma_3}$$

$$\bar{y} = \frac{\int\int yz\,dxdy}{\int\int z\,dxdy} = \frac{\int_0^{2h}\int_0^{2k} dxdy\ y(A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Exy^2 + Gx^2 y^2)}{\int_0^{2h}\int_0^{2k} dxdy\,(A + Bx + Cx^2 + B_1 y + C_1 y^2 + Dxy + Ex^2 y + Fxy^2 + Gx^2 y^2)}.$$

$$= \frac{\frac{hk}{9}\{36Ak + 36Bhk + 48Ch^2k + 48B_1 k^2 + 72C_1 k^3 + 48Dhk^2 + 64Eh^2k^2 + 72Fhk^3 + 96Gh^2k\}}{\frac{hk}{9}\{36A + 36Bh + 48Ch^2 + 36B_1 k + 48C_1 k^2 + 36Dhk + 48Eh^2k + 48Fhk^2 + 64Gh^2k\}};$$

which, after introducing the values of the constant, and reducing, becomes

$$\bar{y} = k\,.\left\{\frac{2(2\beta_1 + \gamma_1) + 8(2\beta_2 + \gamma_2) + 2(2\beta_3 + \gamma_3)}{\alpha_1 + 4\alpha_2 + \alpha_3 + 4(\beta_1 + 4\beta_2 + \beta_3) + \gamma_1 + 4\gamma_2 + \gamma_3}\right\}.$$

Also,

$$\bar{z} = \frac{\int\int z^2\,dxdy}{\int\int z\,dxdy}.$$

But, as before, we avoid the labour of integrations, &c., if we consider the expression $\int\int z^2\,dxdy$ as the volume of a figure, *the squares of the areas* of which may be introduced into "Simpson's Rule."

We should obtain similar expressions for the centres of gravity of the volumes of the other solids, and by introducing the results into the formulæ—

$$\bar{x} = \frac{V_1 \bar{x}_1 + V_2 \bar{x}_2 + V_3 \bar{x}_3 + \&\text{c.}}{V_1 + V_2 + V_3 + \&\text{c.}}$$

$$\bar{y} = \frac{V_1 \bar{y}_1 + V_2 \bar{y}_2 + V_3 \bar{y}_3 + \&\text{c.}}{V_1 + V_2 + V_3 + \&\text{c.}}$$

we obtain the rule, in common use among naval architects, namely:—

If A_1, A_2, A_3, &c. represent the areas of half the horizontal sections, or the sections shown by the half-breadth plan, and h the common interval between those sections, we know that the centres of gravity of the areas in question lie in the planes of these areas at distances 0, h, $2h$, $3h$, &c., respectively, from the origin.

$$\text{(III.)}\ \therefore \bar{x} = \frac{A_1 \times 0 + (n-1)hA_n + 4h(A_2 + 3A_4 + 5A_6 + 6A_8 + \&\text{c.}) + 2h(2A_3 + 4A_5 + 6A_7 + \&\text{c.})}{A_1 + A_n + 4(A_2 + A_4 + A_6 + \&\text{c.}) + 2(A_3 + A_5 + A_7 + \&\text{c.})};$$

$$\text{or } \bar{x} = h\,.\left\{\frac{(n-1)A_n + 4(A_2 + 3A_4 + 5A_6 + \&\text{c.}) + 2(2A_3 + 4A_5 + \&\text{c.})}{A_1 + A_n + 4(A_2 + A_4 + A_6 + \&\text{c.}) + 2(A_3 + A_5 + A_7 + \&\text{c.})}\right\}.$$

In like manner, if A_1', A_2', A_3', &c. represent the half areas of the vertical section, and k the common interval between them.

$$\text{(IV.) Then } \bar{y} = k\left\{\frac{(n-1)A_n' + 4(A_2' + 3A_4' + 5A_6' + \&\text{c.}) + 2(2A_3' + 4A_5' + \&\text{c.})}{A_1' + A_n' + 4(A_2' + A_4' + A_6' + \&\text{c.}) + 2(A_3' + A_5' + \&\text{c.})}\right\}.$$

Hence the centre of gravity of the displacement is determined; for we know that it will lie somewhere in the plane which cuts the vessel into two equal parts, and the value of $\bar{x}$ gives its distance below the load-water plane, $\bar{y}$ gives its distance from the origin,

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which may be taken for convenience at the point of intersection of the load-water plane, the plane just mentioned, and the first vertical plane next the bow, or stern (as the calculator pleases). We will suppose the former, and that the centres of gravity of the small portions, fore and aft, and below the last horizóntal plane, are not taken into account. Let V_f, V_a, V_k, be their volumes, $\bar{x}_f$, $\bar{x}_a$, $\bar{x}_k$, $\bar{y}_f$, $\bar{y}_a$, $\bar{y}_k$, the distances of their centres of gravity from the origin. Therefore, for the whole ship, V representing the volume between the first and last vertical sections,

$$\bar{X} = \frac{V\bar{x} + V_k \bar{x}_k + V_a \bar{x}_a - V_f \bar{x}_f}{V + V_k + V_a + V_f}$$

$$\bar{Y} = \frac{V\bar{y} + V_k \bar{y}_k + V_a \bar{y}_a + V_f \bar{y}_f}{V + V_k + V_a + V_f}.$$

Observe that $V_f \bar{x}_f$ has a negative sign because it is in the opposite side of the origin to the other quantities, that is, x_f is negative.

Note 10.—The mathematical reader will at once perceive that these are not the only rules which might be obtained to calculate the centre of gravity of a vessel. As has been remarked before, the Calculus of Finite Difference again comes to our aid; and, by neglecting small orders of differences, we may obtain any number of rules we please. As an instance, let us take the case given by Mr Weddle for a curve passing through seven points, and suppose sixth differences constant. We have for $\bar{x}$, using the same notation as in Note 3,

$\bar{x} = \int xy\,dx$ taken between proper limits; and $y = \alpha + z\,\Delta\alpha + z(z-1)\frac{\Delta^2\alpha}{1\cdot 2} + \&c.$; where $z = \frac{x}{h}$. Multiplying this by $zdz = \frac{xdx}{h^2}$, we have $\bar{x}$ or $\frac{1}{h^2}\int xy\,dx = \int \left\{ \alpha\,zdz + (z^2dz)\,\Delta\alpha + (z-1)\,dz\,.\,\frac{\Delta^2\alpha}{1\cdot 2} + \&c. \right\} = \frac{\alpha z^2}{2} + \frac{z^3}{3}\,\Delta\alpha + \left(\frac{z^4}{4} - \frac{z^3}{3}\right)\frac{\Delta^2\alpha}{1\cdot 2} + \left(\frac{z^5}{5} - \frac{3z^4}{4} + \frac{2z^3}{3}\right)\frac{\Delta^3\alpha}{2\cdot 3} + \left(\frac{z^6}{6} - \frac{6z^5}{5} + \frac{11z^4}{4} - \frac{6z^3}{3}\right)\frac{\Delta^4\alpha}{2\cdot 3\cdot 4} + \left(\frac{z^7}{7} - \frac{10z^6}{6} + \frac{35z^5}{5} - \frac{50z^4}{4} + \frac{24z^3}{3}\right)\frac{\Delta^5\alpha}{2\cdot 3\cdot 4\cdot 5} + \left(\frac{z^8}{8} - \frac{15z^7}{7} + \frac{85z^6}{6} - \frac{225z^5}{5} + \frac{274z^4}{4} - \frac{120z^3}{3}\right) \times \frac{\Delta^6\alpha}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6} + \&c.\ \&c.$

Taking this integral from $z = 0$ to $z = 6$, or $x = 0$ to $x = 6h$, and multiplying by h^2, we find, after considerable reductions,

$$\bar{x} = h^2\left\{18\alpha + 72\,\Delta\alpha + 126\,\Delta^2\alpha + \frac{606}{5}\,\Delta^3\alpha + \frac{657}{10}\,\Delta^4\alpha + \frac{639}{35}\,\Delta^5\alpha + \frac{123}{70}\,\Delta^6\alpha\right\}.$$

We might obtain a tenth rule by neglecting small quantities; but we shall simply write down the total result, leaving the reader to obtain any other rules he may think proper.

$$\alpha = \alpha_1$$
$$\Delta\alpha = \alpha_2 - \alpha_1$$
$$\Delta^2\alpha = \alpha_3 - 2\alpha_2 + \alpha_1$$
&c. &c.

Introducing these values, and reducing

$$\bar{x} = \frac{h^2}{70}\left\{36\,\alpha_2 + 9\alpha_3 + 136\,\alpha_4 + 18\,\alpha_5 + 180\,\alpha_6 + 61\alpha_7)\right\}$$

$$= \frac{9h^2}{70}\left\{\frac{28\,\alpha_4 + 5\alpha_7}{9} + 4\,(\alpha_2 + 3\alpha_4 + 5\alpha_6) + (\alpha_3 + 2\alpha_5 + 4\alpha_9)\right\};$$

which will give a result much more accurate than that obtained by "Simpson's Rule." The result for $\bar{y}$ may be obtained by "Simpson's Rule," or by squaring the value of y, given above, and neglecting the squares and products of higher order of differences.

Property of Guldinus.

Note 11.—The reader will have no difficulty in obtaining for any plane surface[1]

$$\bar{y} = \frac{\int\int y\,dx\,dy}{\int y\,dx};$$

or $\bar{y} \times A = \frac{1}{2}\int (Y_1^2 - Y_0^2)\,dx$; if A represent the area of the surface, and Y_1 Y_0 denote the limits of y. Multiply both sides by 2π.

$$\therefore\ A \times 2\pi\,\bar{y} = \pi\int Y_1^2\,dx - \pi\int Y_0^2\,dx.$$

The left hand side is the area of the surface multiplied by the circumference described by its centre of gravity, and the right hand side denotes the difference of the volumes of revolution described by the plane surfaces comprised between the axis of x, the extreme ordinates, and the two curves which terminate the generating surface.[2]

Examples.

(1.) Find the centre of gravity of an area, similar to fig. (1.) page 140, the equidistant ordinates measuring 2·5, 3, 3·5, 4, 5, 6, 5·5, 5, 4, 3, 2, 1·5 and 1 feet, respectively, the common interval being 2 feet.

1st, *To find the Area by "Simpson's Rule."*

Ordinates.	Ordinates.	Ordinates.
2·5 first ordinate.	3 second ord.	3·5 third ordinate.
1·0 last „	4 fourth „	5·0 fifth „
——	6 sixth „	5·5 seventh „
3·5 sum of first and last ord.	5 eighth „	4·0 ninth „
	3 tenth „	2·0 eleventh „
	1·5 twelfth „	——
	——	20 sum of odd ord.
	22·5 sum of „	2
	4	——
	——	40 twice sum of ord.
	90·0 four times sum of ordinate.	
	40·0 twice sum of odd „	
	3·5 sum of first and last „	
	——	
	133·5	
	2 common interval.	
	——	
	3)267	
	——	
	89 = area.	

2d, *To find the Distance of the Centre of Gravity from* A_1.

1st,	2·5	× 0	= 0	ordinates multiplied by 0, 1, 2, 3, &c.
2d,	3	× 1	= 3	
3d,	3·5	× 2	= 7	
4th,	4	× 3	= 12	
5th,	5	× 4	= 20	
6th,	6	× 5	= 30	
7th,	5·5	× 6	= 33	
8th,	5	× 7	= 35	
9th,	4	× 8	= 32	
10th,	3	× 9	= 27	
11th,	2	× 10	= 20	
12th,	1·5	× 11	= 16·5	
13th,	1	× 12	= 12	

[1] This and other properties are due to Pappus, and were published by Guldinus, a Jesuit, who was Professor of Mathematics at Rome, in the middle of the seventeenth century.

[2] See any work on the Calculus for the interpretation of the expressions on the right hand side.

Calculations incidental to designing a Ship.

By "Simpson's Rule."

Results.	Results.		Results.
0 first result.	3	second result.	7 third result.
12 last ,,	12	fourth ,,	20 fifth ,,
—	30	sixth ,,	33 seventh ,,
12 sum of ,,	35	eighth ,,	32 ninth ,,
	27	tenth ,,	20 eleventh ,,
	16·5	twelfth ,,	——
	——		112 sum of odd results.
	123·5	sum of even results.	2
	4		——
	——		224
	494	four times ,,	
	224	two times ,,	
	12	first and last ,,	
	——		
	730		
	2	common interval.	
	——		
	3)1460		
	——		
	486·66		
	2	common interval.	
	——		
	973·3		

$\therefore$ Distance of centre of gravity from $A_1 = \dfrac{973\cdot3}{89} = 12\cdot4344.$

$(2\cdot5)^2 = 6\cdot25$	9·00	12·25
$3^2 = 9\cdot00$	16·00	25·00
$(3\cdot5)^2 = 12\cdot25$	36·00	30·25
$4^2 = 16\cdot00$	25·00	16·00
$5^2 = 25\cdot00$	9·00	4·00
$6^2 = 36\cdot00$	2·25	——
$(5\cdot5)^2 = 30\cdot25$	——	87·5
$5^2 = 25\cdot00$	97·25	2
$4^2 = 16\cdot00$	4	——
$3^2 = 9\cdot00$	——	175 twice sum of odd ord. sqd.
$2^2 = 4\cdot00$	389 four times sum of even ord. squared.	
$(1\cdot5)^2 = 2\cdot25$		
$1^2 = 1$	6·25	
	1	
	——	
	7·25 sum of first and last ordinates squared.	
	389·00	
	175·00	
	——	
	571·25	

By last process, we have

$\therefore$ Perpendicular $Gg = \dfrac{571\cdot25 \times \frac{2}{3}}{267 \times \frac{2}{3}} = 2\cdot139$, &c.[1]

Exercises for practice.

2. Find the centre of gravity of a figure similar to the above, when the ordinates are taken 3 feet apart, and measure 1·25, 2·35, 4·56, 7·87, 8·97, 9·65, 10·54, 9·97, 8·65, 7·54, 6·34, 7·43, 5·42, 4·53, 4·23 feet, respectively.

Distance along the axis from A_1 = 20·82.
Distance above the axis at the above point = 3·945.

(3.) Find the same, as in the last example, when the equidistant ordinates measure 20, 20·5, 21, 22, 22·5, 23, 24·5, 25, 26; 25, 24, 23; 23, 22·5, 21, 20; 19, 18, and 17 feet, respectively, and are taken at 6 feet apart.

Distance along the axis $A_1\,A_n$ from A_1 = 52·82.
Perpendicular distance above ditto at the above point = 11·18.

(4.) Find the same, as in the former examples, when the ordinates are 0, 2, 3, 3·5, 4·5, 5, 6, 7·5, 8, 8·5, 9, 8, 7, 6, 5·5, 4·5, 4, 3·5, 3, 2·5, and 2 feet, and their distance apart is 2 feet.

Distance along $A_1\,A_n$ from A_1 = 20 feet nearly.
Distance above $A_1\,A_n$ at the above point = 3·0506.

(5.) Find the same when the equidistant ordinates measure 17, 18, 18·5, 19, 19·5, 20, 20·5, 21, 22, 23, 22, 21·5, 20, 19, and 18 feet, their distance apart being 4 feet apart.

Distance along $A_1\,A_n$ from A_1 = 28·605.
Distance above $A_1\,A_n$ at the above point = 10·134.

Examples on the Calculation of the Centre of Gravity of Displacement.

Common interval, 1 foot.

Half-Horizontal Areas, in square feet, found by Simpson's Rule.			Half-Areas multiplied by 0, 1, 2, 3, &c.
289·25	× 0	=	000·00
300·05	× 1	=	300·05
325·00	× 2	=	650·00
400·25	× 3	=	1200·75
405·25	× 4	=	1621·00
450·65	× 5	=	2253·25
470 75	× 6	=	2824·50
490·00	× 7	=	3430·00
495 25	× 8	=	3962·00
500·00	× 9	=	4500·00
487·65	× 10	=	4876·50
470·55	× 11	=	5176·05
460·65	× 12	=	5527·80
450·75	× 13	=	5859·75
435·25	× 14	=	6093·50
400·15	× 15	=	6002·25
390·00	× 16	=	6240·00
375·25	× 17	=	6379·25
350·00	× 18	=	6300 00

7643 23 = volume by Simpson's Rule.

Common interval, 10·56 feet.

Half-vertical Areas in square feet.			Half-Areas multiplied by 0, 1, 2, &c. respectively.
49·75	× 0	=	000·00
49·95	× 1	=	49·95
52·00	× 2	=	104·00
54·25	× 3	=	162·75
56·45	× 4	=	225·80
78·43	× 5	=	392·15
60·00	× 6	=	360·00
55·25	× 7	=	386·75
48·65	× 8	=	389·20
47·00	× 9	=	423·00
45 75	× 10	=	457·50
43 50	× 11	=	478·50
42·23	× 12	=	506·76
40·22	× 13	=	522·86
38·21	× 14	=	534·94

Volume by Simpson's Rule = 7643·23 nearly.

1st, Beginning with the results in the right hand column of the horizontal section,

Results.	Results.		Results.	
0000·000	300·05		650·00	
6300·000	1200·75		1621·00	
——	2253·25		2824·50	
6300 000 sum of 1st and last	3430·00		3962·00	
	4500·00		4876·50	
	5176·05		5527·80	
	5859·75		6093·50	
	6002·25		6240·00	
	6379·25		——	[results.
	——	[results.	31795·30	sum of *odd*
	35101·35	sum of *even*	2	
	4		——	
	——		63590·6	twice do.
	140405·4	four times		do.
	63590·6	twice sum of odd		do.
	6300·0	sum of first and last		do.
	——			
	210296			
	1	common interval.		
	——			
	3)210296			
	——			
	70098·6	result obtained by "Simpson's Rule."		

[1] The calculator will always have a check on his work by observing the length of the axis $A_1\ A_n$, and observing also whether or not the ordinates near the beginning differ widely from those at the end. If the ordinates do not differ widely in this sense, the centre of gravity will be determined by a line perpendicular to the axis *near* its middle point. If the ordinates are greater near the beginning than at the end, the centre of gravity determined along $A_1\ A_n$ will be nearer the *first* ordinate than the *last*, and *vice versâ*.

Calculations incidental to designing a Ship.

Therefore, distance of centre of gravity of main body *below* the plane of flotation $= \frac{70098\cdot\dot{6}}{\text{volume}} = \frac{70098\cdot\dot{6}}{7643\cdot23} = 9\cdot17$ feet.

2d, Taking the results in the right hand column of the vertical section,

Results.	Results.	Results.
000·00 first result.	49·95	104·00
534·94 last do.	162·75	225·80
	392·15	360·00
534·94 sum of do.	386·75	389·20
	423·00	457·50
	478·50	506·76
	522·86	[results.
	[results.	2043·26 sum of *odd*
	2415·96 sum of *even*	2
	4	
		4086·52 twice do.

9663·84 four times do.
4086·52 twice sum of odd do.
534·94 sum of first and last.

14285·30
10·56 common distance.

857118
714265
1428530

3)150852·768

50284·256 result obtained by "Simpson's Rule."
10·56 common distance.

301705536
251421280
502842560

531001·74336

$\therefore$ distance of centre of gravity from first vertical section $= \frac{531001\cdot74}{7643\cdot23}$
$= 69\cdot47$ feet.

We shall *suppose* the *first* vertical section 49·75 to be that nearest the *bow*, and

234·25 cubic feet, to be the volume of the portion below the last horizontal section, or the portion just above the keel.

22·5 feet, the distance of its centre of gravity below the plane of flotation.
70· „ from the first vertical plane.

324·75 cubic feet, the volume of the portion *before* the first vertical plane, or between this plane and the bow.

10 and 7 feet, the respective distances of the centre of gravity from the same planes as above.

576·00 cubic feet, the volume of the portion *aft* of the last vertical plane, or lying between this plane and the stern.

8 and 160 feet, the respective distances of the centre of gravity from the planes already mentioned.

Then, if d_f, d_v, be the distances of the centre of gravity of the total displacement from the planes of flotation and first vertical, we have

$$d_f = \frac{7643\cdot23 \times 9\cdot17 + 234\cdot25 \times 22\cdot5 + 324\cdot75 \times 10 + 576 \times 8}{7643\cdot23 + 234\cdot25 + 324\cdot75 + 576}$$
$$= 9\cdot48 \text{ feet below the plane of flotation.}$$

$$d_v = \frac{7643\cdot23 \times 69\cdot47 + 234\cdot25 \times 70 + 576 \times 160 - 324\cdot75 \times 7}{7643\cdot23 + 234\cdot25 + 576 + 324\cdot75}$$
$$= 71\cdot8 \text{ nearly.}$$

Stability of Floating Bodies.

The reader will perceive that all the quantities are *added* in obtaining the former result, and that the last one is *subtracted* in the latter case. The reason for this is, that, in the latter case, the portion forward lies on the *opposite* side of the first vertical plane to all the rest, or is measured, what we have called, *backwards*. Now, if we had considered the first vertical section, 49·75, as being taken at the stern, then 324·75 × 7 would have been *added*, and 576 × 160 *subtracted*, in consequence of the portion aft lying, in this case, on the opposite side of the first vertical plane to the other portions. In the first result, all the portions lie *below* the plane of flotation. We also perceive that the centre of gravity lies between the sixth and seventh vertical sections, inasmuch as their common distance is 10·56, and 10·56 × 6 = 63·36; also, 10·56 × 7 = 73·92; therefore 71·8 − 63·36 = 8·44 feet abaft the sixth section.

STABILITY OF FLOATING BODIES.

Theory: General principles.

ART. 6.—Various definitions have been given of the *stability* of floating bodies. The reader will probably comprehend the term from the explanation and definitions which follow.

Euler, in his *Theory of the Construction of Vessels*, &c., as translated by Colonel Watson, observes, that " As soon as a vessel becomes ever so little inclined, or displaced from its state of equilibrium, three consequences may happen:—1*st*, Either the vessel remains in the inclined state; or, 2*dly*, It re-establishes itself in its preceding situation, when its equilibrium will be permanent, or rather, it will be endowed with a stability which may be great or little according to circumstances; or, 3*dly*, The vessel after this inclination will be completely overturned. This equilibrium is called unstable, or ready to fall. We can see, evidently, that neither this last case nor the first can have place in vessels; and, with respect to the second case, a sufficient stability is absolutely necessary."[1]

The last remarks here made are not altogether true when a vessel is inclined through considerable angles by impulsive forces. We shall therefore proceed to investigate the different kinds of stability.

Statical stability.

DEF. (I.)—STATICAL STABILITY *is defined to be the moment of* FORCE *(or effort), by which a floating body endeavours to regain its upright or vertical position, after having been deflected from that position.*

DEF. (II.)—DYNAMICAL STABILITY *is defined to be the amount of work*[2] *done on any body, in order to deflect it through any angle from its upright position.*

As has already been stated, it is shown in books on Hydrostatics, that when a body floats *in equilibrium*, the following conditions must be fulfilled:—

1*st*, $g\varrho V_d = gM$, or simply $\varrho V_d = M$,

where M represents the mass of the floating body, V_d the volume of water displaced, ϱ the density of a cubic unit (say a cubic foot) of water, and g the accelerating force of gravity.

2*nd*, The centres of gravity of the body, and of the water which it displaces, must lie in the same vertical line—that is, in a line at right angles to the plane of flotation.

From the first condition, namely $V_d = \frac{M}{\varrho}$, it is at once manifest, that in many bodies, such as some of the solids of revolution, this will furnish us with an infinite number of positions of equilibrium, for all of which the second condition will be fulfilled.

When a body is inclined through any angle from its upright position, the plane of flotation will differ in position from the plane of flotation in the former case; and for every plane of flotation the centres of gravity of the vessel and its displacement will,

[1] *Vide* chap. iv., sect. 22, of the work here mentioned.

[2] By the amount of work, here alluded to, is meant the weight of the body, in pounds avoirdupois, multiplied by the vertical height, in feet, of the sum or difference of displacements of the centres of gravity of the body and of the water which it displaces.

Stability of Floating Bodies.

in general, have different positions. If we suppose the vessel to *roll* and *pitch*[1] uniformly through any finite angles, the centre of gravity of displacement G_d, or centre of buoyancy, as this point is sometimes called, will describe a portion of a surface in the interior of the vessel.

It will readily be comprehended by the reader, that a vessel may possess a great amount of both kinds of *stability* specified in the definitions up to a certain point, that is, through a given angle from its upright position, and then instantaneously become unstable. Sufficient attention has not been paid to this fact, inasmuch as writers on stability, as applied to ships, generally neglect to discuss the case of unstable equilibrium. It is a well-known fact, that ships have been capsized through unforeseen impulsive forces, as in the case of the Royal George.[2] When the vessel has been inclined through any angle, it has been always customary to assume that the volume of the portion which is *emerged* is equal to that which is *immersed*. This is not accurately true, on account of the inertia of the vessel and the water, as well as on account of the effect of the wind in the sails, which may tend to increase the total displacement.

ART. 7. THEOREM I.—*The line joining the centres of gravity of the displacement of the body in any two positions is parallel to the line joining the centres of gravity of the immersed and emerged portions due to these positions.*

For, let FKL′ represent a transverse section of the body, made by the plane of the paper, and G_d, G'_d the projections of the centre of gravity of displacement in the two positions, g_e, g_i the projections of the centres of gravity of the *emerged* and *immersed* volumes due to the two positions.

Then the immersed portion of the body in the two positions will have the common part

$$V_d - v$$

(the section of which is shown by F′PLK), where v represents the volume of the part emerged or immersed.

Let O′ be the projection of the centre of gravity of the volume $V_d - v$ on the plane of the paper, then by the principles which have been already enunciated (Art. 4, p. 147, &c.), the centre of gravity G_d is determined from

$$G_d\, g_e \times v = G_d\, O' \times (V_d - v) \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

and the centre of gravity G'_d, in like manner from

$$g_i\, G'_d \times v = G'_d\, O' \times (V_d - v) \quad . \quad . \quad . \quad . \quad (2.)$$

By (1.) and (2.) $g_e\, G_d \times G'_d\, O' = g_i\, G'_d \times G_d\, O'$;

or, $g_e G_d : G_d O' :: g_i G'_d : G'_d O'$;

hence $G_d\, G'_d$ is parallel to $g_e\, g_i$. (*Euclid*, vi. 2.)

Next, if we consider the volumes immersed and emerged to be infinitely small, or, in other words, the two planes of flotation, of which FL, F′L′, are the projections, to be indefinitely near, the centres of gravity of these two volumes may be considered as situated in the plane of flotation (FL). In this case $G_d\, G'_d$ becomes parallel to FL, that is, $G_d\, G'_d$ becomes a *tangent* at G_d, to the *curve* traced out by the latter point in the plane of the paper. This is rigorously true at the limit, no matter in which direction we suppose the body to revolve (through an infinitely small angle); it follows, therefore, that all the tangents drawn through G_d are parallel to the plane of flotation; hence

THEOREM II.—*The* TANGENT PLANE,[3] *drawn through the centre of gravity of displacement in position to the surface traced out by this point during the rolling and pitching of the vessel, is parallel to the plane of flotation corresponding to that position.*

ART. 8.—If G (fig. 7) denote the centre of gravity of the floating body, and G_d that of the water displaced, then in positions of equilibrium G_d G is a *normal*[4] to the surface described by the latter points. For, by the second condition of equilibrium, given in Art. 14, G_d G, is necessarily perpendicular to the plane of flotation, and is, therefore, perpendicular to the tangent-plane at the point G_d, since the latter plane is parallel to the former. Let us suppose the surface traced out by G_d to be actually described, then if from G, the centre of gravity of the body, we draw all the normals which it is possible to do from this point to the surface, we shall determine as many positions of G_d as there are

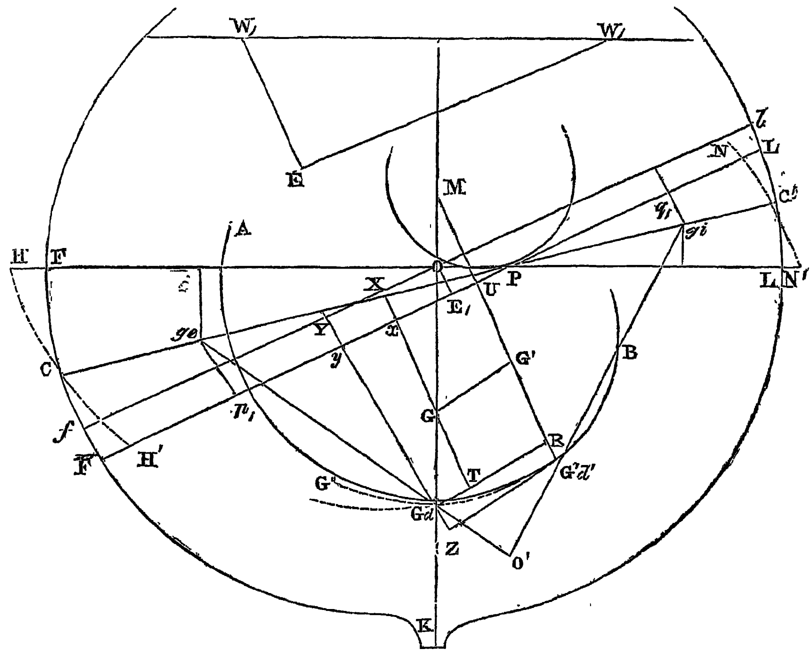

Fig. 7.

normals, and consequently as many planes of flotation, for all of which there will be equilibrium of one kind or the other—that is, *stable* or *unstable*.

A rolling motion will be sufficient to establish the following principles:—

Let us suppose the plane of the paper to be that transverse vertical section of the vessel which contains the centres of gravity of the vessel and its displacement when floating *at rest*. Next let the body be made to roll through any angle, and the point G_d will describe a curve in the same plane, which is represented by AG_dB.

Let G_d, G'_d (fig. 7) be two consecutive positions of the centre of gravity of displacement (that is, two positions indefinitely near to each other); draw normals through these two points to the curve AG_dB, and let them intersect in M, the latter point in geometry and analysis receives the name of the *centre of curvature*; but in regard to the floating body it was named by Bouguer the *metacentre*, and the circle described through G_d with radius MG_d is called the *circle of curvature*, or sometimes the *osculating circle*.

The curve described by the centre of gravity of displacement (centre of buoyancy) has been named the *metacentric curve*. Mr Read, late master-shipwright of H.M. Dockyard, Sheerness, pro-

[1] By a *rolling* motion is understood a motion about a longitudinal axis, or from stem to stern. By a *pitching* motion is to be understood the motion of the vessel about an axis at right angles to the former axis, or about an axis which lies in a transverse vertical section. During a *rolling* motion only, the centre of gravity of the vessel will remain in the same transverse section; and during a *pitching* motion only, the centre of gravity will remain in a vertical section at right angles to the former. When the motion is due to rolling and pitching combined, the vessel will revolve about an *instantaneous axis*, which may be determined.

[2] And in all probability many other vessels.

[3] By a *tangent-plane* is here meant a plane which *touches* the surface described by G_d at a given point, and which, if produced, does not intersect this surface. For the general definition of a tangent-plane and its properties, see Hymers's and Gregory and Walton's *Geometry of Three Dimensions.*

[4] By a *normal* to a surface at a given point is meant the line drawn at right angles to the tangent-plane at that point.

Stability of Floating Bodies.

posed to call it the *metacentric involute*, and the curve described by M the *metacentric evolute*,[1] which terms are strictly in accordance with mathematical theory.

It will be seen hereafter that the position of the metacentre is of the greatest importance in the determination of the stability and times of oscillation of vessels. Its height above the centre of gravity of displacement may be determined as follows—

ART. 9.—The notation and figure remaining the same as in the previous article; the ordinates measured on *the half-breadth plan* at the load-water line being employed.

RULE XIV.—*Cube the ordinates measured on the half-breadth plan, introduce these* CUBES *as ordinates in Rule I., p.* 140, *and proceed as therein stated; divide the result thus obtained by the volume of water displaced, and* TWO-THIRDS *of the quotient gives the distance of the metacentre from the centre of gravity of displacement.*

Let the vessel be slightly inclined from its upright position, we may consider the areas FPF′ and LPL′ to be two equal sectors of the same circle;[2] then $g_e\,g_i$, the line joining their centres of gravity, will bisect this angle. Draw $g_e\,p_1$, $g_i q_1$ perpendicular to FF′, and G_dR perpendicular to MG'_d.

Let $r = FP = F'P = LP = L'P$, and it is well known that the centres of gravity are determined by

$$Pg_e = Pg_i = \frac{2\,r\,.\,\text{chord FF}'}{3\text{ arc FF}'} = \frac{2\,r\,.\,\text{chord LL}'}{3\text{ arc LL}'}$$

$$= \frac{4\,r\sin\frac{\phi}{2}}{3\,\phi},\ \phi\text{ being} = \angle\,FPF'$$

But area of sector FPF′ or PLL′ $= \frac{r^2\phi}{2}$. And

$$P\,p_1 = P\,q_1 = P\,g_e\,.\cos\frac{\phi}{2} = P\,g_i\,.\cos\frac{\phi}{2} = \frac{4\,r\sin\frac{\phi}{2}\cos\frac{\phi}{2}}{3\,\phi} = \frac{2\,r\sin\phi}{3\,\phi}.^{3}$$

Also moment of sector FPF′, or sector LPL′, $=$ area FPF′ $\times P\,p_1$

$$= \text{area LPL}' \times P\,q_1 = \frac{r^2\phi}{2} \times \frac{2\,r\sin\phi}{3\,\phi}.$$

$$= \frac{r^3\sin\phi}{3}. \quad \ldots\ldots\ldots \quad \text{(I.)}$$

Now, since the solids emerged and immersed are supposed to be equal, and that these solids may be conceived to be collected at their respective centres of gravity, it is clear that the centre of gravity of the volume of water emerged has been moved from p_1 to q_1 in the direction F′L′, while the total volume of water displaced by the vessel has been transferred from G_d to R in a parallel direction. Hence taking moments, we have, by elementary mechanical principles,

$$G_dR \times \varrho \times V_d = p_1 q_1 \times \varrho \times v. \quad \ldots\ldots \quad \text{(II.)}$$

Or, $G_dR\,.\,V_d = p_1 q_1\,.\,v$.

But the angle FPF′ $=$ angle $G_dMG'_d$ between two consecutive normals

$$\therefore\ MG_d\sin\phi = G_dR$$

$$\text{From (II.) } MG_d = \frac{p_1 q_1\,.\,v}{V_d\sin\phi}. \quad \ldots\ldots \quad \text{(III.)}$$

Now, if we imagine a plane drawn parallel to the plane of the paper, or to the section shown in the figure, and at the infinitesimal distance Δx, the moments of the volumes of the solids emerged and immersed will be represented by

$$\frac{\sin\phi}{3}\,\Sigma\,r^3\,\Delta\,x,\text{ from (I.), or }\frac{\sin\phi}{3}\int r^3 dx;$$

by employing the notation of the Integral Calculus, observing that the integral here given must be taken from stem to stern.

$$\therefore\ MG_d = \frac{2\sin\phi}{3}\,.\,\frac{1}{V_d\sin\phi}\int r^3\,dx. \quad \ldots \quad \text{from (III.)}$$

$$= \frac{2}{3\,V_d}\int r^3\,dx. \quad \ldots\ldots\ldots\ldots \quad \text{(IV.)}$$

The integral, $\int r^3\,dx$ is sometimes named the *moment of inertia* of the load-water section FL, about a horizontal axis through the centre of gravity.

It ought to be observed that, though we have here obtained the position of the metacentre of the vessel when in a vertical position, this point may in like manner be obtained, by employing the same rule, when the vessel is inclined through any angle, providing we substitute the ordinates of the *inclined load-water section* for those of the load-water section of the vessel when in an upright position.

ART. 10.—Having obtained the position of the metacentre, we are now in a position to determine the *nature* of the equilibrium when a vessel is in any position; for, if we call the lengths of the lines drawn from G, perpendicular to the curve described by G_d, NORMALS, then

THEOREM III.—*Positions of* STABLE *equilibrium correspond to* MINIMUM *normals, and positions of* UNSTABLE *equilibrium correspond to* MAXIMUM *normals: also these normals will have alternately maximum and minimum values.*[4]

Various demonstrations of this theorem have been given in books on Hydrostatics, and the reader will find the subject discussed in the *Mechanic's Magazine*, a periodical which contains many valuable papers on shipbuilding. The following exposition of the principle may be found sufficient for the mathematical reader.

If (fig. 7) M be the *centre of curvature* corresponding to G_d, and situated at first above G, the osculating circle at G'_d will lie both within and without the curve AG_dB in the immediate neighbourhood of G_d, and the circle described from G as a centre, with radius GG_d, will lie entirely within the curve in the vicinity of G_d, and the normal GG_d will be a *minimum* among all those drawn from G to the points of the curve in the neighbourhood of G_d; that is, GG_d will be less than GG'_d and GG''_d. If M lie below G, we learn by the same reasoning that GG_d is greater than GG'_d and GG''_d, since the circle described from G with radius GG_d lies entirely without the curve AG_dB; that is, the contact is of the third order.[5]

These normals are alternately maxima and minima, since between two maximum values there is a minimum, and a maximum between two minima. There are as many maximum as minimum values; hence the number of positions of equilibrium, neglecting the *kind*, is *even*. Moreover,

THEOREM IV.—*When the metacentre lies* ABOVE *the centre of gravity of the vessel, the equilibrium is* STABLE.

For, if we incline the vessel in such a manner that G_d shall be at G'_d, indefinitely near to G_d, the normal at G'_d will pass through M (since the latter point is the intersection of two consecutive normals); then the weight of the water displaced applied at G'_d will be parallel to MG'_d, and will act upwards, whilst the weight of the body at G′ will act downwards in the direction parallel to MG'_d, and it is evident that the effect of these two forces will be to bring the points M and G'_d into their original position.

THEOREM V.—*When the metacentre lies* BELOW *the centre of gravity of the vessel, the equilibrium is* UNSTABLE.

For, inclining the vessel as before, through an indefinitely small angle, the effect of the two forces just mentioned will be to bring G′ and M into a vertical position; and since G is above M, the vessel will be capsized.

THEOREM VI.—*When the metacentre coincides with the centre of gravity, the equilibrium is said to be indifferent or neutral; that is, the vessel will rest in the position in which it is then placed.*

ART. 11.—Having obtained the *kind* of stability, we may

[1] The *metacentric curve* is that made by any plane (a transverse vertical one in the present case) with the metacentric surface.

[2] It is not necessary to consider the sectors as equal, providing we bisect the angle FPF′; and with centre P and radii PC, PC′, we describe arcs of circles intersecting the two planes of flotation (the projections of which are FL and F′L′), the same result as is obtained below may be shown to hold true.

[3] Because $2\sin\frac{\phi}{2}\cos\frac{\phi}{2} = \sin\phi$.

[4] *Maximum* and *minimum* values mean *greatest* and *least* values.

[5] See Hall's *Calculuses*, p. 200.

at once obtain the analytical condition for the NATURAL STABILITY of a body after having proved the following:—

THEOREM VII.—*The centre of gravity of a plane of flotation lies on the line of its intersection, with a plane of flotation indefinitely near to the former plane.*

Let PQ represent the intersection of the two planes here mentioned, g, g', the centres of gravity of the areas EPQ and LPQ, the areas being denoted by A and A′. Now, the centre of gravity of FPLQ is obtained by dividing $g\,g'$ into two parts reciprocally proportional to those areas. Let, then, φ be the infinitely small angle between the two planes of flotation, l and l' the perpendicular distances of g, g', from PQ. As the wedge-like portions emerged and immersed are exceedingly small, we may apply the principle of Guldinus, given at page 147, viz.:—[1]

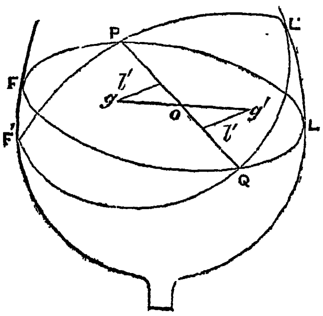

Fig. 8.

Volume F′FPQ $= Al\varphi$, and volume LL′PQ $= A'l'\varphi$; and since these volumes are equal

$$\therefore\ Al\varphi = Al'\varphi \text{ or } Al = A'l';$$

$$\text{that is, } l : l' :: A' : A \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

From the similar triangles ghO, $g'h'O$, we have,

$$l : l' :: gO : g'O \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

hence by (1) and (2),

$$gO : g'O :: A' : A;$$

that is, O is the centre of gravity of the plane of flotation.

It is clear that the point O will trace out a curve in the plane of the paper, provided the body be made to revolve through a finite angle in this direction, and F′L′ is a tangent at O to this curve. Moreover, the vessel might be made to revolve in any direction, and the point O would then trace out what is called the *surface of flotation*. From the manner in which we have obtained the result just given, we arrive at Euler's theorem, viz.,—

The point of contact of the plane of flotation with the surface of flotation is the centre of gravity of that plane.

Moreover, if we conceive (ΔA_1) to represent an elemental portion of the plane FPQF, and r_1 the distance of this element from PQ, then $\varphi\,(\Delta A_1)\,r_1$ will represent the corresponding volume of the portion FPQF′, assuming it to be a solid of revolution, and the total volume is got from

$$v = \varphi\,\{(\Delta A_1)\,r_1 + (\Delta A_2)\,r_2 + (\Delta A_3)\,r_3 + \&c.\} = \varphi\Sigma\,(\Delta A)\,r.$$

We know from the formula for determining the centre of gravity of bodies (p. 146), that

$$gO = \frac{\varphi\{(\Delta A_1)r_1^2 + (\Delta A_2)r_2^2 + (\Delta A_3)\,r_3^2 + \&c.\}}{\varphi\{(\Delta A_1)r_1 + (\Delta A_2)\,r_2 + (\Delta A_3)\,r_3 + \&c.\ \ \}}$$

$$= \frac{\varphi\Sigma(\Delta A)\,r^2}{\varphi\Sigma(\Delta A)\,r} = \frac{\varphi\int dA\,.\,r^2}{\varphi\int dA\,.\,r}.$$

By employing the notation of the Integral Calculus, and bearing in mind that these integrals are to be taken between proper limits:—

Now, $\int dA\,.\,r^2$ is called the *moment of inertia* of the plane PQF in regard to the axis PQ, the density being unity.

$\therefore gO = \dfrac{\varphi k_1}{v}$, . k_1 representing this moment of inertia; also,

$g'O = \dfrac{\varphi k_2}{v}$, where k_2 represents the moment of inertia of the plane LPQ, in regard to the same axis.

But $gg' = gO + g'O = \dfrac{\varphi\,(k_1 + k_2)}{v} = \dfrac{\varphi\,k}{v}$, k being the moment of inertia of the plane FPLQ in regard to PQ. Returning again to fig. 7, where g_e, g_i, represent the centres of gravity of the indefinitely small volumes emerged and immersed, we have shown that $g_e\,g_i$ is parallel to $G_d\,G'_d$.

$$\therefore\ \frac{G_d\,G'_d}{g_e\,g_i} = \frac{V_d}{v} = \frac{\varphi k}{V_d};$$

and φ being the angle between two consecutive normals, then $MG_d = \dfrac{G_dG'_d}{\sin\varphi} = \dfrac{G_dG'_d}{\varphi}$, since φ is exceedingly small, and the sine may be taken equal to the arc, and $g_e\,g_i$ is the same as the value of $g\,g'$ (given above) at the limit; hence

$$MG_d = \frac{k}{V_d} = \frac{\varrho\,k}{W} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (I.)$$

We have seen that the condition of *stable* equilibrium is $MG_d > GG_d$; so that if h denote the distance GG_d, the condition is

$$\frac{k}{V_d} > h, \text{ or } \frac{\varrho k}{W} > h \quad . \quad . \quad . \quad . \quad \quad . \quad . \quad . \quad . \quad (II.)$$

THEOREM VIII.—*The moment of inertia of the plane of flotation must be greater than the product of the volume of water displaced, and the distance between the centres of gravity of the body and its displacement.*

The value of k may be found from Equation IV., Art. 9.

$$\text{From (I.) } G_dM = GG_d + GM = \frac{\varrho k}{W}$$

$$\therefore GM = \frac{\varrho k}{W} - GG_d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (III.)$$

ART. 12.—*To determine the line of intersection of the plane of flotation of the vessel, when in a vertical position with the plane of flotation, when the vessel has been inclined through any angle;* or to determine the point P (fig. 7) of the intersection of FL and F′L′.

Through O (fig. 7), the middle point of FL, draw $f\,l$, making the angle $FOf = LOl =$ given angle φ. Let the volumes, of which FOf and LOl are sections, be represented by V_1 and V_2 respectively; also, let v_1 and v_2 represent the volumes of which $EPOf$ and $LPOl$ are sections, and $v =$ volume emerged or immersed; then

$$V_2 = v + v_2;$$

$$\text{and } V_1 = v - v_1$$

$$\therefore\ V_2 - V_1 = v_1 + v_2$$

$= $ area of plane $f\,l \times$ OE (nearly) where OE is drawn perpendicular to F′L′.

$$\text{But OE} = \text{OP} \sin\varphi$$

$$\therefore\ \text{OP} = \frac{V_2 - V_1}{\text{area plane } f\,l \sin\varphi} \quad . \quad . \quad . \quad . \quad . \quad (I.)$$

Various methods have been recommended for the calculation of the solids V_2 and V_1 as well as for the volume v, all three of which are obtained in the same way. The following plan will guide the reader to find v:—

1*st*. Join FF′ and LL′, and the areas of the triangles FPF′; or LPL′ $= \dfrac{\text{FP . F'P} \sin\varphi}{2}$; or $\dfrac{\text{LP . L'P} \sin\varphi}{2}$.

2*d*. The curves FCF′ and LCL′ may be considered as parabolas, and the areas lying between FF′ or LL′ and the curves are equal to $\dfrac{2\,\text{FF} . \times \text{perpendicular height of segment FCF}'}{3}$, and $\dfrac{2\,\text{LL}' \times \text{perpendicular height of segment LC'L}'}{3}$; or we may employ 3*d* instead of 2*d* to find the areas of the segments just mentioned.

3*d*. When φ is very large, ordinates may be measured at right angles to FF′ and LL′ (seven will always be sufficient), and at equal distances apart, and the area found by Rule (III.) Art. 1. (or by Rule I.)

4*th*. Having found the areas FPF′ and LPL′ made by each vertical section, introduce these as ordinates in Rule (I.), and proceed as therein stated.

Remark.—Several writers have proposed to draw the ordinates, mentioned in (3), parallel to the plane of flotation. There is, however, little labour saved by such a plan.

For a very large number of vessels, which are *full* below the load-water plane, the following method may be applied, and will, it is believed, be found almost as accurate as those just recommended. Bisect the angle FPF′ by the line CC′, and with radii PC, PC′, describe the arcs HCH′ and NCN′; then the sectors will, in general, be very nearly equal in area to the portions FPF′ and LPL′. If CP $= r$, and C′P $= s$, then the area of the sector HPH′ $= \dfrac{r_1^{\,2}\varphi}{2}$, and area NPN′ $= \dfrac{s_1^{\,2}\varphi}{2}$. Summing these areas (by Rule

[1] We here suppose that the volumes emerged and immersed are solids of revolution, that is, solids described by the revolution of the planes FPQ and LPQ round PQ. This assumption will be accurate enough when the angle φ is very small, as we have assumed it to be.

I.) from stem to stern, and writing r_1, r_2, r_3, &c., for the 1st, 2d, 3d, &c., radii, with similar expressions for s, &c., we have

$$\text{Volume emerged} = \frac{h\phi}{6}\left\{r_1^2 + r_n^2 + 4\,(r_2^2 + r_4^2 + \&c.) + 2\,(r_3^2 + r_5^2 + \&c.)\right\}$$

$$\text{Volume immersed} = \frac{h\phi}{6}\left\{s_1^2 + s_n^2 + 4\,(s_2^2 + s_4^2 + \&c.) + 2\,(s_3^2 + s_5^2 + \&c.)\right\}$$

Calling the lines CP, C′P, measured on each vertical section, ordinates, we have the following approximate rule to find the volumes of the solids emerged or immersed:—

RULE XV.—*To the sum of the squares of first and last ordinates add four times the sum of the squares of all the even ordinates, and twice the sum of the squares of all the odd ordinates; multiply this result by the common distance and by the angle through which the ship has rolled—divide by 6, and we obtain the volume required (nearly).*

ART. 13.—Returning to Art. 7, and referring to fig. 7,

Draw GT parallel to $M\overline{G}$ and GG′ parallel to G_dR.

Then, $G^dR \cdot \varrho \cdot V_d = p_1q_1 \cdot \varrho \cdot v$;

And $\quad GG' = G^dR - G_dT$

$$= \frac{P_1q_1 \cdot \varrho \cdot v}{\varrho V_d} - GG_d \sin\phi.$$

$\because \quad \varrho V_d \cdot GG' = p_1q_1 \cdot \varrho \cdot v - GG_d \cdot \varrho \cdot V_d \sin\phi$;

Or, $\quad W \cdot GG' = (p_1q_1 \cdot w - GG_d \cdot W \sin\phi) \quad . \quad . \quad . \quad (I.)$

w representing the weight of water emerged or immersed; Formula (I.) measures the *statical stability*, Def. (I.) of a vessel as given by Atwood in his paper published in the *Transactions of the Royal Society* for the year 1796.

ART. 14.—The rule most frequently used by naval architects to determine the centre of gravity of a vessel, when fully equipped for sea, is due to Chapman, and is as follows:—

Suppose any weight (or weights) W_1, either on the upper deck or elsewhere, is moved from its position at W_1 (fig. 7) to another position, as W'_1, and that by this change of position the ship has been inclined through the angle ϕ. From W'_1 (the centre of gravity of the weight or weights) draw W'_1E parallel to $F'L'_1$, and W_1E perpendicular to W'_1E; then $W'_1E = W_1W'_1 \cos\phi = c \cos\phi$; if $W_1W'_1 = c$.

So long as the disturbing weight W_1 remains in its new position W'_1, the vessel will remain in equilibrium, and therefore its centre of gravity must lie in the line G'_dM by the second condition of equilibrium. Hence it has been transferred a distance GG′ parallel to the plane of flotation F′L′, while W_1 has been moved through a distance W'_1E in a parallel direction. Taking moments, we have

$$W \cdot GG' = W_1,\ c \cos\phi.$$

From Equation I. of last article—

$$GG' = \frac{p_1\,q_1\,w - GG_d \cdot W_1 \sin\phi}{W}.$$

Writing this latter value of GG′ in the former equation, we get

$$GG_d = \frac{p_1q_1\,w_1 - cW_1 \cos\phi}{W \sin}$$

which determines the centre of gravity of the ship, when the centre of gravity of displacement has been determined.

Mr Abethell, master-shipwright of H.M. Dockyard, Portsmouth, proposed the following method, in the second volume of the *Papers on Naval Architecture*:—

"It is applicable whenever a ship is taken into dock with the under side of her keel deviating from parallelism with the upper surface of the blocks. This is almost always the case; and it also not unfrequently occurs that ships are docked 'all standing,' and with so large a portion of their armament and stores on board, that the correction necessary to be made to the result which would be obtained by the experiment and investigation about to be described, in order to make that result agree with the circumstances of any additional armament and equipment, would be comparatively easy. We will now quote from the article in question.

"'We will suppose, by the falling of the tide in the dock, the after-extremity of the keel to come first in contact with the blocks; then, as the tide continues to fall, the after-body is gradually forsaken by the water, and the fore-body further immersed, a constant equilibrium being maintained between the total weight of the ship and the pressure of the water against the immersed part of the body, until the ship is aground fore and aft. At any intermediate instant the ship may be considered as a lever of the second kind, of which the fulcrum is the transverse line or point of contact of the keel and after-block, and the power and weight, the weight of the immersed volume and that of the ship respectively, each acting in the vertical line passing through its centre of gravity. As we can, by mensuration and calculation from the draught of the ship, easily find its weight, that of the immersed volume, and the perpendicular distance of the line of pressure from the fulcrum: in the equation of the moments, the distance of the vertical line passing through the centre of gravity of the ship is the only unknown quantity, which is therefore readily determined. AN (fig. 9) represents the

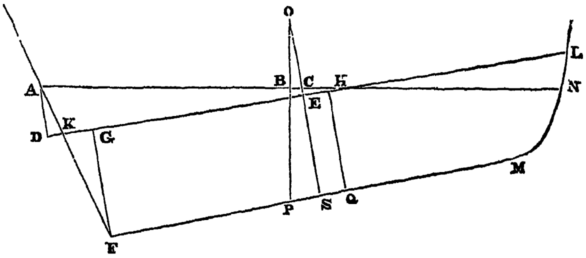

Fig. 9.

water-line corresponding to the floating position of the ship, and KL the observed water-line just previously to the fore-part of the keel touching the blocks. The line PBO, perpendicular to AN, passes through the centre of gravity of the displaced volume AFMN, and consequently through that of the ship. Draw QH through the centre of gravity of the volume KFML, perpendicular to KL, and FG through the fulcrum F, parallel to QH. Then, putting the total displacement AFMN $= V$, KFML $= v$, and GH $= b$; if the line SEO, parallel to QH, be drawn at the distance GE from G equal to $\frac{bv}{V}$, it will, as well as PBO, pass through the centre of gravity of the ship, which will be in O, the point of their intersection.

"'To obtain from these considerations a general expression for the perpendicular distance of the point O from the water-line AN, draw AD perpendicular to EG, and meeting it, when produced, in D; and having calculated the values of AB and GE, put AB $= a$, DE or DG+GE $= d$, and the angle of inclination between the water-lines AN and KL $= \Delta$; then BO $= \left(\frac{d}{\cos} \backsim a\right)\frac{1}{\tan\Delta}$; which must be set off upon the perpendicular PBO, above or below AN, according as $\frac{d}{\cos\Delta}$ is greater or less than a.'"

Dynamical Stability.

ART. 15.—Making the same construction as in fig. 7, and drawing GX and G_dY perpendicular to fl, meeting F′L′ in x and y respectively. Through G'_d draw G'_dZ parallel to F′L′, intersecting YG_d produced in Z.

Here it may easily be shown, that while W, the weight of the water displaced, has been moved through the distance G'_dR, the weight of that portion of the water *emerged* has been moved through a distance $g_e\,p_1 + g_i\,q_1$ in the same direction.[1] Taking moments,—

$$G'_dR \cdot W = w\,(g_e\,p_1 + g_i\,q_1) = wz;\ \text{if } z = g_e\ p_1 + g_i\,q_1$$

$$\text{But } GO - Gx = GO - (GX - Xx) = GO - GO\cos\phi + Xx$$
$$= GO \operatorname{vers}\phi + Xx \quad . \quad . \quad . \quad . \quad . \quad . \quad I.$$

which is the vertical distance through which the centre of gravity of the body has been raised.

$$\begin{aligned}\text{Also, } G'_dY - G_dO &= G^dY + G_dZ - G_dO\\ &= \overline{G}'_dR + G_dY - Xx - G_dO\\ &= G'_dR + G_dO\cos\phi - G_dO - Xx\\ &= G'_dR - (G_dO \operatorname{vers}\phi + Xx) \quad . \quad . \quad . \quad II.\end{aligned}$$

[1] See Moseley's paper, p. 619.

Stability of Floating Bodies.

which represents the height through which the centre of gravity of displacement has been raised.

Then there will be two cases: 1*st*, When the centres move in the *same* direction; 2*d*, When they move in *opposite* directions. In the first case, we shall have to subtract (I.) and (II.); in the second case add these results. Performing these operations, we have for the sum, or difference of the vertical displacements of the centre of gravity of the body, and that of the fluid which it displaces,

$$G'_d R - (G_d O \text{ vers } \varphi + Xx) + (GO \text{ vers } \varphi + Xx);$$

$$\text{Or, } G'_d R - GG_d \text{ vers } \varphi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{III.}$$

by taking the upper sign.

The dynamical stability is readily obtained by multiplying this result by the weight of the vessel; that is—

$$\text{Dynamical stability} = W\,(G'_d R + GG_d \text{ vers } \varphi) \quad . \quad . \quad . \quad \text{IV.}$$ [1]

Canon Moseley makes the following remarks at page 634 of his paper:—

"The force of the winds and waves, to the action of which a vessel is liable, may be supposed to vary as the surface she opposes to them; that is, to the area of her sails and the superficial dimensions of the hull. In vessels geometrically similar, these vary as the squares of any of their linear dimensions; their lengths, for instance. On the other hand, the weights of such vessels, supposed to be similarly loaded, varying as the cubes of their lengths; and the depths of their centres of gravity, and of the centres of gravity of their immersed parts varying as their lengths, their dynamical stabilities, with reference to a given inclination, vary as the fourth powers of their lengths. Since then, in reference to vessels thus geometrically similar, the disturbing forces, to the action of which they are subject, vary as the squares of their lengths, and their stabilities as the fourth powers, it follows that their actual steadiness in the water will vary as the *square* of their lengths, the greater vessel being more steady than the less in this proportion."

Time of Performing an Oscillation.

ART. 16.—There is much difficulty attending the investigation of the times of rolling and pitching of vessels through large angles, inasmuch as the *axis* about which the motion takes place is *instantaneous*. This axis can, however, be determined at any instant, providing the *direction* in which the ship is rolling or pitching be *given*.[2] All methods hitherto given are incomplete, yet all tend to show, that no matter what may be the amplitudes (the angles through which the vessel revolves, providing the position of the ballast, cargo, and other weights retain their original positions), the *time* of performing a complete oscillation, in smooth waters, is the same.

Writers on Hydrostatics, in investigating the time of an oscillation, have usually considered the plane of flotation as constant throughout the motion. The Rev. Canon Moseley, in his paper already quoted, endeavoured to obtain new results for the time of performing an oscillation, as well as for the dynamical stability of the vessel. Notwithstanding that several corrections have been made in the paper, as published in his second edition of *The Mechanical Principles of Engineering and Architecture*, the results are still open to the same objection, since they are made to depend upon the *moment of inertia of the plane of flotation*, which is itself a *variable* quantity throughout the motion. It would seem that the Calculus of Variations might be advantageously applied to the question, or, at all events, Canon Moseley's paper might be made available, providing *we were to calculate the amount of probable error in assuming the plane of flotation constant within given limits.*

As the question stands, we do not know that a better and more simple method can be brought before the practical man than the following, which is due to the Rev. Dr Woolley:—

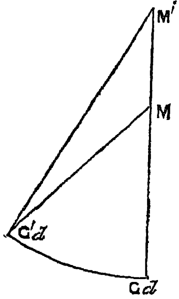

Fig. 11.

"Suppose $G_d\,G'_d$ to be an arc described by the centre of gravity of displacement, corresponding to the half-angle through which the vessel rolls, and let M, M′, be the limits within which the normals to the curve cut, G_dM, the former corresponding to the upright position of the vessel, G the centre of gravity of the vessel, then the time of rolling, supposing M to be fixed during the motion, is too great; and if M′ were the point of suspension, the time would be too small; but taking intermediate points, and calculating the time for each, supposed fixed, let T be the true time, α_1, α_2, α_3, &c., the errors, t_1, t_2, t_3, &c., the calculated times, then—

$$T + \alpha_1 = t_1$$
$$T + \alpha_2 = t_2$$
$$T + \alpha_3 = t_3$$
$$T + \alpha_n = t_n$$
$$\therefore \quad T = \frac{t_1 + t_2 + t_3 + \&c. + t_n}{n} - \frac{\alpha_1 + \alpha_2 + \alpha_3 + \&c. +.}{n}.$$ [3]

Now, since some of these errors are negative and some positive, we may make this result as small as we please, by taking n sufficiently great.

$$\therefore \quad T = \frac{t_1 + t_2 + t_3 + \&c.\ t_n}{n}, \text{ very nearly.}$$

When the distance between M and M′ is very small, as is the case in most vessels for a moderate amplitude, then the question is reduced to the case of a simple pendulum, the length of which is G_dM. Therefore K being the radius of gyration of the ship round a longitudinal axis through its centre of gravity,

$$T = \frac{\pi K}{\sqrt{g.G_dM}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(I.)}$$ [4]

K is obtained by multiplying each of the elementary weights of the vessel by the square of its distance from the horizontal axis through the centre of gravity, and extending the summation throughout the whole ship. Divide this result by the total weight of the ship when ready for sea, and extract the square root of the quotient, which gives K.[5]

We see from (I.), that the time of a natural oscillation varies directly as the radius of gyration, and inversely as the square root of the distance between the centre of gravity of the vessel and its metacentre. Hence, by increasing K, which may be done by moving the weights on board further from the axis about which the ship revolves, the time of oscillation is increased; also K remaining constant, if GM be diminished, T is also increased, and *vice versâ*.

Canon Moseley gives the following approximate result for the time of performing an oscillation:—

$$T = \frac{\pi K}{\sqrt{g\left(+GG_d + \frac{gk}{W}\right)}} = \frac{\pi K}{\sqrt{g\,G_dM}}. \quad \text{For } \frac{gk}{W} = MG_d.$$ [5]

Art. 11, formula (I.), where k represents the moment of inertia of the plane of flotation about one of its principal axes.

The Forces which act upon a Ship in motion, as they influence her general dimensions, form, and qualities.

The methods by which the displacement of a ship are found, and those by which the positions of her centres of gravity are determined, having been described, and the principles on which her stability depends having been

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[1] The reader who is desirous of learning more on this subject may consult the paper just cited, or Fincham's *Outlines of Ship-Building*, 3d edit.

[2] See Moseley's paper.

[3] It would be a very easy matter to compare the time of a vessel's rolling through any angle with a pendulum whose length varies between the limits G_dM and G^dM'. For we have only to conceive a fine string suspended from A, and carrying a bob at G_d, and passing through an exceedingly fine aperture in a rod G_dM', the latter rod making a vertical motion=MM′ in the same time that G_d completes the arc $G_dG'_d$,—that is, much on the same plan as the motion of the slide-valve of a steam-engine. Indeed, it would not be difficult to make the point M′ describe the exact curve traced out by this point during the motion of the ship, providing that curve be calculated; we should then be in a position to learn accurately what error is made by assuming M to be the point of suspension.

[4] See Earnshaw's *Dynamics*, p. 229; Poisson's *Mechanics*, vol. ii., chap. iii., art. 2 (Dr Harte's translation); or, Pratt's *Mechanical Philosophy*, chap. vii.

[5] From a paper by the Rev. Dr Woolley.

Forces affecting a Ship in motion.

Laws of resistances.

pointed out, it is now proposed to consider the forces which affect her speed through the water.

It was at a very early period pointed out by mathematicians, that the velocity with which water will run out through a hole in the bottom of a vessel is the same as that acquired by a body falling from a height equal to the depth from the surface of the water to the hole. The truth of this has been at various times tested by many experiments, and has been confirmed by all that have been made. Euler, in his work, *Theorie Complette de la Construction des Vaisseaux*, took this as the basis of his investigations of the theory of the resistances which solid bodies moving in a fluid have to overcome. A passage in the English translation of his work is given thus:—

"We know, both from theory and experience, that the water contained in a vessel, whose height is $= h$, will run out through a hole in the bottom with the same velocity that a body falling from the same height, h, would acquire. And if the letter g denotes the height through which a body falls in one second, we also know the velocity will be such that it would run through a distance $= 2\sqrt{gh}$ in the same time. Since, therefore, this velocity is supposed $= c$, or $2\sqrt{gh} = c$, and, by taking the square, $4gh = c^2$; whence we have the height sought, $h = \frac{c^2}{4g}$; consequently, the force of the resistance which a supposed plane surface $= f.^2$ will experience by moving in water, with the velocity c, will be $= \frac{c^2 f^2}{4g}$; and by this force the surface will be acted on, in a direction contrary to its motion. Hence, we see that this resistance is always proportional to the square of the velocity, and also proportional to the area of the surface itself, so that by this means the resistance is perfectly determined."

If the direct resistance to the motion of a vessel through the water were not lessened by her form, it would, by this rule, be ascertained by finding the weights of a column of water, whose base is equal to her midship section, and whose height is equal to that from which a body must fall to acquire the velocity at which she is propelled, and the resistances of similar vessels when moved with the same velocity, would be proportional to their midship sections. The direct resistance, however, to any plane surface will be diminished by placing a triangular, or other form of body, before and behind it; and many experiments have been made on the form to be added, with a view to discover the law of the diminution of this resistance, and thus to be able to approximate to the form of least resistance. All attempts to reconcile the theory of the resistances on the oblique surfaces thus presented to the fluid with the observations by experiment, have as yet failed. Bossut[1] gives the theoretical resolution of the resistance on the sides of a wedge-shaped body as follows, and then shows that this is found by experiment not to be true with respect to bodies with sharp ends moving in water:—

Let ADB (fig.12) be an isosceles triangle, moving in a fluid of infinite extent in the direction of its height QD. The face AD is subject, according to theory, to a resistance in the direction FE perpendicular to itself, such that in calling π the perpendicular and direct resistance experienced by the half-base AQ. When moved with the same velocity as the triangle, we have force

$$FE = \pi \times \frac{AD \times (\sin ADQ)^2}{AQ \times (AD)^2}$$

$$= \pi \times \frac{AD \times AQ^2}{AQ \times AD^2}$$

$= \pi \times \frac{AQ}{AD}$; and in a similar manner we have, for the other force BD, force $fe = \pi \times \frac{BQ}{BD}$, $= \pi \times \frac{AQ}{AD}$. Resolving each of the two equal forces FE and fe into the two others, FH FK, and fh fk, the one perpendicular, and the other parallel to the base AD of the triangle, it is evident that the two forces equal, and directly opposed to each other, FK and fk, destroy each other, and that the triangle is simply acted on in the direction QD by one force $= FH + fh = 2\,FH = 2\,FE \times \frac{AQ}{AD}$ $= 2\pi \times \frac{AQ^2}{AD^2}$. Hence, if we call this force $2\,FH = p$, and call the perpendicular and direct force which acts upon the base AB, when moved with the same velocity as the triangle $= P$, we have $p = P \times \frac{AQ^2}{AD^2}$. Comparing this formula with his experiments, Bossut found the following results in four instances of experiments with different models:—

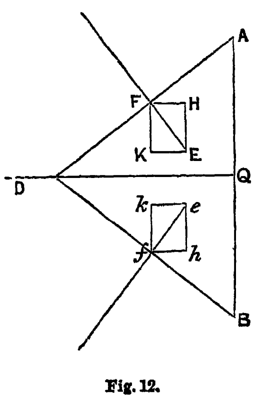

Fig. 12.

Forces affecting a Ship in motion.

Resistances on oblique surfaces.

Distinguishing No. of Model Experimented upon.	Angle of Incidence.	Value of p in Marcs	
		by Experiment.	by Theory.
9	45°	12·96 nearly	12
10	33° 41′	10·80 „	7·38 nearly
11	26° 34′	8·39 „	4·80
12	21° 49′	8·32 „	3·31 nearly

From the above it is seen that the results of theory differ further and further from those of experiment, the smaller the angle of incidence or the finer the angle of entrance of a ship is made. Further experiments have been made with a view to discover the law of this branch of the theory of resistances, but as yet without any results such as will enable any calculation to be made to determine beforehand, with any accuracy, the extent to which the resistance of a body of any given form will be diminished from that due to the base or midship section of the body. Even if a law were discovered for different angles of incidence, the difficulty of the investigation would still be great, when it is considered how constantly this angle varies in the form of the fore-body of a ship.

Resistances vary as the squares of the velocities, and are proportional to the surfaces.

Theory, therefore, fails to give any rule by which to ascertain, by any abstract calculation, the resistance of a vessel of any given form, and consequently to ascertain the velocity that she will obtain by the exertion of any given amount of power to propel her; and the naval architect is thus driven to ascertain these points by comparison with the results obtained from vessels of known form and power.

It has already been shown in the extract from Euler, that the resistances experienced by the same body, when moved at different velocities, vary as the squares of the velocities, and that the resistances of similar vessels, moved at the same velocity, are proportional to their surfaces or the areas of their midship sections. Many experiments have been made to test the accordance or otherwise of these theoretical deductions with the actual results obtained in practice. M. Bossut reported, as the result of the experiments conducted for the Royal Academy of Sciences at Paris in the year 1776, that the resistances of the same surface, moved with different velocities through a fluid infinite in extent, follow nearly the proportion of the squares of the velocities, and also that the perpendicular and direct resistances of several plane surfaces, moved with the same velocity, are very nearly proportional to the areas of the surfaces; and, consequently, that experiment and theory may be said to agree on these points. The experiments made in 1796 and 1798 in this country by the Society for the Improvement of Naval Architecture, and conducted by Colonel Beaufoy, lead to the same conclusion. These experiments were made with bodies of various forms, and at velocities varying from 1 to 8 nautical miles per hour. The relative proportion or degree in which the resistances and velocities varied in the bodies of different

[1] *Nouvelles Expériences sur la Resistance des Fluides*, Paris, 1777.

Forces acting on a Ship in motion.

forms differed comparatively slightly, being in some cases above the square or second power, and in other cases below it; in one instance it reached as high as the power of 2·2061, and in another instance as low as 1·7914, but the average of the results obtained from these experiments may safely be taken as corroborative of the theory.

Exception has been taken by some to the results of these experiments, because the bodies were entirely submerged, but the reasons for so conducting them appear to be stronger than those for conducting a series of experiments on bodies only partially submerged, and then subject to other influences than the action of the water through which they are passing. Deductions based upon the grounds thus established, as furnishing correct data on the subject of resistances, are of great practical value to the naval architect.

Propulsion of vessels by steam power.

The resistances, whatever they may be, of the same body, having been shown to be as the squares of the velocities, it follows necessarily that the horse-powers exerted to produce the different velocities will vary as the cubes of the velocities. This is evident, because the power is the product of the distance passed over, multiplied into the force exerted, while the distances vary directly as the velocities and the forces vary in the proportion of the squares. The origin and the truth of the formula in common use $\frac{V^3 \times \text{Mid. Sec.}}{\text{I.H.P.}}$ equal to a co-efficient C is therefore apparent; the resistances being in proportion to the areas of the midship sections; and I.H.P. being put to represent the indicated horse-power.

It is sometimes preferred to use a ratio of the displacement instead of the midship section, and as the ratio of the midship section of similar bodies is also expressed by the ratio of the cube root of the square of their cubical contents, this may be substituted in lieu of the midship section in the foregoing formula. It will then become $\frac{V^3 D^{\frac{2}{3}}}{\text{I. H. P}} = C$, and hence V, or any one unknown element in the formula may be found, all the others being known. A ready means of comparison between different ships is thus obtained. If the vessels are different in size, but mathematically similar, that is, if one is a type of the other, and the whole particulars of one are known, the velocity of the other, for any supposed amount of power, or the necessary amount of power to produce any proposed velocity, will be obtained.

The practical application of these principles to the propulsion of vessels by steam-power, which is always applied in the direction of the keel, would be easily carried out if the amount of power which is actually effective in propelling the vessel could be accurately ascertained separately from the power expended in working the parts of the engine itself, and in the friction. The total horse-power generated or exerted by the steam, is measured by the indicator, and is called the indicated horse-power; but engineers have as yet failed to discover any satisfactory method by which the effective can be separated from the gross horse-power. It is usual, therefore, to assume that, for every indicated horse-power, a given amount of effective power is exerted, and the gross power is argued upon as a measure of the effective power. In many cases this assumption is no doubt correct, but in many others it is open to great question, and results thus obtained must not be argued upon as by any means definite, or anything more than an approximation sufficiently accurate for most practical purposes.

The form of the engines and boilers to be used in the propulsion of a vessel is generally left by the naval architect to be determined by the engineers; but at the same time, the amount of power to be placed in the vessel, the weight and the positions of the centres of gravity, both vertically and longitudinally, of the machinery, must be duly considered and determined in concert with the naval architect. The form of the vessel at the place where the paddle-wheels, or where the screw are to act, also require special consideration on the part of the naval architect, otherwise the power exerted by the engine may be wasted, as it formerly was in churning the water when the paddle-wheels were boxed up in sponsons.

Forces acting on a Ship in motion.

The arrangements for the propulsion of vessels by the agency of the wind come within the province of the naval architect, and much consideration has been given to the subject in many works.

Resultants of forces acting on a ship under sail, and centres of effort.

When the ship is under sail, there are two forces acting on it—the one, the force of the wind on the sails, to propel the ship; and the other, the resistance of the water to oppose her motion. These forces, immediately the ship has acquired the velocity due to the strength of the wind, are equal, and, as is the case with all forces, may each be reasoned on as if acting only on one point of the surface over which its effect is diffused. This point is that in which, if the whole force were to be concentrated, its effect would be the same as when dispersed over the whole area: it is usual to call these, "resultants of forces," and the points on which they are supposed to act, "centres of effort."

Action of wind on the sails, and water on the hull.

From what has been before said, the resultant of the force of the wind on the sails, and the resultant of the force of the water on the hull, are equal; the one acting on the weather-side of the ship, in the direction into which the force of the wind resolves itself, and the other opposed to it, acting on the lee-side, in the direction into which the force of the water resolves itself; and their effect is necessarily in proportion to their distance from the centre of gravity. If they are equally distant, they will destroy each other, and the ship will remain at rest with respect to the line of its course; if the resultant of the resistance of the water passes before the resultant of the wind, the ship will turn to the wind; but if the resultant of the wind passes before that of the water, the effect will be the contrary, and the ship will fall off from the wind. In either case it will be necessary to equalize the forces, by the action of the water on the rudder, on its lee-side, to bring the resultant of the water more aft, and on its weather-side to destroy a part of the effect of the wind. This is the principle of the action of the wind on the sails, and of that of the water on the hull, with respect to the course of the ship through the water; and it is on these considerations only that the various alterations can be regulated, which it may from time to time be necessary to make in the trim either of the sails or of the ship; and hence the accurate determination of the positions and directions of these two forces is a point of great importance in naval architecture. The position of the centre of effort of the wind on the sails may be found under certain reservations; and that being known, enough is determined to lead to correct conclusions on the other circumstances attendant on the subject.

Centre of effort of wind before centre of gravity of ship, determines positions of masts.

In order to find the distance of the centre of effort of the wind on the sails before the centre of gravity of the ship, the moment of each sail is calculated by multiplying its area by the horizontal distance of its centre of gravity from that of the ship; the sum of the negative moments, or those abaft the centre of gravity of the ship, is then subtracted from the sum of the positive moments, or those before the centre of gravity of the ship; the remainder is then divided by the total area of the sails, and the result gives the required distance of the centre of effort of the wind on the sails before the centre of gravity of the ship. The situation of this point with respect to the length of the vessel must determine in a considerable degree the positions of the masts; for experience has proved that it is among the most essentially requisite good qualities of a ship, that she shall carry a weather-helm.

Effect and position of the rudder during continuous motion.

With respect to ships carrying a weather-helm, it may be assumed that the particles of water have a motion at the stern of the vessel, the direction of which forms an acute angle with the middle line of the ship produced aft, which angle will evidently be dependent on the fulness or the fineness of the after-part of the body, and on the angle which the line of the ship's course, or that of the lee-way, makes with the middle line of the ship; consequently, the

Forces acting on a Ship in motion.

inactive position of the rudder will be when it forms this angle with the middle line of the ship, that is, when the rudder is to leeward, and consequently, the helm a-weather. And this position should be the theoretic limit of the degree of weather-helm a ship should carry, as in any other position there must be a force acting on the rudder, which must increase the resistance the ship experiences in her passage through the water. A practical confirmation of the correctness of this principle, and of the fact that this generally advantageous position of the rudder is a-lee of the middle line of the ship, may be drawn from the common observation, that when a ship is in good trim, the helm, being a-weather, has a very perceptible tremulous motion, which must arise from the rudder being in a position in which it is not acted upon on either side by any constant force. This method of considering the direction of the flow of the water to the rudder considerably diminishes the estimate of the excess of its effect on the lee-side of the rudder over that on the weather. But there are several other considerations which operate in increasing the effect of the weather-helm. From the direction in which the water flows past the ship, there will be a much greater reduction of pressure on the weather-side of the rudder when the helm is to windward, and therefore a greater positive pressure on its lee-side to turn the ship, than will occur under the opposite circumstances, or when the helm is a-lee. Also, the broken and disturbed state of the water on the after-part of the weather-side of the ship, and the consequent various degrees of resistance it opposes, must lessen its effect when the helm is a-lee.

Experience confirms theseviews.

Weather-helm.

Ships with lee-helm leewardly.

It has been said to be proved by practice, that ships which carry lee-helms cannot be weatherly; that is, will fall faster to leeward than those which carry weather-helms. But though the fact is correct, the reason assigned is in some degree mistaking the effect for the cause. It has before been said, that a part of the force of the wind acts in driving a ship bodily to leeward; of course its effect will be greater or less in proportion to the lateral resistance opposed to it, and the ship which opposes less lateral and greater longitudinal resistance to the water than another, will in the same period of time have fallen farthest to leeward, and the line of her course will have made a larger angle with her middle line, by which the effect of the water on the after-part of the lee-side is increased, while that on the fore-part, both of the lee and weather sides, is diminished, and the helm must consequently be kept less a-weather. A practical proof of the correctness of this reasoning may be drawn from the practice of the older class of merchant-vessels, which are generally, from form, more leewardly than men-of-war. They have their fore-mast placed much nearer the centre of the ship than is usual in sharper and finer formed bodies. This has evidently arisen from the operation of the cause above mentioned, which has shown that they require the resultant of the effort of the wind on the sails to be proportionately farther aft to insure their carrying a weather-helm. From this reasoning it is evident that, under some circumstances, it may be the leewardliness of the ship which causes her to carry a lee-helm; and that when such is the case, the defect might be remedied, not only by the usual methods of placing the masts farther aft, and altering the draught of water, but by increasing the lateral resistance by the addition of false keel, or by greater depth in the water.

Effect mistaken for cause.

Disadvantage of lee-helm.

There is another disadvantage arising from a ship's carrying a lee-helm, which is, that the action of the water on the weather-side of the rudder acts in conjunction with the force of the wind in forcing the ship bodily to leeward; while, on the contrary, when the helm is a-weather, the action of the water on the rudder is in opposition to the force of the wind. The ardency of a ship, which is her tendency to fly to the wind, depends on the relative positions of the resultant of the effort of the wind on the sails, and the resultant of the resistance of the water on the hull. The position of the centre of effort of the wind on the sails is calculated under the supposition that the sails are plane surfaces, and equally disposed with regard to the longitudinal axis of the ship; but when a ship is on a wind, as the force of the wind acts in a direction oblique to the surface of the sails, a greater proportion of the sail is carried to leeward of this axis, and the whole sail assumes a curved surface, the curvature of which increases from the weather to the lee side. From these circumstances, the centre of effort is in fact carried gradually farther aft as the action of the wind takes place on the sails. Also, as the force of the wind inclines the ship, the centre of effort of the wind on the sails is carried, by this inclination, over to the lee-side, by which, as also by the effect produced on the resultant of the water, which has been before mentioned, the distance between them is farther increased. It therefore appears that, the quantity and disposition of the sail set remaining the same, the ardency will increase as the force of the wind increases, and diminish as that force diminishes. The defect of a vessel carrying a lee-helm may be lessened by those means of trimming either the sails or the ship, which will tend to increase the distance of the resultant of the water before the centre of effort of the wind. Great caution is necessary before altering the position of the masts with a view to remedy this defect, because her working quickly depends on the proportion of sail before and abaft the axis of rotation, and not on the position of the centre of effort of the whole surface of the sails. The limits of this article will not permit the subjects of masting, or rigging, or sail-making to be gone into. Much valuable information on the subject of the effect of the wind upon the sails, the angle of lee-way, the position of the centre of effort, and other points, will be found in the article SEAMANSHIP.

Forces acting on a Ship in motion.

Sails assumed to be plane surfaces.

Effect of their curvature.

Of increase of wind.

Pitching and scending.

The motion of pitching and scending is generally the most violent action to which a ship is subjected, and the most injurious, both to the connection between the parts of her structure and the velocity of her sailing. It is the longitudinal motion caused by the variable support afforded to the body by the waves as the vessel meets and passes over them; pitching being dipping of the bows into the water, and scending, the dipping of the stern. To obtain ease of motion in this respect, Mr Henwood advocated, in a paper published in the *Papers on Naval Architecture*, that the after-part of the ship, or that part abaft the centre of gravity, should be constructed so as to have precisely the same cubic contents as the fore-body, and that its centre of gravity should be at the same distance from the centre of gravity of the ship as that of the fore-body. The disposition of the weights, and especially of the masts, influences this motion in a powerful degree; because, though the weights in the fore and after bodies may balance each other while at rest, a greater weight, perhaps at a less distance, balancing a less weight at a greater distance; yet, when the ship is set in motion the balance will no longer hold, because the moments of the weights in motion will be according to the squares of their distances from the common centre of gravity. If a vessel pitches heavily, the moments of the weights forward are too great, and the contrary if she scends heavily abaft. An uneasy motion in pitching is much more common than in scending, and this no doubt arises from the generally very forward position of the fore-mast, especially in men-of-war. The importance of a little attention to this subject on the part of naval men will be at once apparent, when it is considered that the effect of moving or placing 5 tons at a distance of 120 feet from the centre of gravity of the ship is represented by the number $72{,}000 = 120^2 \times 5$, while it would be necessary to move 720 tons to a distance of 10 feet on the opposite side

Forces acting on a Ship in motion.

of the centre of gravity to produce the same effect on the pitching and scending motions of a ship.

Rolling.

The rolling motion of a ship is caused more by the undulations of the waves than by the shock of a wave striking the side of a ship. The principles on which the rolling of a vessel depends have been already investigated, and a few practical remarks will only be added here. The remark is common, and it is true, that the crank ship is the easy ship—that is, the more readily a vessel rolls, the easier will be the rolling motion. Mr Wilson, late of the Admiralty Office, in an able article in the *Papers on Naval Architecture*, says, "If stability is too great, the most efficacious way of diminishing the rolling is to bring up the ballast, because it raises the centre of gravity, and it increases the distance of the centre of oscillation from the axis of rotation. The ballast removed from near the keelson to the wings, even if placed as high as the deck, is as far from the metacentre as when it was in the hold, and consequently its weight multiplied into the square of that distance is the same as before; the rollings, therefore, will be slower." The cables, shot, stores, &c., in any ship, if placed near the side, while this will not affect the stability, will increase the distance between them and the axis of rotation, and will consequently lengthen the time of vibration. Mr Wilson proceeds to say, that it is by no means a difficult task to reduce a ship of extraordinary stability, which is always an uneasy one, to a state of easy rolling by increasing the masts and yards, and increasing the weights above and putting them in the wings, and removing some ballast, if she has any on board.

Fincham, in his *History of Ship-Building*, gives a remarkable instance of the extent to which the qualities of a ship may be influenced by other circumstances than her form. "The Mutine, an experimental brig, built to compete with others, was beaten on the first experimental cruise, but she afterwards beat the others, alterations having been made in the trim of her sails and in her stowage. After the alterations, instead of rolling the shot out of the racks and the wind out of the sails, as before, she rolled little, and neither deep nor quick. At first her weights were carried too low down."

Motion as influenced by general dimensions or form.

Length.

The motions of a vessel are much affected by the proportions which the general dimensions bear to each other. An increase of length gives an increase of displacement, or if this is not desired, it allows of finer lines forward and aft, and it also increases the stability and the resistance to lee-way. The power of turning, tacking, wearing, or making any other change in her course, is lessened by an increase of length; but this effect may be much modified by diminishing the amount of fore-foot, or of dead-wood forward, which will alter the position of the resultant of the action of the water, and will consequently also require a corresponding alteration in the amount or position of the forward and aft sails. A vessel need not necessarily pitch more heavily on account of any increase of length, but it is necessary in long vessels to take greater care that the weights of the fore and aft bodies are properly balanced in regard to their moments. It will be evident that the moments of small weights when placed well forward or aft, become very much greater in long vessels, when it is considered that all weights are multiplied by the squares of their distances from the centre of gravity of the ship for their moments.

The friction upon the sides of a vessel, from any additional length of parallel body amidships, appears to be very trifling, if we may judge from the results of cases where vessels have been cut in midships and lengthened, without any other alteration in their form having been made. The following is a statement of the results obtained by lengthening the Candia, a vessel belonging to the Peninsular and Oriental Company, by putting 35 feet into her amidships:—

	Trial before being lengthened, May 31, 1855.	First trial after being lengthened Aug. 8, 1857.	Second trial after being lengthened, Aug. 12, 1857.
Draft forward	18 ft. 6 in.	18 ft. 2 in.	18 ft. 2½ in.
„ aft	18 ft. 6 in.	19 ft. 5 in.	19 ft. 7 in.
„ mean	18 ft. 6 in.	18 ft. 9½ in.	18 ft. 11 in.
Area midship section	536 feet	551 feet	556 feet
Displacement	2,435 tons	3,036 tons	3,069 tons
Nominal horse-power	450	450	450
Indicated horse-power	1,415	1,250	about 1,400
Revolutions	34½ to 37	31	33
Pressure	22 lb.	16 lb.	20 lbs.
Vacuum	26½	26	26½
Speed	12,651	11,675	12,443
Pitch of screw	20 feet	21 feet	21 feet
Diameter of ditto	15 ft. 6 in.	15 ft. 6 in.	15 ft. 6 in.
Blades	3	3	3

Breadth.

By increasing the breadth amidships, as well as the average breadth throughout the whole length of the vessel, while the length and depth are kept the same as before, the stability, which varies as the cube of the breadth, is increased. As the angular momenta of the weights, estimated from the axis of rotation, vary as the squares of their distances from that axis, and the momentum of the action of a wave is increased in the same proportion, therefore the increase of stability is accompanied by increased violence in the motions, and consequent increased strain on the combinations and materials of the structure, and especially danger to the masts, by which the safety of the vessel may be compromised. The stability of a ship of war, being the quality on which the efficiency of her armament is essentially dependent, and which also, by enabling her to carry a press of sail in circumstances of danger, as a lee-shore, or an enemy of superior force, is essential to her safety; the only limit to its increase is involved in the consideration of easiness of motion. But if this consideration be neglected, and the breadth be such that the moment of stability in proportion to the moment of sail is so large, or of such sudden increase, that the masts are endangered or the combinations of the structure prematurely destroyed, the object for which a large moment of stability was desirable is frustrated. The breadth, therefore, is limited by easiness of motion. The best mode of insuring stability is to give a large area and great fulness and similarity of form immediately above and below the average water-line, as by this means the centre of gravity of the displacement will be kept at as short a distance as possible below the surface of the water.

Effect thereof on the stability of a ship.

Depth.

The depth of a ship, or her draught of water, may vary according to local circumstances or the objects for which she is to be employed, or by a judicious arrangement of her other proportions and of her form, and the positions of the centre of gravity. Good ships may be produced varying considerably in the proportions of their depth to their breadth.

Alteration of seat in water from consumption of stores.

An important consideration connected with the forming the design of a ship is involved in the gradual alteration of the vessel's seat in the water from the consumption of stores. It is not only essential that a ship should be possessed of stability combined with easiness of motion, be weatherly and quick in manœuvring when she is stored and completed for foreign service as a ship of war, or fully laden as a merchant-ship, but it is equally essential that she should be possessed of these qualities towards the expiration of her cruise, or on her return light from her voyage.

The loss of stability which results from the diminution of draught of water cannot be compensated by a proportionate arrangement of sail, without incurring other evil consequences. If the quantity of sail, which at all times is comparatively small in a merchant-ship, be lessened, the wind

Forces acting on a Ship in motion.

on the increased hull might so counterbalance its effect that she would be utterly unable to beat off a lee-shore, or make any way on a wind.

causing diminution of stability, and increased uneasiness.

A ship is not only subject to a loss in stability when lightened, but becomes laboursome, on account of top-hamper: her rolling motion is more violent as her diminished depth in the water decreases the resistance which is opposed to the inclination, and she also generally becomes more leewardly, owing to the difference made in the resultant of the resistance, the diminution of the lateral resistance, and of her power of carrying sail.

Difference of draught of water.

It is almost a universal custom in all vessels to give a greater draught of water abaft than forward. Occasional attempts have been made to discontinue this practice, as involving a supposed unnecessary increase in the water required for floating a ship; but the increased draught of water for the after-body has been reverted to as essentially requisite in practice.

Its advantages.

There are several minor advantages which result from this arrangement; such as the more easy and unchecked flow of the water to the rudder, and its consequent increased effect in governing the motions of the ship; also the diminution of the negative resistance which the vessel would otherwise experience from the greater difficulty with which the flow of water would fill the vacuity caused by the passage of the vessel, if the fulness of the after-body were such as would be required to preserve an even draught of water; and again, the adjustment of the resultant of the resistance of the water to that position of the masts which experience has determined to be requisite for the facility of manœuvring the sails. But the principal reason for the inequality in the draught of water appears to be the advantage which results from it to the more easy regulation of the motions of the vessel by an adjustment of the resultant of the resistance of the water on the lee-side when on a wind.

Designing of vessels.

The considerations which lead to a settlement of the general dimensions of a vessel, and which must vary greatly according to the purpose for which she is intended, having been touched upon, it is proposed to give an outline of the course pursued in designing the form, or making the *constructive drawing*, as it is termed, of any vessel. Three plans are required in all designs of vessels—the body-plan, the sheer-plan, and the half-breadth plan (see Plate III.) The form of the midship section, or a vertical cross-section at the point of greatest breadth, is generally the first portion of a ship that is designed; the outline of the sheer-plan may then be delineated, and after that the half-breadth plan may be begun. The vessel is supposed to be divided into a certain number of horizontal sections, and these are represented by the lines on the sheer-plan, marked 1st, 2d, 3d, 4th, and 5th water-line. The sheer-plan is either a vertical longitudinal section, or a side-plan of the ship, and on it may be delineated any points in her length or height. On the half-breadth plan are delineated the outlines of the horizontal sections previously referred to, and marked water-lines. These horizontal sections may either be parallel to the keel or to the intended water-line of the vessel if she is intended to draw more water abaft than forward. When parallel with the keel, they are sometimes called level-lines. The midship section is not necessarily in the middle of the length; it is called dead-flat, and is always marked as shown on the plate. The length of the vessel is divided into any desired number of sections, and these sections are marked forward and aft from dead-flat with distinguishing letters and figures. The water-lines being also drawn upon the midship section or body-plan, the form of the body at each section in the half-breadth plan is obtained by finding the distance from the centre-line at each water-line, and transferring it to the body-plan, showing the sections of the fore-body and of the after-body on different sides of the middle-line. In addition to these lines, the vessel is supposed to be cut into various longitudinal sections, at given distances from the centre-line; these lines of sections are shown on the half-breadth and body plans; and the form of the body where these cut the exterior surface of the ship are shown on the sheer-plan; they are marked 1v, 2v, 3v, in all the plans. The sections represented in all these plans must be fair and of easy curvature, and many little alterations will probably require to be made by the draughtsman, to get them to coincide.

The constructor or designer is now in a position to test his work by making the necessary calculations. These will be comprised in ascertaining the area of the midship section, the area of the load-water section, the displacement, the positions of the centres of gravity of these two sections, and also the position of the centre of gravity of the displacement.

The areas of the two sections, and the positions of their respective centres of gravity, are required to be determined, on account of the influence of these areas and their positions on the content of the displacement, and the position of its centre of gravity, and also in consequence of their influence on the stability of the ship. If the results of these calculations do not accord with the intentions of the constructor, or are inadequate to the development of his design, he must make such alterations in his curves or in his dimensions as he may consider necessary, before proceeding further with his design; and if he shall have sufficiently informed himself on the theory of ships, he will be enabled to do so with considerable confidence at this stage of his progress, as to the final result of his work.

These calculations are no doubt laborious, but there is no difficulty in them, and any moderately educated subordinate may soon be taught to assist greatly in working them out. Space will not permit an example to be given here; but the labour will be greatly facilitated by tabular forms, and examples will be found in Mr Peake's work on Ship-building, and in one of a series of articles on Ship-building in the *London Mechanics' Magazine* for 1859.

Before the design can be considered complete, it is necessary to ascertain the weight of the hull and of the whole of the proposed contents of the ship, and compare these with the calculated displacement. It is seldom that these weights can be obtained with perfect accuracy, and it is therefore scarcely necessary in practice to go to any undue labour to bring out results to fractions.

Scale of displacement.

It is usual to delineate the results of the calculations of the displacement in the form shown in Plate IV. The curved line representing the displacement of the ship at any draught.

Proportion of circumscribing parallelopipedon.

As a guide in commencing a design, it is also usual, and very useful, to know what proportion the circumscribing parallelopipedon will bear to the body of the ship—that is, multiply the intended length, breadth, and draught of water of the ship together, and deduct such portion as will leave a body of a form of any desired fineness. The amount to be deducted, or the decimal fraction by which the parallelopipedon is to be multiplied, varies, of course, for every class of ship.

Influence of form on rolling.

The form of the midship section, and of the other sections near it and therefore influenced by it, affect the question of rolling, by affecting the position of the centres of gravity of the displacement and of the ship and her weights; but there is no doubt but that if it were possible to keep these centres of gravity relatively in the same position with different forms of bodies, the rapidity and extent of rolling would still be influenced by the form, and be different. No rules can be laid down definitely on this subject; but ships with a form of midship-section approaching a semicircle have a bad reputation for rolling; as also those with a very rising floor, if accompanied with great beam, or such beam that the half-breadth exceeds the draught of water by more than 1 or 2 feet. A flat floor is also injurious, as tending

Form and Tonnage of Vessels.

to keep the centre of gravity of the displacement too low. Some good midship-sections of ships of various classes will be found in Fincham's *Outlines of Ship-Building;* but the great length now given to the fore and after bodies of ships renders the effect of the form of the midship-section much less influential on the general properties of a vessel than formerly, when the proportion of length was so much less.

Forms of water-lines. For the water-lines of vessels no definite instructions have been attempted to be laid down that have been of any practical value. A few general remarks may be made, to the effect that certain degrees of sharpness seem suited for different degrees of speed—the faster the vessel, the finer are the lines required; and if a moderate amount of power only be applied to a vessel, so that her speed cannot be great, it will be of little avail to give her finer lines than those suited to her actual speed. Hollow water-lines below the surface of the water seem to be beneficial for high velocities, but not at the water-line or above it, as the waves seem then to dash into the hollow and obstruct the vessel's way, by their being confined and not passing freely away.

Vertical lines. In all the plates given with this article, vertical lines are shown. The form of vessels, in respect of the sections shown by these lines, would appear to have been too much neglected by naval architects. It is considered that the form of vessels at the bows or at the stern, may be looked upon as made up of lines representing a wedge with its face vertical, and dividing the water sideways, combined with other lines representing an inclined plane, as in the Thames barges. Bodies of a wedge form were experimented upon by Colonel Beaufoy, as also others, with an inclined plane forward and aft to compare with them, and the results were decidedly in favour of the inclined plane; the inclined plane in the after-body having been proved decidedly superior.[1] The bodies which gave these results were those designated *m, b, m,* and *p, b, p,* and the experiments were conducted at the surface, and not with the bodies totally submerged.

Tonnage. The tonnage of a ship is her assumed capacity for carrying cargo of any description. The capacity or space required for a ton of iron being very different from that required for a ton of light goods, a certain number of cubic feet are necessarily taken as the measure of a vessel's tonnage. An empirical rule, founded upon obsolete proportions of a vessel's dimensions, continued in use for many years, serving as a measurement, not only of builders' tonnage, but also of the register tonnage for regulating the dues payable by the ship. This rule is still continued by builders as the measure by which ships are bought and sold; but as the price per ton may be varied in the same proportion as the dimensions, and are known at the time of purchase or sale, no evil results arise from this adherence to the old rule, however far the measurement may be from the truth.

This rule for old or builders' measurement was established by act of Parliament in the reign of George III. It enacted, that "the length shall be taken in a straight line along the rabbet of the keel of the ship, from the back of the main stern-post to a perpendicular line from the fore-parts of the main-stem under the bowsprit. The breadth also shall be taken from the outside of the outside plank, in the broadest part of the ship, either above or below the main wales, exclusive of all manner of doubling planks that may be wrought upon the sides of the ship." If the ship be afloat, the directions are, "to drop a plumb-line over the stern of the ship, and measure the distance between such line and the after-part of the stern-post, at the load-water mark; then measure from the top of the said plumb-line, in a parallel direction with the water, to a perpendicular point immediately over the load-water mark at the fore-part of the main-stem; subtracting from such admeasurement the above distance, the remainder will be the ship's extreme length, from which is to be deducted 3 inches for every foot of the load draft of water for the rake abaft; from the length, taken in either of the ways above-mentioned, subtract $\frac{3}{5}$ths of the breadth taken as above, the remainder is esteemed the just length of the keel to find the tonnage; then multiply this length by the breadth, and that product by half the breadth, and dividing by 94, the quotient is deemed the true contents of the lading."

The existing act for ascertaining the tonnage is a great improvement upon the above, and its directions are as follow:—Divide the length of the upper-deck, between the after-part of the stem and the foremost part of the stern-post, into six equal parts. Depth,—at the foremost, middle, and aftermost of these points of division, measure in feet, and decimal parts of a foot, the depths from the under-side of the upper-deck to the ceiling at the limber-strake. In case of a break in the upper-deck, the depths are to be measured from a line stretched in a continuation of the deck. Breadths,—divide each of these three depths into five equal parts, and measure the inside breadths at the following points; viz., at $\frac{1}{5}$th and at $\frac{4}{5}$ths from the upper-deck of the foremost and aftermost depths, and at $\frac{2}{5}$ths and $\frac{4}{5}$ths from the upper-deck of the midship depth. Length,—at half the midship depth, measure the length of the vessel from the after-part of the stem to the foremost part of the stern-post; then to twice the midship depth add the foremost and aftermost depths for the sum of the depth; add together the upper and lower breadths, at the foremost division, three times the upper breadths and the lower breadth at the midship division, and the upper and twice the lower breadth at the after-division, for the sum of breadths; then multiply the sum of the breadths by the sum of the depths, and this product by the length, and divide the final product by 3500, which will give the number of tons for register. If the vessel have a poop, or half-deck, or a break in the upper-deck, measure the inside mean length, breadth, and height of such part thereof as may be included within the bulkhead. Multiply these three measurements together, and dividing the product by 92·4, the quotient will be the number of tons to be added to the result as above found. In order to ascertain the tonnage of open vessels, the depths are to be measured from the upper edge of the upper strake. In vessels propelled by steam, the tonnage due to the cubical contents of the engine-room is to be deducted from the gross tonnage thus found. It is enacted that the tonnage due to the cubical contents of the engine-room shall be determined in the following manner; that is to say, measure the inside length of the engine-room in feet, and decimal parts of a foot, from the foremost to the aftermost bulkhead, then multiply the said length by the depth of the ship or vessel at the midship division aforesaid, and the product by the inside breadth at the same division, at two-fifths of the depth from the deck, taken as aforesaid, and divide the last product by 92·4, and the quotient will be deemed the tonnage due to the cubical contents of the engine-room.

Among the plates will be found vessels of the highest character of the present day. The Pera of the Peninsular and Oriental Company's fleet is a well-known vessel, and one whose results are looked upon as of the highest character; and if the form of her body, as shown by the vertical lines on the sheer-plan, be examined and compared with those of any of the other vessels, it will be seen that she excels in this particular. The kindness of the different owners and builders in permitting the lines of their different vessels to be published has been great, and it is to

[1] Beaufoy's *Nautical and Hydraulic Experiments,* Introduction, p. 43.

Performances.

be hoped that so much public spirit as is now manifested in this respect may be rewarded by still further improvements upon the forms of vessels.

The clipper sailing-ship Schomberg, represented in Plate III., is a specimen of a first-class Aberdeen clipper, built by Messrs Hall of Aberdeen.

The Lord of the Isles is a very fine iron vessel, built by Messrs Jn. Scott and Company of Cartsdyke, near Greenock. Although a sharp ship, she carries a good cargo of weight and measurement goods combined. On her first voyage from Clyde to Sydney she had 1300 tons of weight and measurement cargo on board, and made the passage in 70 days—a passage which, it is believed, has not yet been surpassed. Her register tonnage is $691\frac{23}{100}$ tons; and her tonnage, by builders' measurement, is 770 tons. She also made a passage from Shanghae to London in 87 days, with 1030 tons of tea on board. On one voyage she averaged 320 nautical miles for five consecutive days; and on her last voyage to China, in crossing the N.E. trades, her average way was over 12 knots.

Plates V. and VI. represent the rival yachts Titania and America, when the prize was carried off from all England by the latter. The sections of the vertical lines are shown upon the drawings of both of these yachts; and if the vertical lines on the sheer-plan of the one are traced and laid upon those of the other, a marked difference in favour of the America will be apparent.

Plate VII. is a representation of a paddle-steamer, the Delta. The engines in this vessel were taken out of a vessel of 500 tons, and put into the Delta, of nearly four times this tonnage, and the result is a specimen of what may be achieved by fine lines with a judicious application of power; the larger vessel having nearly a knot more speed.

Plates VIII. and IX. represent the Great Eastern, and from the fineness of her lines there can be no doubt of her success, if the engines do their duty.

Plate X. is a representation of the Bremen, a vessel whose performances have been such as to attract special attention, and to lead the Committee appointed by the British Association for the Advancement of Science to make the following report concerning her:—

"This Committee are assured, on authority which they believe to be unquestionable, that a certain vessel, the Bremen,[1] of 3440 tons displacement at the time of trial, propelled by engines working up to 1624 indicated horse-power, attained the speed of 13·15 nautical miles per hour. Now, if we estimate the dynamic duty thus performed by the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{Ind. H.P.}} = C$, we shall hav the co-efficient, $C = \frac{(13{\cdot}15)^3 \times (3440)^{\frac{2}{3}}}{1624} = \frac{2274 \times 227{\cdot}88}{1624} = 319$, and this co-efficient of dynamic duty, resulting from the mutual relation of displacement, speed, and power, appears, from the statements which have been communicated to this Committee, nearly 50 per cent. higher than that realised by the average performance of the steamships of the present day. The following are the co-efficients of dynamic duty deduced by the foregoing rule from the performances of mercantile steamers of high repute, of which the trial data have been communicated to this committee, viz. 325, 294, 291, 288, 259, 248, 231, 230, and 204, and many others below 200.

"This Committee, therefore, regard the Bremen as being a felicitous exemplification of naval architecture as respects type of form adapted for easy propulsion; and as we conceive that the promulgation of some of the constructive elements of this vessel may be of public importance, we are happy in being authorised and enabled, by Messrs Caird and Company, of Greenock, the constructors of the ship and of the engines, to communicate to the British Association the following statistical data as to the elements of construction of the Bremen:—

Performances and Tonnage.

Length between perpendiculars of stem and rudderpost		318 feet.
Breadth of beam		40 „
Depth of hold		26 feet.
Mean draught of water at the time of trial		18 ft. 6 in.
Displacement (D) at trial draught		3440 tons.
Area of maximum immersed section (A) at the trial draught		606 sq. ft.
Distance of maximum section (A) measuring from the stem		159 feet.
Constructors' load draught	forward	18 feet.
	aft	19 „
Displacement at constructors' load draught		3440 tons.
Rate of ships' displacement at constructors' load draught		25 tons per inch.

Data for laying off Peake's curve of sections.	Area of immersed vertical section at the distance of $\frac{1}{8}$ length measuring from stem			256·5 sq. ft.
	Do. $\frac{1}{4}$	do.	do.	486 „
	Do. $\frac{1}{2}$	do.	do.	606 „
	Do. $\frac{3}{4}$	do.	do.	489 „
	Do. $\frac{7}{8}$	do.	do.	253·5 „

Data for laying off curve of Displacement.	Displacement at draught of 4′ $7\frac{1}{2}$″, being $\frac{1}{4}$ load draught	300 tons.
	Displacement at draught of 9′ 3″, being $\frac{1}{2}$ load draught	1165 „
	Displacement at draught of 13′ $10\frac{1}{2}$″, being $\frac{3}{4}$ load draught	2240 „
	Displacement at draught of 18′ 6″, or load draught	3440 „

"The foregoing data afford all the particulars required for the construction of Peake's curve of vertical sections, whence may be deduced the position of the vertical line passing through the centre of gravity of displacement, and also the positions of the centre of gravity of the fore and aft bodies respectively.

"It will be observed, from the foregoing data of the constructive elements of the Bremen, that the maximum immersed section is at the middle of the length, and that the vertical sections are in such ratio to each other, with reference to their respective positions, that the curve of vertical sections will be a close approximation to a parabola.

"The ratios deducible from the foregoing particulars of constructive data, combining Peake's curve of immersed vertical sections with the curve of displacement, will give a close approximation to the type of form of the immersed hull.

"The engines of the Bremen consist of two direct-acting inverted cylinders, 90 inches diameter and 3 feet 6 inches stroke, fitted with expansion-valves capable of working expansively to a high degree. All parts of the engines are felted and lagged with wood wherever practicable, the lower 16 feet of the funnel being surrounded by a casing forming a superheating chamber, the steam entering at the lower end, and passing off at the top into the steam-pipes leading to the cylinders.

"On the important question as to the extent to which the ordinary smooth-water trial of a steamer affords a criterion of the general average performance that may be expected of the vessel at sea, this committee has not been able to obtain such an extent of returns of the comparative smooth-water trials and sea performances of the same ships as enable them fully to respond to this part of the inquiry, and they refrain from expressing any speculative opinion, because they have adopted the principle which they desire to recommend to the notice of the British Association, that shipping improvement is to be discovered by statistical record and analysis of the constructive elements of ships that have practically shown themselves to possess good sea properties, rather than by assuming the mere theories of opinionative speculation, from whatever source such opinions may emanate; in short, that experience of actual performances at sea, statistically recorded and utilized by being made the basis of comparison, is the most reliable base on which to construct an inductive system of progressive improvement in naval architecture and marine-engine construction. This committee, however, have much satisfaction in being enabled to commence this inquiry by recording the sea performance of the before-mentioned vessel Bremen, on a passage from Bremen Haven to New York and back, during the months of June and July last, during the whole of which passages indicator-cards were frequently taken, and the indicated working power of the engines ascertained. On the out-passage the mean displacement was 2878 tons, the mean indicated horse-power was 1078, and the mean speed 10·28 knots per hour, giving a coefficient by the formula referred to = 204; but on the return-passage the mean displacement was 2990, the

[1] The Bremen is referred to as being the vessel which gave the highest co-efficient of dynamic performance of any vessel which was brought before the Committee, and of which the statistical data of construction were also given in a complete form.

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mean indicated horse-power 1010 and the mean speed at the rate of 11·92 knots per hour, giving a co-efficient = 348. Hence, the mean co-efficient of the out and home passage = 276, being about 13 per cent. below the co-efficient (319) obtained on the smooth-water test-trial of the ship. The state of the weather and the sea was also recorded daily: it appears to have been adverse on the out passage, but favourable on the home passage. The committee are therefore of opinion, that by following up this course of statistical record of the smooth-water trial and subsequent sea performances of ships respectively, a tabular statement might be compiled, showing the probable ratios of the coefficients of smooth-water and sea performance, corresponding to the various rates of speed for which steamers may be respectively powered, whence the smooth-water test-trials of ships may be made available as approximately indicative of the sea service capabilities of ships as respects their dynamic properties.

"Such are the statistical data of the constructive elements and dynamic capabilities of the Bremen; and if all steam-vessels engaged in the mercantile transport service of Britain were equally effective as respects the mutual relations of displacement, speed, and power; that is, capable of producing a coefficient of dynamic capability = 319, by the formula referred to, it is probable that the prime cost expenses of steamship transport per ton weight of cargo conveyed on long passages would, on the aggregate of the foreign trade of Britain, be reduced not less than 25 per cent. as compared with the prime cost expenses incurred by steam-vessels of the average dynamic capability in present use."

Tabulated results of the performances of many vessels will be found in the article Steam Navigation; but the following results of the trials in smooth water of four of the vessels, whose lines and dimensions are given in the plates, may be quoted here:—

Name of ship.	Draught of water.	Indicated Horse-power.	Speed in knots.
	ft. in.		
Delta	15 0	1612	14·609
Ceylon	18 6	2054	13·340
Pera	18 3$\frac{1}{4}$	1373	12·633
Nubia	17 3	1422	12·149

Plates XI., XII., XIII., and XIV. are specimens of very fine vessels in the fleet of the Peninsular and Oriental Company. The Pera is especially celebrated for her performances, as also the Ceylon. The following table is interesting as showing the performances of the Nubia on her actual voyages at sea:—

S.S. Nubia.—*Calcutta to Suez.*

									Under Weigh.	Under Steam.	Aver. Speed.	Coal Consumption.		
Voyage.	Sandheads to Madras, 663 Miles.		Madras to Point de Galle, 545 Miles.		Point de Galle to Aden, 2134 Miles.		Aden to Suez, 1308 Miles.		Sandheads to Suez, 4650 Miles.	Calcutta to Suez, 4757 Miles.	Sandheads to Suez.	Calcutta to Suez per		
	Time.	Speed.	Time.	Speed.	Time.	Speed.	Time.	Speed.				Voyage.	Hour.	Mile.
No.	H. M.	K. F.	H. M.	K. F.	H. M.	K. F.	H. M.	K. F.	H. M.	H. M.	K. F.	Tons.	c. qr. lb.	c. qr. lb.
4	52 25	12 5	43 8	12 5	178 55	11 7	114 20	11 4	388 48	431 0	12 0	974	45 0 22	4 0 11
5	66 55	9 7	52 30	10 3	201 27	10 5	112 45	11 5	433 37	464 0	10 6	1140	49 0 15	4 3 5
6	67 5	9 7	56 5	9 6	244 55	8 6	124 30	10 4	492 35	530 0	9 4	1194	45 0 6	5 0 2
7	54 55	12 0	46 30	11 6	193 48	11 0	118 0	11 1	413 13	474 0	11 2	1058	44 2 16	4 1 22
8	56 0	11 7	42 20	12 7	166 28	12 6	113 58	11 4	378 43	411 0	12 2	1046	50 3 17	4 1 16
9	59 40	11 1	57 0	9 4	176 50	12 1	124 40	10 4	418 10	441 0	11 1	1090	49 1 23	4 2 9
Under weigh, 27,900 miles; Under steam, 28,542 miles } Total									2525 6	2751 0		6502		
Average									420 51	458 30	11 0	1083$\frac{2}{3}$	47 1 2	4 2 6

Suez to Calcutta.

									Under Weigh.	Under Steam.	Aver. Speed.	Coal Consumption.		
Voyage.	Suez to Aden, 1308 Miles.		Aden to Point de Galle, 2134 Miles.		Point de Galle to Madras, 545 Miles.		Madras to Sandheads, 663 Miles.		Suez to Sandheads, 4650 Miles.	Suez to Calcutta, 4757 Miles.	Suez to Sandheads.	Suez to Calcutta per		
	Time.	Speed.	Time.	Speed.	Time.	Speed.	Time.	Speed.				Voyage.	Hour.	Mile.
No.	H. M.	K. F.	H. M.	K. F.	H. M.	K. F.	H. M.	K. F.	H. M.	H. M.	K. F.	Tons.	c. qr. lb.	c. qr. lb.
*3	112 15	11 5	178 0	12 0	51 15	10 5	55 30	12 0	397 0	431 0	11 6	1060	49 0 21	4 1 23
5	108 10	12 1	174 40	12 2	44 50	12 1	50 45	13 0$\frac{1}{2}$	378 25	433 0	12 2	1092	50 1 21	4 2 10
6	112 0	11 5	190 55	11 1	48 50	11 1	52 30	12 5	404 15	443 0	11 4	1048	47 1 7	4 1 18
7	122 10	10 5	206 30	10 3	53 0	10 2	65 25	10 1	447 5	478 0	10 3	1176	49 0 23	4 3 22
8	129 40	10 1	194 15	11 0	47 25	11 4	55 15	12 0	426 35	454 0	10 7	1174	51 2 24	4 3 23
·9	118 15	11 0	192 10	11 1	47 20	11 4	47 45	13 7	405 30	434 0	11 4	1082	49 3 12	4 2 5
Under weigh, 27,900 miles; Under steam, 28,542 miles } Total									2458 50	2673 0		6632		
Average									409 52	445 30	11 3	1105$\frac{1}{3}$	49 2 14	4 2 16
Under weigh, 55,800 miles; Under steam, 57,084 miles } Grand Total									4983 56	5424 0		13134		
Average											11 1$\frac{6}{10}$		48 1 20	4 2 11

Distance in calculating speed taken from Sandheads; but, in calculating consumption of coal, the whole distance to Calcutta is taken.—Coal account not available for other distances.

*** Instead of Voyage 4, on which iron shaft was broken.**

Materials used in Ship-Building.

MATERIALS USED IN SHIP-BUILDING.

Import-ance of a knowledge of the pro-perties of materials.

Nothing can be more important to the naval architect than a thorough knowledge of the properties of the materials with which he has to deal. He requires this to enable him to dispose them to the greatest advantage, and with the least possible expenditure; and thus to produce a well-proportioned structure of great and uniform strength. The introduction of iron as a material for ship-building has enlarged this field of inquiry, and has led to much discussion as to its merits in comparison with those of timber.

Timber.

The properties of timber will be first considered. A lengthened examination into the nature and qualities of the different varieties used in ship-building cannot, however, be attempted here, as the space which can be allotted to the subject will not admit of more than a few practical observations. Deterioration and decay, in timber-built ships, may result either from the decay to which timber itself is subject, in common with all organic matter, and which may be hastened or retarded according as destructive or preservative influences are brought into action; or they may be the consequences of an injudicious combination of destructive agents with the inorganic compounds of the timber, thus inducing not only premature but unnatural decay. All large masses of timber in close contact are subject to deteriorating influences, such as a high degree of temperature, an increase of moisture, or a want of free circulation of air. These and other agencies, by promoting fermentation, lead to the first stage of decomposition, whereas the reverse of these conditions would in like manner retard its progress. Moisture as well as heat is necessary to produce fermentation, but when heat and the other agencies are at work, moisture will generally be found to exist, either left in the timber itself, or absorbed by it from the atmosphere.

Durability.

Dry-rot.

Decay of timber, when accompanied by the growth of fungi upon its surface, has received the name of *dry-rot*. This term was probably applied to it in consequence of the peculiarity, that wood so decomposed becomes a dry friable mass without fibrous tenacity, the parasitical fungi robbing the timber of its substance to support their own growth. In general, decay, when it takes place in this particular form, may be traced to imperfectly seasoned material, and the inference may be drawn with a considerable degree of probability, that the natural juices of the timber are necessary to the growth of fungi, and consequently that if these juices could be entirely abstracted or destroyed, this species of decay might be prevented. It does not follow that the presence of any of these juices will necessarily produce dry-rot, should the circumstances in which the timber is placed be such as to tend to their dispersion, or to their remaining in a dormant state. But as they do undoubtedly remain in much timber that is considered seasoned, any alteration of circumstances to prevent a free circulation of air, to lead to a deposition of additional moisture, and at the same time to an increased temperature, will in all probability induce the growth of fungi, and cause the destruction of the timber.

In ships, the frequent presence of these injurious elements must necessarily tend to produce fermentation. But though these facts are perfectly well known, it is remarkable how little attention has been paid to the necessity of a free circulation of air upon the timber of such parts of a ship as are below the surface of the water. This may be effected in various ways, though it is doubtful whether in all cases the current of air produced by natural causes would induce a sufficiently rapid circulation. This subject was forcibly brought before the Admiralty by Mr Creuze in 1827, but was not taken up or acted upon. In the navy, the decrease of expense which would be occasioned by any increase of durability in ships, laid up in ordinary, would be great; and in reality, with proper care and arrangements, there is no reason why the timbers of a ship so situated should not be almost as durable as the same wood employed in houses and other structures. The expense caused by decay is even greater in ships than in houses, yet the attention paid to the subject has been in an inverse ratio. The same facilities for the prevention of decay are not available for ships in commission, and if their timbers should have been unseasoned, or have had much of the natural sap left in them, dry-rot must almost necessarily ensue. It may be especially looked for in ships sent to a warm climate immediately after their construction, and exposed to a high temperature, and of its attacking these, many instances have occurred even within the last few years.

The same evils exist to a greater degree in merchant-vessels. Private ship-builders are unable to keep their capital locked up in a large stock of the different classes of timber fit for the different ships they may be called upon to build, and as the purchaser ordinarily requires a speedy execution of his order, the use of unseasoned timber is the necessary consequence. No better arrangements for the prevention of decay seem to be made on board of merchantmen, after they are built, than on board of men-of-war. Lloyd's register of shipping may be said to have an injurious influence on this question. The register is kept by a joint-stock company, and a committee of their body composed of ship-owners, merchants, and underwriters, with a staff of professional surveyors, have laid down a code of rules for the construction of ships as a guide to their classification on survey. By these rules, a ship built of the very best species of timber, thoroughly seasoned, can be classed as a first-class ship for twelve years only; a renewal for eight years may be obtained, but not without much trouble and expense; and further extension again of four years involves another expensive survey. Sufficient inducements are apparently, therefore, not held out for increasing the durability of ships. Many teak-built ships have lasted longer than these assigned limits, and yet no attempts have been made to rival them, thus leading to the belief that Lloyd's rules have had the effect of rendering builders and owners satisfied with existing results. It has been argued that, to season a ship after she is built, by a free circulation of air, will cause shrinkage, and thus injure the good fitting and the strength of the fabric, and that it will strain the fastenings, and admit damp, and thus cause the decay it was intended to obviate. In reply to this it may be urged, that shrinkage could never be produced to this extent on the timbers of a ship by the circulation of air, had they not been in such an unseasoned state as to be totally unfit for use; and that even in such a case, it would be far better to take the chance of less certain mischief, than to leave the ship to inevitable destruction by dry-rot. These remarks show the importance of well-seasoned timber for ship-building, and have been insisted upon here, not from any supposed want of general knowledge of the fact, but to show the importance of applying the means which exist to remedy the evil.

It must be evident that when timber is to be closely jointed to other timber, to form a compact mass, the whole should not be wet with rain, or water-soaked when put in place. The importance of this is recognised by Lloyd's rules allowing one year to be added to the prescribed period of durability of any ship built under a roof. All vessels laid down in royal dockyards have this advantage.

Different qualities in different species of woods.

Different species of timber are possessed of very different qualities, both as regards their durability and their strength. Oaks and other hard close-grained woods, being the most durable, are chiefly used for the frames of ships. The juices of the oak are of an acid nature, and besides the ligneous, which it has in common with other woods, it contains the Gallic acid peculiar to itself. Oak when used in

an unseasoned state is extremely liable to dry-rot, which in some cases has been found to destroy it in the space of a few months. Teak is a very valuable timber for ship-building, but like other woods it varies much in quality according to the soil in which it is grown, and consequently requires great care in its selection. Morning saul, green heart, morra, and iron-bark, are also valuable woods. Like teak they are extremely durable, and are more oily and resinous in their nature than oak. The whole of the foregoing are classed together by Lloyd's committee as superior woods, and are admitted for the construction of ships classed for a durability of twelve years. The general classification of woods by this committee is as follows:—

Mahogany of hard texture, Cuba Sebicu, and pencil cedar, Adriatic, Spanish, and French oak	10 years.
Red cedar, Angelly, and Venatica; other continental white oaks, Spanish chesnut, stringy bark, and blue green..	9 „
North American white oak, and American sweet chesnut	8 „
Larch, hackmatack, tamarac and juniper, pitch pine and English ash..	7 „
Cowdie, American rock elm......................................	6 „
Baltic and American red pine, European and American grey elm, black birch, spruce fir, English beech......	5 „
Hemlock	4 „

There are some slight variations in the durability assigned to these when used for other parts of the ship than the ribs or frames. Elm, which decays very rapidly when alternately wet and dry, is very durable if kept constantly submerged in water. On this account, as well as for its qualities of strength and toughness, it is well adapted for the keels of vessels. Other woods will be mentioned hereafter when the sources of the supply of timber for ship-building are considered.

Means of preserving timber.

The difficulty of obtaining properly seasoned timber whenever it may be wanted, and the great expense attending the early decay of unseasoned timber, have led to various means being proposed for its preservation. Saturating the timber with various chemical compounds, has been the method generally suggested for its accomplishment. In India, Machonochie, by steaming his timber, and then condensing the steam in the tank, and producing a partial vacuum, endeavoured to dissolve and carry off the juices of the timber, and he then submerged it in an oil obtained from the chips and sawdust of teak. Steaming or stoving timber has always been considered advantageous for wood used in a green state. Exposing it to the action of water has been advocated with the same view, and this certainly tends to shorten the time required for weather seasoning thereafter. About 40 years ago the timber used in the royal dockyards was ordered to be submerged in salt water for some time, and then stamped with the word "salt." Pieces of sound timber with this mark are found in men-of-war up to the present day. Mr Kyan patented a process for preserving timber, by saturating it with corrosive sublimate; and Sir W. Burnett, late Medical Director-General of the Navy, patented the use of chloride of zinc, but with neither of these processes is the effect in all cases certain. Creozote appears to preserve timber with greater certainty than any other chemical material yet used. The timber is put into a close tank, the air is abstracted, and the vacuum is kept up for two or three hours by continued pumping, to allow the air to escape from the pores of the wood. The creozote is then introduced, and is forced into the tank, until a pressure of about 150 lb. to a square inch is obtained. This pressure is kept up by continued pumping during successive days for forty-eight hours, or for as long as may be required to make the timber absorb the requisite amount. This process is chiefly used for pine timber. Yellow pine should absorb about 11 lb. to the cubic foot, and Riga pine about 8 lb. The timber is weighed before it is put into the tank, and again after it is taken out, to ascertain the amount absorbed. Should this prove less than the amount required, it is returned to the tank for a repetition of the process.

Steaming and pickling timber. Corrosive sublimate. Chloride of zinc. Creozote.

Creosoted timber has hitherto been chiefly used by civil engineers in land and sea works. The objections to its use in ship-building are its offensive smell and its great inflammability. Its power of protecting timber from natural decay, and of resisting the *toredo novalis*, or any of the other worms to whose ravages ship's timber is subject, if it be not thoroughly covered with copper sheathing, appear to render it peculiarly fit for such a purpose as doubling upon a ship. If found to answer, it might be used in thin boards as a sheathing instead of copper.

Dr Boucherie's process with sulphate of copper.

Another process which is applicable to the preservation of certain descriptions of straight-grained and porous timber, has been patented by Dr Boucherie, a French chemist of note, and been brought forward in this country by a company formed for the maintenance of the permanent way of railways. They have published the following information respecting it. Instead of using great pressure, as before explained, to impregnate the tree, a moderate pressure only is applied to one end of it; the effect is to expel the sap, and fill the tubes or pores of the timber with the preserving liquor. The tubular structure of trees has been long known, and Dr Boucherie's process shows that no connection exists between the tubes laterally. Colouring liquid applied in the form of a letter or word at one end of the tree appears in the same shape at the other. The fluid used by Dr Boucherie is a solution composed of one part of sulphate of copper to one hundred parts of water by weight. The specific gravity of the solution, when of proper strength, at 60° Fahr., is 1·006, or nearly so. A water-tight cap is placed on one end of the tree which is to be saturated, and the solution is introduced within it by a flexible tube. The pressure required not being more than from 15 to 20 lb. on the square inch, it may be obtained in a very simple way, by raising the tank which contains the solution 30 or 40 feet from the ground. When the pressure is applied the sap runs in a stream from the opposite end of the tree; and a ready means exists of discovering when it is exhausted and the whole length of the tree penetrated, by rubbing the end with a piece of prussiate of potash, which will leave a deep brown mark when brought into contact with the copper of the solution. The sap and surplus solution, should any pass through the tree, may be pumped back into the reservoir, the sap being a better solvent of the sulphate of copper than water, if it should happen to be impregnated with lime or other impurities. There are certain kinds of timber which are impenetrable by the solution applied in the manner described. It answers best with trees that are the least costly, as beech, birch, larch, Scotch fir, alder, elm, poplar, &c. Trees felled any time between November and May may be prepared in the latter month. But when they are cut down in May or any month between then and November, they should be prepared within three weeks of the time of felling. It has been found, in the preparation by this system of vast quantities of timber for the French navy and railways, that the time necessary for the operation depends both on the length of the tree and on the description of timber. Trees of 40 feet in length, prepared at Fontainbleau for the French navy, required from eight to ten days to become sufficiently impregnated; whereas for lengths of 9 feet only, the process was accomplished in twenty-four hours. A summary of experiments made in Derby with this process is given in the following table. It will be observed from the facts there stated, that the pores of the poplar are more pervious than those of other woods; and the rapid and large absorption of the fluid by the memel timber shows, that the pores of fir timber, when the natural juices are dried up, still afford a continuous channel for its flow:—

Materials used in Ship-Building.

Summary of Experiments.

No. of Experiment.	Date.	Description of Wood.	When cut down.	Length.	Average Diameter.	Cubic Content.	Amount of pure Sap forced out before Solution perceptible.	Amount of Solution used to effect this.	Time in forcing pure Sap out.	Total Amount of Solution run out of Tank during operation.	Time of Operation.	Amount of Solution used per cube foot.
				Feet.	Inches.	Feet.	Quarts.	Quarts.	Hours.	Quarts.	Hours.	Quarts.
1	April 29, 1856	Beech	January, 1856	18	12¼	14¾	33	64	4	104	8½	7·04
2	May 1, 1856	Spruce Fir	April 23, 1856	18	11¼	13½	27	50	5	95	12	7·00
3	May 5, 1856	Poplar	April 1, 1856	18¼	11¼	13½	Copper perceptible from commencement.			130	11	9·60
4	May 7, 1856	Elm	Dec. 1855	18	11¼	13½	—	—	—	156	23	11·52
5	May 9, 1856	Alder	Feb. 1856	18	11	12	43	58	1½	176	31	14·64
6	May 10, 1856	Memel	—	18¼	11 by 11	15¼	Copper perceptible from commencement.			230	50	15·08
7	May 22, 1856	Birch	May 21, 1856	18	12¼	14¾	32	34	25 minutes.	184	3½	12 00
8	May 23, 1856	Scotch Fir	—	18	12¼	14¾	35	47	6	130	58	8 80

One great advantage attending this method, and which is likely to render its application very general, is the inexpensive nature of the apparatus required.

Weather seasoning.

Seasoning timber, by exposing it for a lengthened period without subjecting it to any other process, has received much attention, and much controversy has arisen upon the best mode of carrying it into effect. It may perhaps be stated as the general opinion, that rough timber may be improved in this country by stacking it off the ground, that it may not be injured by damp. Sided timber, thick stuff, and plank, should always be stowed under sheds, and these must be airy and well ventilated, without partial draught which could affect the ends or any one portion of the timber more than another. Two or three years are required to season these descriptions of timber to a moderate degree only. Mast spars are best protected when submerged under water, and if buried in mud they are still more effectuallly preserved. Boards of mahogany or fir are well seasoned by being stacked on end in the open air without covering, but raised a little from the ground to avoid damp. In the royal yards it was formerly the custom to allow ships to stand in frame for various periods before they were planked, but the necessity of building ships rapidly has of late years precluded the possibility of doing this; and the evil effects have been too apparent. The following tables show the results of weather seasoning, as collected by Mr Fincham, and published in his work on the *Outlines of Ship-Building* :—

A Table of the Shrinkage and Loss of Weight in Seasoning, of the principal Timbers used in Ship-building : the period of seasoning was ten years.

Species of Timber.		Green.		Seasoned.		Relative shrinkage and loss of weight.		Weight of a cubic foot.	
		Dimens.	Weight.	Dimensions.	Weight.	Dimens.	Weight.	Green.	Seasoned.
		in. in.	lb. oz.	in. in.	lb. oz.			lb.	lb.
English Oak	butt	6 by 6	7 8	6 by 5 14/16	6 7	1·000	1·000	60	51½
	top	,,	7 10	5 14/16 ,, 5 15/16	6 6	1·010	1·176	61	51
	butt	,,	8 0	5 15/16 ,, 5 14/16	6 5	1·010	1·588	64	50½
	top	,,	7 4	5 15/16 ,, 5 15/16	6 0	1·000	1·176	58	48
African Oak	butt	,,	9 2	5 12/16 ,, 5 12/16	8 0	1·068	1·059	73	64
	top	,,	8 6	5 13/16 ,, 5 13/16	7 2	1·066	1·176	67	57
	butt	,,	7 12	5 13/16 ,, 5 14/16	7 2	1·033	0·588	62	57
	top	,,	7 4	5 14/16 ,, 5 15/16	6 10	1·010	0·588	58	53
Italian Larch	butt	,,	4 15	5 15/16 ,, 5 14/16	4 8	1·000	0·411	39½	36
	top	,,	4 15	5 14/16 ,, 5 14/16	4 9	1·021	0·354	39½	36½
	butt	,,	5 0	5 14/16 ,, 5 14/16	4 9½	1·021	0·384	40	36¾
	top	,,	5 1	5 15/16 ,, 5 14/16	4 11	1·021	0·354	40½	37½
Scotch Larch	butt	,,	4 8	5 14/16 ,, 5 14/16	4 2½	1·021	0·323	36	33¼
	top	,,	4 10	5 15/16 ,, 5 15/16	4 1	1·000	0·530	37	32½
	butt	,,	4 5	5 15/16 ,, 5 14/16	4 0	1 010	0·300	34½	32
	top	,,	3 12	5 14/16 ,, 5 14/16	3 7	1·021	0·300	30	27½
Cuba Cedar	butt	,,	4 0	5 15/16 ,, 5 15/16	3 12	1·000	0·235	32	30
	top	,,	4 3	5 15/16 ,, 5 14/16	3 12½	1·010	0·411	33½	30¼
	butt	,,	3 14	6 ,, 6	3 0	0·979	0·823	31	24
	top	,,	3 10	5 15/16 ,, 6	3 5	0 989	0·300	29	26½
New South Wales Cedar	butt	,,	4 0½	5 15/16 ,, 5 14/16	3 10	1·010	0·382	32¼	29
	top	,,	3 12	5 15/16 ,, 5 15/16	3 6½	1·000	0·323	30	27¼
	butt	,,	4 6	5 15/16 ,, 5 15/16	3 8	1·000	0·823	35	28
	top	,,	4 5	5 14/16 ,, 5 14/16	3 9	1·021	0·706	34½	28½

A Table of the Transverse Shrinkage in Seasoning of Board,** 12 **inches square and half-an-inch thick : the period of seasoning was thirteen years.

Species of Timber.		Shrunk in Seasoning.	Species of Timber.		Shrunk in Seasoning.
English Oak	butt	1/12 the breadth.	Yellow Pine	butt	1/38 the breadth.
	top	1/13 ,,		top	1/48 ,,
African Oak	butt	1/27 ,,	Larch	butt	1/27 ,,
	top	1/32 ,,		top	1/48 ,,
Riga Fir	butt	1/32 ,,	English Elm	butt	1/24 ,,
	top	1/32 ,,		top	1/27 ,,
Dantzic Fir	butt	1/38 ,,	Canada Elm	butt	1/18 ,,
	top	1/38 ,,		top	1/21 ,,
Virginia Pine	butt	1/27 ,,	Cowdie	butt	1/64 ,,
	top	1/38 ,,		top	1/64 ,,

Materials used in Ship-Building.

Seasoning timber by desiccation.

Seasoning timber by exposing it to a current of heated air at a higher velocity than is engendered by natural causes, was introduced by Mr Davison. The desiccating process, as he terms it, and as explained by him to the institution of civil engineers in 1853, consists in impelling rapid currents of air through a chamber or chambers containing the wood; spaces being left between the ranges or tiers of timber for the heated air to act uniformly upon all its sides. The moisture, as soon as it is cooled, passes instantly away through an opening in the roof of the chamber, and this appears to be a distinguishing and essential feature in the process. The wood remains in the chamber until by weighing a sample from time to time, the whole aqueous matter had been expelled from its pores. Charring wood in a sand-bath was practised in the beginning of the last century, and apparently with some success; but the heat must have been much greater than that employed by Davison, and the process probably was much more rapid. In carrying out the desiccating system, attention must be paid to the following points:—Different woods and different thicknesses of wood, require different degrees of heat; hard woods and thick logs of wood require a moderate degree of heat, from 90° to 100° Fahr. The softer woods, such as pine, may be safely exposed to 120°, or even to a still higher temperature; and when cut extremely thin and well clamped, 180° or 200° have been found rather to harden the fibre and to increase its strength. Honduras mahogany in boards of one inch in thickness may be exposed with advantage as regards colour, beauty, and strength, to a heat as great as 280° or 300° Fahr. A slab of Honduras mahogany 1½ inch thick, cut fresh from the log, was wholly deprived of its moisture, amounting to 36 per cent. by exposure to the temperature of 300° for fifty consecutive hours. In practice, however, it is found that from 115° to 120° of temperature brings almost every kind of timber in slabs or boards of moderate thickness, safely and steadily towards complete desiccation in a comparatively short space of time. For boards up to 4 inches thick, one week is sufficient for every inch of thickness, thus one week for 1 inch thick, and four weeks for 4 inches thick, but beyond this thickness the proportions require to be increased. For 6 inches thick, seven weeks should be allowed; for 8 inches ten weeks, and so on. These periods are fixed on the supposition, that the rapid forced current of heated air will be kept up only during the day of twelve hours, and that the chamber will then be closed till the following morning, that being the customary mode of working.

English oak requires more than ordinary care when thus prepared. It should never be exposed under any circumstances for any length of time to a higher temperature than 105°; more intense heat has been found to act upon the Gallic acid, or on the fibres in some peculiar way, so as to produce internal fissures. Mr Davison also stated, that still heat like that of an oven had an effect upon wood totally different from that produced by a current of heated air. In the one case the fibre is rendered short, brittle, and weak; in the other, all that is valueless is driven away, and the albumen becomes solidified or coagulated into a hard compact substance, and the fibres gain a great increase of strength and rigidity. Seasoning under ordinary degrees of temperature has a completely different effect on the albumen, which, if not previously dissolved or washed out by any of the processes previously referred to, remains, when dried, in a soft spongy state, ready to become an absorbent of moisture.

It has been found by experience that 100 feet per second is the best velocity for the current of heated air, and with a proportionate area of inlet-pipe, a sufficient quantity should be delivered into the chamber to cause a complete displacement of the air and moisture in three minutes. If a desiccating chamber contains 30,000 cubic feet of air, 10,000 cubic feet ought therefore to be propelled into it per minute, care being at the same time taken that the area of the outlet or outlets for the escape of the moisture exceed the area of the inlet-pipe, and that they be so arranged as to avoid a direct current between them.

The Board of Ordnance adopted this system for gun-stocks in 1840. Previous to its introduction, about 400,000 stocks were undergoing regularly a course of seasoning, each requiring to be turned once or twice every year to avoid the ravages of worms or decay. In a report from Mr Lovell, then her Majesty's inspector of fire-arms, he states respecting some gun-stocks subjected to the process:—"One half of the number were quite fresh cut and green wood, the other moisty, had been about twelve months in store; the total weight before the process, 536 lb. 9 oz., and after sixteen days' exposure to a current of air heated to 110°, or 114° Fahr., that weight was reduced to 413 lb. 14½ oz.; that is to say, 122 lb. 10½ oz. of moisture had been driven off. Some of the stocks had been purposely selected with seen cracks in the butts and other faults, for I expected that those cracks and faults would be exaggerated by the heat of the chamber. But the result was not so; on the contrary, they were closed considerably behind the marks that had been stamped upon the ends of them before they were put in, and the whole number of stocks came out in good condition, and fit for immediate use." He proceeds to say,—"The wood is better seasoned than when dried in the open air; 1*st*, Because the albumen being dried on the pores and in the capillary tubes, renders the fibre stronger and less liable to absorb moisture; 2*d*, The wood is stronger, tougher, and, of course, more capable of withstanding the effects of violent vibration from the laternal adhesion of the fibre being better preserved; 3*d*, It works smoother and more waxy under the chisel, and has less tendency to speel and crumble away, which is generally the great fault of steam-dried timber. I have now worked nearly 30,000 desiccated stocks, none of which had been under the process more than twenty-one days; and my opinion is very decided, that the wood is more thoroughly seasoned, and with much greater certainty, than if it had been merely exposed to the open air in the usual way for three or four years. The desiccating chamber created in the royal manufactory at Enfield continues in full activity. The heat is kept down to a medium degree, between 90° and 100°; and at this temperature it delivers the stocks perfectly seasoned in fourteen to sixteen days, according to the quality of wood, whether of sap or heart; and I propose to subject the whole of the stocks to it in future, whether they have been air-dried previously or not, in order to make sure that the whole shall have been equally seasoned."

Some bearers of Riga pine and American elm, after they had been in use for about six years, and exposed for that length of time to a temperature of 115° or 120° of heat, at which the chamber invariably stood, were examined, and were found to be perfectly sound and in excellent condition; thus proving that the process, even though continued for so long a period, did not injure in the slightest degree the fibre or the strength of the wood.

It is difficult to understand how the timber subjected to this process can be rendered more capable of sustaining a tensile strain, if this be the case, but it is natural that the albumen, when hardened in the pores, should render it more incompressible, and therefore more capable of resisting any strain when the strength depends on this property. For hard woods, to which Dr Boucherie's process is not applicable, desiccation seems to be admirably adapted, Mr Lovell's experience with the walnut-tree gun-stocks appearing conclusive.

The following table is interesting, giving the results of experiments made by Mr Davison:—

Materials used in Ship-Building.

General Results of Desiccation, showing the Percentage lost by four kinds of Timber of different dimensions, seasoned by the Desiccating Process; the Number of Days in which the Seasoning was effected; and the Ratio of Time in which equal degrees of Seasoning were produced, upon duplicate Specimens by the artificial and by the ordinary processes.

Description.	Dimensions.	Yellow Pine. Average Percentage lost.	Yellow Pine. Average No. of Days desiccating.	Yellow Pine. Ratio of time in which equal degrees of desiccation were effected by the natural and artificial processes.	Mahogany. Average Percentage lost.	Mahogany. Average No. of Days desiccating.	Mahogany. Ratio of time in which equal degrees of desiccation were effected by the natural and artificial processes.	Riga Pine. Average Percentage lost.	Riga Pine. Average No. of Days desiccating.	Riga Pine. Ratio of time in which equal degrees of desiccation were effected by the natural and artificial processes.	English Oak. Average Percentage lost.	English Oak. Average No. of Days desiccating.	English Oak. Ratio of time in which equal degrees of desiccation were effected by the natural and artificial processes.
Board.	Inch. 1	20·76	21		25·8	26	6 : 1						
	1¼	18·	26										
	1½	14·15	26	36 : 1	24·0	37	16 : 1						
	Mean results	17·63	24·3	36 : 1	24·9	31·5	11 : 1						
Plank.	Inch. 2	35·	42	6 : 1	21·2	37	15 : 1	14·61	34·3	62 : 1	32·36	47	20 : 1
	3	23·43	47	9 : 1	19·69	44	71 : 1	19·48	46·66	36 : 1	28·43	58	36 : 1
	4	27·79	49	9 : 1	18·7	47	20 : 1	13·59	47·	42 : 1	28·98	58	20 : 1
	5	24·1	63	6 : 1	13·92	47	20 : 1	15·69	52·	18 : 1	29·69	58	36 : 1
	6	21·9	63	7 : 1	19·24	51	20 : 1	17·2	49·	59 : 1	26·51	58	36 : 1
	Mean results	26·44	52·8	7·4 : 1	18·55	45·2	29·4 : 1	16·11	45·79	43·4 : 1	29·19	55·8	29·6 : 1
	Sq. inch. 1	17·19	7	28 : 1	13·97	7	71 : 1	13·46	7	71 : 1	22·72	12	16 : 1
	1½	19·35	13	44 : 1	15·94	14	71 : 1	10·92	7	71 : 1	23·36	21	10 : 6
	Mean results	18·27	10	36 : 1	14·95	10½	71 : 1	24·38	7	71 : 1	23·04	16·5	13 : 1
Scantling.	Sq. inch. 2	37·19	23	6 : 1	17·56	23	71 : 1	12·05	12·33	71 : 1	29·38	37	20 : 1
	3	25·6	35	4 : 1	8·64	26	71 : 1	12·33	24·33	71 : 1	24·26	42	10 : 1
	4	13·27	35	20 : 1	17·81	40	16 : 1	10·94	35·66	59 : 1	19·36	40	16 : 1
	5	28·57	47	8 : 1	17·61	37	36 : 1	11·95	41·33	71 : 1	22·95	74	20 : 1
	6	22·48	47	7 : 1	16·93	47	36 : 1	15·95	43·66	53 : 1	16·13	86	36 : 1
	Mean results	26·2		9 : 1	15·7	34·6	46 : 1	12·64	32·11	65 : 1	22·57	55·8	20·4 : 1

Comparative Strength and Deflection of Desiccated Specimens and their Duplicates, denominated Woolwich Specimens.

Description.	Yellow Pine. Dimensions.	Yellow Pine. Broke with	Yellow Pine. Deflection.	Mahogany. Dimensions.	Mahogany. Broke with	Mahogany. Deflection.	Riga Pine. Dimensions.	Riga Pine. Broke with	Riga Pine. Deflection.	English Oak. Dimensions.	English Oak. Broke with	English Oak. Deflection.
	Sq. inch.	lbs.	inch.	Sq. inch.	lbs.	inch.	Sq. inch.	lbs.	inch.	Sq. inch.	lbs.	inch.
Desiccated specimens.......	1	45½	6	1	70½	9½	1	46	8¼	1	54½	9½
Woolwich „	1	40½	11	1	62½	8¾	1	48½	8¾	1	47½	11½
Desiccated „	1½	138	6	1½	185½	6¾	1¾	100	4⅞	1½	84½	4¼
Woolwich „	1½	107	4	1½	156	6⅛	1¾	127	5¾	1½	128½	7
Desiccated „	2	237	4	2	436	5¼	2	345	4½	2	385	4½
Woolwich „	2	282	3¾	2	394	5¼	2	363	4¼	2	327	4¾
Desiccated „	3	884	3⅝	3	1514	4¾	3	996	3¾	...	...	...
Woolwich „	3	716	4½	...	1318	5⅝	3	793	4½	...	...	...
Desiccated „	4	Were	⅞	...	...	...	4	Were	⅞	...	...	...
Woolwich „	4	not broken	1¼	...	...	...	4	not broken	1	...	...	...

The weights were applied at one end of the piece, at a distance of 3 feet from the fulcrums.

The slow progress made in the introduction of this process has doubtless arisen partly from a fear that so speedy a method of drying or seasoning is likely to warp and rend the timber. Though this result does ensue from exposing it to draughts in covered sheds, yet as the evil in this case arises from the partial action of the currents of air on the log or piece of timber, it need not be feared where the temperature and the current are equally diffused, as in the desiccating chamber. The expense of the apparatus is, however, a serious drawback to its introduction, except in works where a very large quantity of timber is used.

Season of felling timber.

The best season for felling timber has been a subject of some discussion; but the evidence that has been collected seems to be in favour of that which is winter-felled. Its specific gravity is less than if summer-felled; and it is natural to suppose that the less amount of sap in the tree will render it more readily and easily seasoned.

The relative value of the various woods must also de-

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pend upon their strength as well as upon their durability. The cohesive strength per square-inch, or power of resisting a tensile strain to tear the particles asunder, varies in different species. Professor Barlow, in his work on the strength and stress of timber, gives it as under for the following kinds of wood:—

Cohesive strength of timber.

Species of Timber.	Cohesive strength per square inch in lbs.
Ash	17,000
Teak	15,000
Fir	12,000
Beech	11,500
Oak	10,000
Pear	9,800
Mahogany	8,000

These being the breaking weights, it will not be safe in practice to expose timber to more than about one-half of them.

Power to resist a crushing force.

Professor Hodgkinson has investigated the powers of different species of timber to resist a direct crushing force, and the results which he obtained show that this power varied greatly according to the state of seasoning. He found that timber, when in a wet and unseasoned state, could be crushed by a force less than one-half of that which would be required to crush it when properly seasoned, the moisture acting as a lubricating medium to allow the particles to slide upon each other more easily.

The following, however, may be taken as the crushing weights of the different species named, in an ordinary state as regards their degree of seasoning:—

Specific Gravity of Specimen.	Species of Timber.	Resistance per square inch in lbs.
·560	Yellow Pine	5375
·540	Cedar	5674
·580	Red deal	5748
·640	Birch	6402
·660	Sycamore	7082
·753	Spanish mahogany	8198
·780	Ash	8683
·700	Dry English oak	9509
·980	Box	9771

No satisfactory rules have yet been promulgated to determine the weights which may be placed with safety upon wooden columns of different diameters and different lengths. It is not unusual in practice to confine the load to 500 lb. per square inch of section on a column of oak, and when required to carry this load per sq. inch, the length is generally limited to fifteen times the diameter. But, however short the column may be, it should never be loaded to a greater degree than one-third of the weights in the foregoing table, and the length should never exceed twenty, or at the utmost twenty-five, times the diameter without a great diminution of the load proposed above.

The strength of similar columns varies inversely as the squares of their lengths. Thus, if the weight which a column of oak of 5 inches diameter and 6 feet long will support with safety be taken at 9800 lb., a column of oak of 5 inches diameter, and 10 feet long, will support only 2450 lb., with an equal degree of safety, because by the proportion mentioned above

$$10^2 : 5^2 :: 9800 : 2450.$$

Transverse strength of timber.

The annexed table of data is given by Professor Barlow, in his work, for determining the weights which the different woods enumerated will respectively carry, when exposed to a transverse strain, and the rules which follow for its practical application are also taken from the same authority:—

Teak	2462	Elm	1013
English Oak	1672	Pitch Pine	1632
Canadian, ditto	1766	Red Pine	1341
Dantzic, ditto	1457	New England Fir	1102
Adriatic, ditto	1383	Riga Fir	1108
Ash	2026	Mar Forest Fir	1262
Beech	1556	Larch	1127

To find the ultimate strength of any rectangular piece of timber fixed at one end and loaded at the other:—

Rule.—Multiply the value given in the table of data by the breadth and square of the depth, both in inches, and divide the product by the length, also in inches; the quotient will be the breaking weights in pounds.

Example 1.—What weights will a beam of English oak sustain before it breaks, when the breadth is 8 inches, the depth 12 inches, and the length 10 feet from the point of support?

The relative strength of English oak, as given in the table, is 1672.

$$\text{Then } \frac{1672 \times 8 \times 12^2}{120} = 16{,}051 \text{ lb., or } 7{\cdot}255 \text{ tons.}$$

Example 2.—What weight will a beam of larch sustain before it breaks, when the breadth is 4 inches, the depth 6 inches, and the length 5 feet from the point of support? Answer—2704 lb.

To find the ultimate transverse strength of any rectangular beam, when supported at both ends and loaded in the centre:—

Rule.—Multiply the value given in the table of data by four times the breadth and square of the depth in inches, and divide that product by the length, also in inches, for the weight.

Example 1.—What weight will be necessary to break a beam of teak, the breadth being 10 inches, the depth 14 inches, supported at each end, and the distance between the faces of the supports being 20 feet, the beam being loaded in the middle?

For teak, the value given in the table is 2462.

$$\text{Then } \frac{2462 \times 4 \times 10 \times 14^2}{240} = 80{,}425 \text{ lb., or } 35{\cdot}904 \text{ tons.}$$

Example 2.—What weight will a beam of English oak carry before it breaks, the breadth being 8, the depth 12 inches; the beam being loaded in the middle, and supported at each end, and the distance between the faces of the supports being 15 feet? Answer—42,803 lb., or 19·153 tons.

If the dimensions of a beam be required so as to support a given weight, the following rule must be used:—

Rule.—Multiply the weight in pounds by the length in inches; and this product, divided by the tabular value, will give the product of four times the breadth and square of the depth; then the breadth being known, we can find the depth; or the depth being known, we can find the breadth.

Example 1.—What must be the dimensions of a beam of English oak to carry a weight of 5 tons in the middle, where the distance between the supports is 20 feet?

The tabular value for English oak is 1672, $\frac{11200 \times 240}{1672} = 1607$, which is the square of the depth multiplied by four times the breadth.

Let the breadth be 6 inches; then $6 \times 4 = 24$, or four times the breadth.

$$\text{Then } \frac{1607}{24} = 66.96 = \text{the square of the depth,}$$

and $\sqrt{66{\cdot}96} = 8{\cdot}18$ inches, or $8\frac{1}{8}$th inches nearly.

Or, if we take the depth at 8 inches, then

$$8^2 = 64 \text{ and } \frac{1607}{64} = 25{\cdot}1,$$

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and $\frac{25\cdot 1}{4} = 6\cdot 27$, or a little more than $6\frac{1}{4}$th inches = the breadth.

Example 2.—What must be the dimensions of a beam of red pine to carry a weight of 15 tons in the middle, when the distance between the supports is 30 feet? Answer—10 inches in breadth by 15 inches deep nearly.

If a beam be supported at both ends, and the load be equally distributed over its length, it will carry twice the weight; that is, the result obtained by the foregoing rule must be doubled.

If the beam be firmly fixed at both ends, so as to prevent the ends from rising, when the weight is applied in the middle, the result will be increased by its half; that is, a weight of 10 tons may be increased to 15 tons.

If the beam be fixed at both ends and loaded uniformly throughout its length, the result must be multiplied by 3; that is, a beam which will carry 10 tons in the middle when it is laid loosely upon its supports, will carry 30 tons when fixed at both ends, and the load distributed uniformly over its length.

It must always be remembered, in applying these rules to practice, that the weights found by them are the breaking weights. The proportion of the breaking weight with which it is considered safe to load a beam in actual use varies according to the nature of the material. In the case of cast-iron, which breaks without giving any warning, it is not considered safe to place more than one-third of the breaking weight upon it. In wrought iron and timber, which both show symptoms of being overstrained before they break, by becoming crippled, or by an amount of flexure so great as to be very observable to the eye, the load in practice may be one-half of the breaking weight, as found by the rules.

Experiments on the strength of materials are always valuable to practical men, as adding to the store of knowledge, and acting as a check on any rules which may be in use. A series of experiments on timber were made by Colonel Fowke, of the Royal Engineers, at Paris, during the universal exhibition held there in 1855, and the results were published at great length in the report upon that exhibition.

Mr Fincham made some experiments, with great care, on the transverse strength of timber, and the following table, showing the results, is extracted from his work on ship-building:—

A Table of a Series of Experiments on the Strength of the undermentioned species of Timber. In each case the piece was three inches square and four feet long between the supports, and the weights were placed in the middle.

Species of Timber and No. of Experiments.	Specific Gravity.	Weight at which the piece broke.
		Cwts.
English oak, the mean of 8 experiments	·791	32·973
Italian oak, the mean of 4 experiments	1·077	38·792
Dantzic oak, the mean of 4 experiments	·704	39·732
African oak, the mean of 4 experiments	1·021	59·897
Malabar teak, the mean of 4 experiments	·724	43·723
Moulmein teak, the mean of 4 experiments	·909	34·292
Riga fir, the mean of 4 experiments	·576	35·558
Dantzic fir, the mean of 4 experiments	·708	36·718
Italian larch, the mean of 4 experiments	·645	40·047
Scotch larch, the mean of 4 experiments	·561	27·750
Hackmatack larch, the mean of 4 experiments	·708	37·886
Cowdie, the mean of 4 experiments	·614	33·317
Bermuda cedar	·932	36·776
Cuba cedar, the mean of 4 experiments	·524	24·348
Van Dieman's Land cedar	·616	18·303
Mahogany, the mean of 4 experiments	·636	30·093
New South Wales mahogany, the mean of 4 experiments	1·382	36·777

Rigidity of timber.

Rigidity, or the opposite of elasticity, is the power of resisting deflection or bending, when a weight is placed upon a beam, or when a side pressure is brought to bear against it. This power is increased in a much more rapid ratio than the power to sustain loads without fracture; thus, in order that a beam may bear 10 tons with the same degree of deflection as one bearing 5 tons, much less increase of dimensions will be required than will be necessary for a beam whose breaking weight is to be 10 tons, in comparison with one whose breaking weight is 5 tons. The possession of rigidity in a lateral direction is necessary to every beam to a certain extent, to prevent its bending side-wise and becoming crippled, and hence beams must not be too much reduced in their breadth relatively to their depth. In practice, the proportions of 2 for the breadth to 3 for the depth, and also of 3 for the breadth to 5 for the depth, are very common; but in joists of floors, and in other situations, where side props, or supports to prevent flexure, can be introduced, the depth is often made in a greater proportion, with the advantage of a saving of material, to carry the same weight.

Supply of timber.

The supply of timber for ship-building purposes is a subject that has at various periods attracted much attention, both as regards the species grown in this country and those which are imported from abroad.

Some valuable remarks on foreign woods were lately made by Mr Leonard Wray, in a paper read before the Society of Arts, and published in their journal of 6th May 1859. He called attention to the fact, that before forests of the finest timber can be brought into beneficial use, a population is required to fell and trim the trees, as well as a good shipping port, and the cheapest possible means of bringing the timber from its native forests to the port of shipment. Honduras has long had its organised bands of wood-cutters, and has long been one of the most important timber-exporting countries. It now exports about 25,000 tons of mahogany and 6000 tons of logwood annually, and the woodsmen in pursuit of these two staple products continually pass and repass other species of the finest quality of timber in the world. Amongst many other fine trees found there, Mr Wray specially enumerated the following:—The green heart, the live oak (Bignonia), and other oaks; the mahoc, the bullet-tree, the Neesberry bullet-tree, the iron-wood, the locust, used for ships' planking and treenails; the dogwood, the red pine, the pitch pine (much superior to that of Carolina and the other southern states of America), the cedar *(Cedrela odorata)*, a light and durable wood, not liable to dry-rot, nor subject to the attack of insects, and of which the trunk is 70 or 80 feet long, with a diameter of from 4 to 7 feet.

The morra is described by Mr Wray as a most valuable timber, the trees often attaining a height of from 100 to 150 feet, the lowest branches being 60 feet from the ground. The wood is extremely tough, close, and cross-grained, so that it is difficult to split, and not liable to splinter, which renders it particularly adapted for ship-building, more especially in the royal navy. The trunk makes admirable keels, timbers, and beams; and the branches having a natural crookedness of growth, are unsurpassed as knees.

Sir R. Schomburgk, referring to this tree, states that it grows abundantly in Guiana, on the banks of the river Berima, which is navigable for vessels drawing 12 feet of water, so that they might load close to the spot where the trees are cut down.

Mr Wray also mentions many other fine timber trees as the growth of Guiana, and Assam, Tenassarim, and the provinces and settlements in the neighbourhood of the Straits of Malacca. He states that a quantity of teak has for many years been exported from Moulmein, and other parts along the coast, but that the field which this healthy and most pleasant country still presents is so inexhaustible

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that he considers it to stand unrivalled as a timber-producing country. Hitherto teak alone has been exported, but there are others which are considered quite equal, and even superior to it. He gives the following list of some of the best timber woods, which will serve to give an idea of the capabilities of these neglected provinces:—

Anan.—One of the hardest and most compact woods known.
Ahnaun.—Strong and very durable; used in ship-building.
Keoun-lac (Rottlera).—Excellent for rudders.
Kat-wat-na (Cedrela).—Large timber, 40 to 70 feet long; used for ship-building.
Ka-nyeng-kyaung-khyay.—For ship-builders; contains an aromatic oil, and is not attacked by insects.
Kyess-yo.—Similar to teak.
Kud-doot-alaiu.—A large tree; used in ship-building.
Kunnazoo.—A very large tree; very hard and durable timber.
May-Mayka.—Used in ship-building.
May-raug.—Said to be very durable.
May-tobek.—Used for the bottoms of ships, considered preferable to teak.
Mayam.—An indestructible, strong, heavy, dark-red wood.
Podauk.—A beautiful, compact, and hard wood, sometimes called rosewood.
Pengadoh.—Strong and durable.
Pien-mahne.—Yields very strong knee-timber.
Pyau-ga-deau.—Hard, dense, and durable; called iron-wood.
Soondra.—A very tough, elastic wood; said to be the strongest of all the Indian woods.
Thab-bau.—Fine solid timber, sometimes 70 feet long; used for boats.
Thau-kya.—A species of wood similar to Saul.
Tha-nat.—A kind of grey teak.
Tha-nat.—More resembling Saul.
Thau-That.—A capital wood, like Saul.
Theet-ya-hau.—A species of teak; close grained.
Theug-gau (Hopea odorata).—An enormous tree of the Saul tribe; yields a strong, compact, and excellent timber, considered superior to teak; also a quantity of good dammer or resin. Insects never attack this wood, nor is it liable to rot.
Tirbbac (Quercus Amherstiana).—An oak; large tree; used in boat-building.
Thounsauga.—A large tree; used in boat-building.
Thingau-kyauss.—Close grained, strong, heavy wood; used in ship-building.
Thubbae (Mimusops).—Used in ship-building.
Thubbor (Uvaria).—A large tree; used in boat-building.
Toung-byeng.—A kind of red Saul.
Thym-bro.—A good, strong, durable wood; used in boat-building.

Of the Malacca woods Mr Wray gives a long list, and of these he describes the following from his own experience while resident in the straits:—

Murbouw.—Very strong, hard, and heavy; used in shipping; not attacked by insects; will last 100 years.
Binlaugoor.—Valuable wood for ship-building, especially for planks, mast, spars, &c. It grows in great abundance, especially near Singapore, and is largely exported to Mauritius, California, &c.
Vamerlaut.—Hard, tough, and very durable.
Giham.—A pale yellow wood, close grained, hard, elastic, very durable, and generally used in boat-building.
Tampauce.—Used for house-building; hard, and exceedingly durable.
Tamboosu.—House beams; considered very durable.
Galam, *Tikoos* }—Hard, tough, elastic; used in boats.
Marautee.—Very large; light resinous wood, much used for planking, and in building boats.

Australia is the next country to which he directed attention; and though distant, it may yet become an important timber-exporting country, the timber being brought here as a home freight in return for our large exports. The trees of this country which are mentioned are the iron-bark, the tuart, the jarrah blue-gum, and morrell.

The tuart is especially mentioned as adapted for ship-building, as it is most difficult to split, and not liable to splinter.

The jarrah, whose stems average 65 feet long, nearly parallel, and without a branch or knot, is also a most important tree of this colony. It is not attacked by insects of any kind, nor has it any tendency to dry-rot.

There are forests of this wood, almost unmixed with other trees, in Western Australia, of more than 4 miles in depth, and which are known to extend for a length of 150 miles. Planks may be obtained from it 10 feet wide if desired. It is not only valuable as a ship-building timber, but also for furniture, being found of various shades of colour, and of almost every variety of grain.

A ship may therefore be loaded very advantageously with this timber after proper sawing-machinery has been erected in the country, as it may be converted into scantling and other pieces for furniture, which may be stowed along with the balk timber of any size that may be desired.

Some very fine specimens of pine have likewise been imported lately from Vancouver's Island, of immense size, of great strength, and very durable.

Specimens of foreign woods may be found in the collections at Kew; at the Kensington Museum; East India House; Somerset House, Admiralty branch; and at the Crystal Palace.

Since the publication of this paper, containing so much valuable information, and so liberally contributed by Mr Wray to the *Transactions of the Society of Arts*, and from which the foregoing extracts have been so copiously taken, contracts have been made by the government for green-heart Tuart and Jarrah timber. It is to be hoped that this is a prelude to timber from our own colonies being hereafter used in the royal dockyards in larger quantities.

The importance of ship-building timber for the merchant service is undoubtedly decreasing, on account of the increasing use of iron; and it therefore behoves the government to make its own arrangements to originate and foster this trade in those districts pointed out by Mr Wray.

Though insignificant in comparison with these magnificent trees of foreign growth, the increasing quantity of larch now grown in this country deserves attention.

The larch (*Pinus Larix*) now so much grown in England as well as in Scotland, is frequently called Scotch fir, thus being mistaken for the "Scotch fir" as so called in Scotland (*Pinus sylvestris*), which has a dark-coloured foliage. The latter is considered superior for the purposes of architecture, but larch is better adapted for ship-building purposes whenever its size is sufficient. Like most other woods, it varies extremely, according to the soil on which it is grown, and care must therefore be taken in its selection and use. It stands exposure to wet and dry better than most timber, and is hence much used for pit-props in coal mines. The late Duke of Atholl induced the government to build a vessel of larch from his forest. She was called the Atholl; and though her durability has been very great, no further attention appears to have been as yet paid to the subject by the authorities.

Weight of timber.

A knowledge of the weight of the different species of timber is necessary to the naval architect, to enable him to compute or estimate the weight of the hull of the vessel which he is designing or constructing. Mr Edye, the late assistant-surveyor of Somerset House, published an elaborate work containing tables of the weights and the displacements of the different classes of men-of-war of his day, but now rendered comparatively valueless by the introduction of steam-vessels and the great changes in the proportion of ships. The following table, containing the weight of a cubic foot of timber in a green and seasoned state, is extracted from this work; and if the weights of the different timbers be compared with their strengths as previously given, it will be seen that the heavier timbers may be used without increasing the weight of the vessel, as their scantling may be reduced, and the same strength be retained, and with advantage, also, as to durability:—

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Name of Timbers.	Green.		Seasoned.	
	lb.	oz.	lb.	oz.
English oak	71	10	43	8
Dantzic oak	49	14	36	0
African teak	63	12	60	10
Indian teak, green or seasoned, about the same...				
Malabar*	...		52	15
Rangoon*	...		26	4
Indian mast peon	48	3	36	0
Cedar	32	0	28	4
Larch	45	0	34	4
Riga fir	48	12	35	8
New England fir	44	12	30	11
Elm	66	8	37	5
Beech	60	0	53	6
Ash	58	3	50	0

* Malabar teak is the heaviest, and Rangoon the lightest of all the Indian teaks imported.

Materials in combination with timber.

Special care is required in the selection of materials to be used in combination with timber, in order that no chemical or other action, which may tend to premature decay, may take place between them and the timber. Great care is required in the use of iron for fastenings on account of the great affinity which exists between this metal and oxygen. The oxidation of the iron not only destroys the fastening itself, but has an injurious effect upon the timber surrounding it. If the nature of the wood be such that a supply of oxygen from the atmosphere can be kept up through its pores, the oxidation and destruction of the iron will be very rapid. The use of iron in combination with oak is particularly objectionable on account of the acid nature of this wood, and the quantity of oxygen which it contains. In oily and resinous woods the surface of the bolt, when driven, receives a coating of this matter, and is thus rendered less liable to oxidation. Such woods are also more impervious to the passage of a continued supply of oxygen. Iron fastenings, under copper sheathing, are also liable to be destroyed by the galvanic action which takes place between these metals. Many attempts have been made to prevent this action by driving the bolt so far into the wood that a cement of some kind could be put over the head of it, so as to break the connection between the metals, but no important results of any system of this kind are as yet known to have obtained.

Copper is therefore used largely for the fastenings of ships. This metal is liable to a very slight oxidation only upon its surface, and when this has taken place, all further oxidation ceases, and the metal is not destroyed, as is the case with iron. Copper, however, is not possessed of the same strength as iron, and is soft and ductile in comparison with it. It is therefore far from being so good a fastening, especially when driven through iron-knees and iron-riders. It is liable to be bent and crushed, or crippled at the neck, by the iron through which it has passed, if the ship be severely strained and work in any degree.

Some valuable experiments were made on the tensile strength of bolts of dockyard copper, Grenfell's copper, and Muntz's yellow metal, by Mr Jn. Kingston, of Woolwich dockyard.

The results are shown in the following table:—

Description of bolt.	Tensile strength per square inch.
Dockyard copper, average of 12 experiments	49,490 lb., or 23 tons very nearly.
Grenfell's copper, average of 11 experiments	46,592 lb., or 20¾ tons nearly.
Muntz's yellow metal, average of 11 experiments	49,945 lb., or 22¼ tons nearly.

Copper, from its ductile nature, is quite unfit to be used for any purpose where a cross-strain has to be resisted.

A late invention, by which a coating of copper is put upon iron, in the same manner that iron-plates are coated with tin, promises to be very valuable. Fastenings of this kind will then combine all the good qualities of both metals, and will tend materially to strengthen the general fabric of the ship.

Treenails of timber, equal in quality to that through which they are to be driven, make excellent fastenings, but their strength and their power of holding are not such that they can be used to the entire exclusion of metal fastenings.

Sheathing.

The materials used for the sheathing of ships to protect them from fouling, and from the attacks of the *teredo navalis*, and other destructive worms, are chiefly copper and Muntz's metal. These metals are kept clean by the sea-water acting slightly upon them as a solvent, or by oxidation; and a gradual waste is therefore taking place continuously from their surface, thus preventing the adherence of any animal or vegetable matter. With a view to obviate this gradual wearing away, Sir H. Davy proposed to induce a galvanic action upon the sheathing by attaching protectors of iron on its surface. He succeeded to some extent; but in proportion as the iron was eaten away and the copper preserved, it became foul with sea-weed and shell-fish, so that his proposal was abandoned.

Iron for Ship-building.

The use of iron having now become common in the construction of ships instead of timber, a thorough knowledge of its properties is thus rendered necessary to the naval architect. The properties of wrought or malleable iron, as a material for the construction of the component parts of ships, will first be considered in a general point of view.

Cohesive strength.

The strength of rolled iron varies with its quality; the results given will be those due to an average quality, such as ought to be used in ship-building. The cohesive strength of bar-iron, or its power to resist a tensile strain, may be safely taken at 25 tons, or 56,000 lb. per square inch of section. Messrs Robert Napier and Sons of Glasgow have made some valuable experiments on the cohesive strength of wrought-iron, and steel bars and plates, which have been published in the *Transactions of the Institution of Engineers in Scotland*, vol. ii., 1859, and the results, along with others, by Mr Fairbairn of Manchester, on iron-plates, are given here by their kind permission.

Bar-iron.

Table of the average Strength of Steel-bars, as found by Messrs Napier and Sons.

Steel-bars.	Strength per sq. inch of section.
Cast-steel for rivets	106,950 lb.
Homogeneous metal for rivets	90,647 „
Puddled steel-forged bars	71,486 „
„ „ rolled bars	70,166 „

The average cohesive strength of rolled bars of Yorkshire iron was found by Messrs Napier to be 61,505 lb. per square-inch, this being the mean of twenty experiments on bars varying from $\frac{11}{16}$th inch diameter, up to 1 inch square. And the average strength of bars manufactured by nine different makers in different parts of the country, and purchased promiscuously in the market, was 59,276 lb.; this being the mean of 110 experiments on bars varying from $\frac{11}{16}$th up to $1\frac{1}{8}$th inch diameter, and it is most satisfactory to find that the experiments showed a remarkable uniformity of results.

Experiments on plates by Mr Fairbairn.

Mr Fairbairn of Manchester directed his attention, at a very early date, to the subject of iron for ship-building, commencing his operations by the construction of various small vessels for canal navigation. In 1830 and 1831 he built three iron steam-vessels for the Forth and Clyde Canal Company, and to be employed as coasting traders to Grangemouth. These vessels made the voyage from Liverpool to Glasgow, and showed such symptoms of strength as to induce Mr Fairbairn to enter more largely into the business.

Materials used in Ship-Building.

Within the next four years he constructed a vessel for the Lake of Zurich, and two river-steamers of about 170 tons for the navigation of the Humber; and in 1836 he commenced the building of iron-ships at Millwall, on the Thames, in company with others. With a view to the introduction of correct principles into what was then a new line of manufacture, he made some valuable experiments at Manchester in 1838, to test the strength of iron-plates and of riveted joints. The results were communicated to the Philosophical Society of that town, and have since been republished by him.[1] The results which he obtained were as follow:—

Cohesive strength of plates.

Species of Iron.	Mean breaking Weight in the Direction of the Fibre, in tons per sq. inch.	Mean breaking Weight across the Fibre, in tons per sq. inch.
Yorkshire plates....................	25·770	27·490
„ „	22·760	26·037
Mean......................	24·205	26·763
Derbyshire plates....................	21·680	18·650
Shropshire plates....................	22·826	22·000
Staffordshire plates....................	19·563	21·010
Mean......................	21·350	20·553

The plates experimented upon were as nearly $\frac{1}{4}$ inch thick as could be obtained; due allowance being made, in calculating the results, for any excess or deficiency in thickness in the different specimens.

The section through AB was 2 inches wide. The plate having been made narrower there to ensure its breaking at that part. Plates were riveted on each side of the ends to stiffen them. The holes O (fig. 14) were bored through the

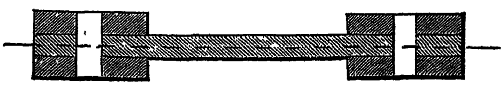

Fig. 13.

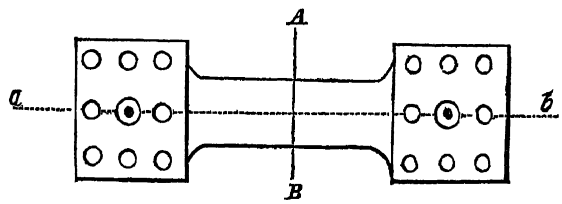

Fig. 14.

ends at right angles to the plates, with their centres in a direct line along the centre line of the part AB; and the apparatus for tearing the plates asunder was attached by bolts passing through these holes.

Iron-plates are supposed to be fibrous lengthwise, or in the direction in which they are rolled; but their cohesive strength ought to be nearly equal, whether the strain be applied with the fibres or across it. This uniformity of strength is attained by the shingles, or piles from which the plates are rolled, being composed of layers of bars carefully selected and laid at right angles to each other. When plates are very inferior in this respect, they may be supposed to have been manufactured from masses or blooms made up of irons and ores of different qualities, and these not sufficiently worked to amalgamate them properly. In testing iron-plates, it is therefore important to test their strength in both directions.

Messrs Napier's experiments.

The very extensive series of experiments on the strength of iron-plates by Messrs Napier have fully corroborated the results previously obtained by Mr Fairbairn. The strengths per square inch of sections were as follow:—

Materials used in Ship-Building.

Yorkshire Plates.

Lengthwise..55.433 lb.
Crosswise..50,462 „
Mean strength..52,947 „

This result being obtained from 45 experiments upon plates varying in thickness from $\frac{1}{4}$ inch up to $\frac{3}{4}$ inch.

Ordinary best, and best best boiler-plates, as manufactured by ten different makers in different parts of the country, and purchased promiscuously in the market—

Lengthwise......................................50,242 lb.
Crosswise......................................45,986 „
Mean strength......................................48,114 „

This result being obtained from ninety-three experiments upon plates varying in thickness from $\frac{1}{4}$-inch up to $\frac{3}{4}$-inch.

Glasgow Ship Plates.

Lengthwise......................................47,773 lb.
Crosswise......................................44,355 „
Mean strength......................................46,064 „

This result being obtained from twelve experiments on plates, varying in thickness from $\frac{5}{16}$-inch up to $\frac{3}{4}$-inch.

Messrs Napier made some experiments upon steel-plates also, with a view to test their value for the construction of light boats for river navigation, or for any portion of iron-ships generally. The results were as follow:—

The Mersey Company's Steel-plates, for Ships.

Per sq. in. of section.
Lengthwise......................................101,450 lb.
Crosswise...................................... 84,968 „
Mean strength...................................... 93,209 „

Steel-plates for Ships—Puddled Steel—"Mild"—by the same makers.

Lengthwise ....71,532 lb. per sq. in.
Crosswise..........................not recorded.

Blochairn Boiler-plates—Puddled Steel.

Per sq. in. of section.
Lengthwise......................................96,320 lb.
Crosswise......................................73,699 „
Mean strength......................................85,010 „

Homogeneous Metal.

Per sq. in. of section.
Lengthwise......................................96,280 lb.
Crosswise......................................97,150 „
Mean strength......................................96,715 „

Same Metal—Second Quality.

Per sq. in. of section.
Lengthwise......................................72,408 lb.
Crosswise......................................73,580 „
Mean strength......................................72,994 „

The portions of the plates tested by Messrs Napier and Sons were made of a similar form to those tested by Mr Fairbairn. As the result of these experiments, it may fairly be assumed, that iron-plates of good average quality should stand a strain of 56,000 lb., or 21 tons, as their breaking weight per square inch of section.

The results from the Yorkshire plates have been kept separate, because their quality and their price are such as to preclude their general use in ship-building. In boiler-making they are only used for furnaces, and those parts which require especial care.

The strength of rivets and of riveted joints, to connect plates in various ways, was also made the subject of experiment by Mr Fairbairn in 1838; and as no subsequent experiments appear to have thrown any further light upon the subject in its bearing upon ship-building, the results obtained at that time will be given.

The experiments were conducted in the same manner as those to test the strength of plates.

[1] *Useful Information for Engineers,* London, Longman & Co., 1856.

Materials used in Ship-Building.

In lap-joints with a single line of rivets, the edges are made to lap over each other, thus—

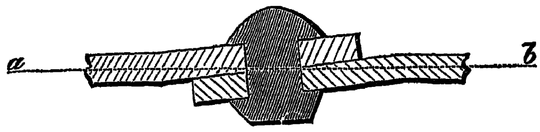

Fig. 15.

When the strain is applied to a joint of this kind, the edges of the plates turn up, and the plates themselves bend till they take the direct line of the strain, as indicated by the dotted line, *a b*.

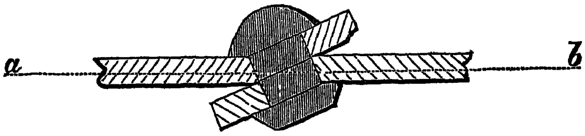

Fig. 16.

Plates may also be united by bringing their edges together to make a flush or butt-joint, putting an extra piece of plate behind the joint to which both plates are riveted by single lines of rivets, thus—

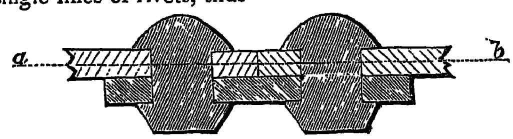

Fig. 17.

This joint also gives way by the plates bending and taking the line of strain; and no material difference of strength was found between this and the preceding joint.

Tredgold has shown that when the line of strain is not in the axis or centre of the material, the strength decreases with the divergence in a much more rapid ratio than the direct distance of the divergence. It is therefore evident that this evil is greatest in thick plates, and that the strength of thick plates will not be proportioned to that of thin plates, though the sections of each through the rivet-holes may bear the same relative proportion to the sections through the solid plates.[1]

Double-riveted lap-joints are those in which a second line of rivets is introduced. The edges are overlapped as in single riveting, but to a greater breadth, thus—

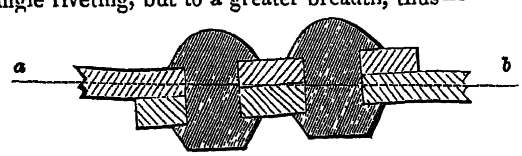

Fig. 18.

The line of rivets nearest the edge keeps it from rising.

In this joint the strength is much increased, but the plates bend as before, and take the line of tension when a direct tensile strain is brought upon them.

The edges may also be brought together flush, with a broader piece of plate behind the joints, and a double line of rivets, thus—

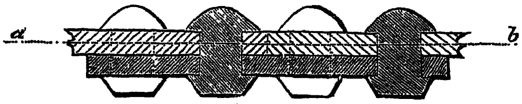

Fig. 19.

In this joint, also, the plates bend before they give way, and the strength is similar to that of the preceding double-riveted joint.

The relative strength of these joints, in comparison with the strength of the body of the plate, was found to be as follow:—

Strength of the plate	100
Double-riveted joints	70
Single do. do.	56

Materials used in Ship-Building.

Countersinking the rivets, or making the heads flush on the outside, was not found to make any appreciable difference of strength.

The strongest mode of jointing plates is by bringing a lapping piece of plate upon each side, and passing the rivets on each side of the joint through the three thicknesses. In the experiments of 1838 upon this joint, double-riveting only was tested; but in subsequent experiments suggested by Mr Fairbairn, and carried out in the construction of the Menai tubular bridge, four lines of rivets were used, thus—

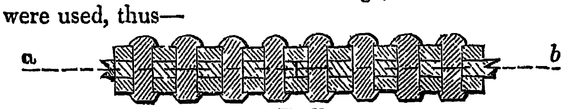

Fig. 20.

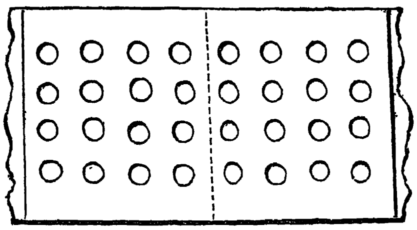

Fig. 21.

In this joint a tensile strain is directly in the line of the joint, and the material is therefore in the best position for exerting its full strength.

This joint, however, is not applicable to the sheathing of ships, on account of the necessity of keeping the exterior surface flush and smooth. But no other joint should be used in uniting plates in the construction of beams, or other parts, in the interior of a ship.

A complete system of two thicknesses of plates, for the whole surface of the plating, has been occasionally used, so as to break joint where a large flat surface of great strength has been desired, with a lapping piece on each joint, thus—

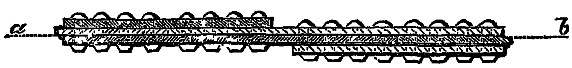

Fig. 22.

The evil, however, which results from the line of the strain not being in the centre line of the joint affects this system of double plating, and the full strength attainable from the material is not secured. The only advantage gained is, that in the event of one plate being defective, a partial remedy will thus be supplied by the second plate.

By the same series of experiments in 1838, the diameter and distance apart of the rivets, and the proper amount of lap for plates, up to ¾ inch thick, were very accurately ascertained, and the following table was formed:—

Table exhibiting the strongest forms and best proportions of Riveted Joints, as deduced from Experiments and actual Practice.

Thickness of Plates in inches.	Diameter of Rivets in inches.	Length of Rivets from the Head in inches.	Distance of Rivets from Centre to Centre in inches.	Quantity of lap in Single Joints in inches.	Quantity of lap in Double-Riveted Joints in inches.
·19 = $\frac{3}{16}$	·38 } 2	·88 } 4·5	1·25 } 6	1·25 } 6	For the double-riveted joint add ⅔ds of the depth of the single lap.
·25 = $\frac{4}{16}$	·50	1·13	1·50	1·50	
·31 = $\frac{5}{16}$	·63	1·38	1·63 } 5	1·88	
·38 = $\frac{6}{16}$	·75	1 63	1·75	2·00 5·5	
·50 = $\frac{8}{16}$	·81 } 1·5	2·25	2·00 } 4	2·25 } 4·5	
·63 = $\frac{10}{16}$	·94	2 75	2·50	2·75	
·75 = $\frac{12}{16}$	1·13	3·25	3 00	3·25	

[1] This subject has also been ably investigated in a pamphlet and report on W. Bertram's patent welding process, by Mr Renton, C.E.

Materials used in Ship-Building.

The figures 2, 1·5, 4·5, 6, 5, &c., in the preceding table, are multipliers for the diameter, length, and distance of rivets, also for the quantity of lap allowed for the single and double joints. These multipliers may be considered as proportionals of the thicknesses of plates to the diameter, length, distance of rivets, &c. For example, suppose we take $\frac{3}{8}$ plates, and require the proportionate parts of the strongest form of joint, it will be

$·375 \times 2 = ·750$ diameter of rivet, $\frac{3}{4}$ inch.
$·375 \times 4\frac{1}{2} = 1·688$ length of rivets, $1\frac{5}{8}$ inch.
$·375 \times 5 = 1·875$ distance between rivets, $1\frac{3}{4}$ inches.
$·375 \times 5\frac{1}{2} = 2·063$ quantity of lap, $2\frac{1}{16}$ inches.
$·375 \times 8 = 3·438$ quantity of lap, for double joints, $3\frac{1}{2}$ inch.

In practice plates and rivets of certain thicknesses and diameters only are obtainable in the market, and for these the table would stand thus:—

Thickness of Plates in inches.	Diameter of Rivets in inches.	Length of Rivets from the Heads in inches.	Distance of Rivets from Centre to Centre in inches.	Quantity of lap in Single Joint in inches.	Quantity of lap in Double-Riveted Joints in inches.
$\frac{3}{16}$	$\frac{3}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{16}$
$\frac{1}{4}$	$\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$2\frac{1}{2}$
$\frac{5}{16}$	$\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$3\frac{1}{8}$
$\frac{3}{8}$	$\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$2\frac{1}{16}$	$3\frac{1}{2}$
$\frac{1}{2}$	$\frac{13}{16}$	$2\frac{1}{4}$	2	$2\frac{1}{4}$	$3\frac{3}{4}$
$\frac{5}{8}$	$\frac{15}{16}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	$4\frac{1}{16}$
$\frac{3}{4}$	$1\frac{1}{8}$	$3\frac{1}{4}$	3	$3\frac{1}{4}$	$5\frac{5}{16}$

By using these proportions, it will be found that the rivets will not be sheared in two by the plates when a strain is brought on them, and that efficient joints will be made for all vessels which require to be steam or water tight. When this is not required, some additional strength may be obtained by enlarging the rivets and increasing the distance between them.

Machine riveting.

In forming the hull of a ship, the riveting is at present entirely performed by manual labour; but in the construction of beams, or any such separate parts, considerable advantage, both as regards strength and economy, will be obtained by riveting them by machine. The rivet by the latter process is more compressed, and thus made to fill the hole; and the operation being completed while the rivet is still hot, its shrinkage in cooling draws the plates together. This adds to the strength of the joint by causing friction, when a strain is applied to pull it asunder. The extent, however, of the advantage so obtained is necessarily very variable, depending on the amount of compression by the machine in forming the head of the rivet, and on the temperature of the rivet when closed, Mr Fairbairn does not attach much importance to it, and as it certainly does not exist to any important extent in hand-riveted work, it is safest to disregard it when any calculations of strength are being made.

Rigidity of plate.

The liability of plate to yield by flexure depends upon its thickness, and upon the amount of lateral support given to it, compared with the area of its surface. To give to different plates an equal capability to resist flexure, the unsupported lengths should vary as the thickness.[1]

Transverse strength of iron.

The transverse strength of iron equally requires the attention of the iron ship-builder. It is necessary to bear constantly in mind, that in supporting a load, or resisting a transverse strain, the upper portion of a beam, which is supported at both ends, is subjected to compression, while the lower portion is in a state of tension. The line between the particles exposed to these opposite forces is called the neutral axis; but its position and direction, whether straight or curved, has not yet been definitely or mathematically determined. If the material of which a beam is composed be better able to resist compression than extension, it is evident that there may be less material in the upper than in the lower portion of the beam. The power to resist fracture is therefore looked upon as mainly concentrated in these portions; and while the duty of the centre portion, called the plate or the web of the beam, has not yet been brought clearly under the rigid laws of mathematics, its chief duty may be said to be to keep the top and bottom flanches separate from each other, and in their relative positions.

Power to resist compression.

The power of iron to resist compression is generally taken at $31\frac{1}{4}$ tons, or 70,000 lb. per square inch.

It is one of the advantages of iron over wood that it can be made of any form, and that we can thus bring the foregoing principles, in as far as we are acquainted with them, into action.

Advantageous forms can be given to iron.

The accompanying sections may be taken as representing the sections of the beams in general use at the present day.

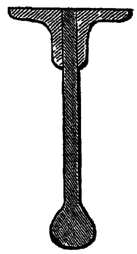
Fig. 23.

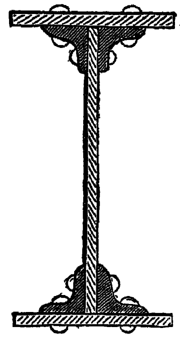
Fig. 24.

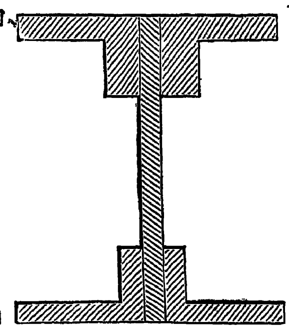
Fig. 25.

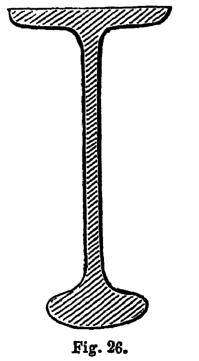
Fig. 26.

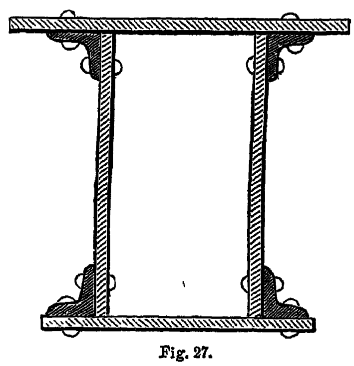
Fig. 27.

The proper proportions of iron-beams, and the consequent rules for their strengths, have been much discussed.

Box-girders were used for the paddle beams of vessels built at Millwall by Messrs Fairbairn and Co. as early as 1840. They are stronger than any of the forms of plate-beams given above; and for long spans on board ship, plate-beams should not be used on account of their want of lateral stiffness, unless they are supported by trimmers or fore and aft carlines.

The ordinary rule for the strength of iron-beams, as given by Mr Fairbairn, is applicable to all the foregoing forms, the number 80 being used as the constant to represent the strength of the box-beam, and 75 that of the plate-beam.

Let W represent the breaking weight in tons, a the area of the bottom flanche, d the depth of the beam, and l the length of the beam, C representing the constant as usual. Then the area of the bottom flanche multiplied by the depth of the beam, and by 80 for a box-beam, and 75 for a plate-beam, and the product divided by the length of the beam (all these dimensions being

[1] See *Proceedings C. E. Inst.*, vol. xv., p. 176; and the subject will be found further investigated, vols. xi., xiv., and xvi.

Materials used in Ship-Building.

taken in inches), will give the breaking-weight in tons—or $W = \frac{adc}{l}$.

It will be observed that the top flanche is not an element in this formula. Its correctness, therefore, is dependent upon the maintenance of certain relative and definite proportions in the parts, and it is not applicable to beams of indefinite forms or proportions. For beams of the ordinary length used in ships, the top and bottom flanches may be made of equal sectional area, and the greater the length of the beam the greater should be the comparative sectional area given to the top flange, to prevent its buckling or bending.

It has been argued that one-half the area of the centre web or plate should be added to the sectional areas of the top and bottom flanches, so as to include its strength as one of the elements of the formula, and a new formula be then deduced, but the rule, as given, is more simple, and may be relied upon.

From the nature of the material it is considered that wrought-iron beams may be loaded up to one-half of their breaking weight, though with cast-iron this limit is not permitted to exceed one-third.

The following are given as examples of the rule:—

(1.) What is the breaking weight of a box-beam 60 feet long, between the supports 18 inches deep, and the area of the section of the bottom flanche being 16 inches?

$$W = \frac{16 \times 18 \times 80}{720} = 32 \text{ tons.}$$

(2.) What is the breaking weight of a plate-beam 30 feet long, between the supports 10 inches deep, and the area of the section of the bottom flanche being 5 inches?

$$W = \frac{5 \times 10 \times 75}{360} = 10{\cdot}41 \text{ tons.}$$

Power of wrought-iron to resist a crushing force.

The crushing force which malleable iron is capable of sustaining has been stated to be 70,000 lb. per square inch, but it could only sustain this great load when the force applied is so truly in the axis of the material, and when the specimen under pressure is so short that no deflection is produced. Wrought-iron, however, is very liable from its nature to give way by bending or buckling when the length bears too great a proportion to the area of the cross-section. This was previously mentioned when the relative sections of the area of the top flanches of beams which are exposed to a crushing force were recommended to be increased.

It has been found by experiment that wrought-iron is crippled, and its power of resistance destroyed by a weight of 30,000 to 40,000 lb. per square inch, whenever the length is such as to permit of its bending. The load, therefore, which it may be considered safe to put upon it in practice may be assumed at 6000 to 8000 lb. per square inch for columns of ordinary proportions. With this load the length of the column should not exceed ten times its diameter, and however short the column may be made, the load should never exceed 10,000 lb. per square inch of section.

The strength of similar columns of wrought-iron, as before stated to be the case with wooden columns, also varies as the squares of their lengths inversely. In all columns it is most important that the pressure should be applied in the line of the axis of the material.

By Hodgkinson's valuable experiments on the subject of columns, it was found that the strength of a column rounded at both ends, in comparison with one whose ends were flat, was as one to three. This result no doubt arose mainly from the strain not being correctly conveyed and kept in the axis of the material. If the strain on a column be in any degree greater on one side than on the other, this side will be unduly compressed, while the other side will be extended, and fracture or crippling will take place with a very small proportion of the load which the column ought otherwise to have sustained.

Dr Young was the first to investigate this subject properly, and his work may still be consulted with advantage by any one who is desirous of following up this inquiry. When treating of the strength of riveted joints, the importance of attending to the line of the strain, when the material was exposed to a tensile force, was dwelt upon; and it is evident, from what has now been said, that this is equally important when it is exposed to a crushing force. In the latter case, if the column be in the least degree curved, the strain increases the deflection, whereas in the former any curvature will be diminished, the tendency being to pull the material into a straight line. Hence, it is of the greatest importance to place columns directly under the weight which they have to support, and by all means to avoid unequal strains on the sides, whether the columns be round or square. With wrought-iron it is also very evident, that by using a hollow column much greater strength is obtained from the same quantity of metal, great stiffness being obtained by the increased dimensions. Hollow wrought-iron tubes, such as those used by engineers in boiler-making, may therefore be used with great advantage. They may be rolled to almost any diameter and length likely to be required in shipbuilding. No experiments appear yet to have been made on the power of such tubes to resist a direct crushing force, but the following experiments were lately made at Portsmouth Dockyard, by Mr Lynn of that yard, to test their power of resistance when used at an angle, as a pair of sheer-legs, to raise screw-propellers on board ships. The tubes were $\frac{1}{2}$ inch thick, 4 inches external diameter, and 12 feet long. They were fitted with wrought-iron ends, the lower ends being prepared to rest on a step on the deck, and the upper ends had a double and single eye to fit into each other, and receive a pin for the shackle to carry the weight. The length was thus increased, from step to eye, to 12 feet 5 inches. At 9 feet spread at the base, one of the tubes which had been annealed in the fire for the purpose of straightening it, as it was slightly curved when received from the maker, deflected $\frac{3}{4}$ inch when the weight reached 26 tons. On removal of the weight it returned $\frac{3}{8}$th inch, leaving a permanent set of $\frac{3}{8}$th inch. At 7 feet spread at the base, the same tube yielded when the weight reached $29\frac{1}{2}$ tons, the other tube remaining uninjured.

Strength of wrought-iron tubes.

Durability of iron.

The durability of iron is entirely dependent upon the state in which its surface is kept. Under ordinary circumstances there is probably no better preservative than good paint; but in the interior of iron-vessels it tends materially to their preservation, if the surface be coated with asphalte, or cement sufficiently thickly to cover the heads of the rivets. In some cases it is even desirable, especially in the sharp run of a ship fore and aft, in the position of the dead-wood in a wooden vessel, to fill up the entire spaces between the frames, and form a flush surface. The exterior also of an iron-vessel is easily maintained in good condition by frequent painting. Below the water-line, where the surface cannot be reached by heeling the ship to a moderate degree, the iron is not apt to corrode. There is no chemical action by sea-water upon malleable iron, and there is not sufficient oxygen present below the surface to induce oxidation. In every instance in which an iron-vessel has been rapidly destroyed, it has been by corrosion on the interior surface. Great injury has in some cases resulted from acids leaking from certain cargoes, such as sugar, and also in parts where the leakage of brine from provision casks has been allowed to lie upon the plates.

For gun-boats or vessels, which it may be desired to lay up or preserve for any lengthened time, iron is peculiarly adapted, as, under such circumstances, the whole of the

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surfaces can always be attended to both externally and internally.

Malleable-iron, when submerged in salt-water, rapidly becomes foul by sea-weed and shell-fish adhering to its surface; but these do not cause decay; they may rather be said to form a coating to protect the iron from decay of any kind as long as it is submerged.

Iron in contact with copper acted on.

The decay of iron externally on ships' bottoms has, however, been observed to take place in the neighbourhood of copper-pipes. This is caused by a galvanic action which takes place between the copper and the iron, tending to the preservation of the former and the destruction of the latter, on the same principle as that proposed to be brought into action by the use of Sir Humphrey Davy's protectors for the preservation of copper sheathing. A layer of zinc at the point of junction, to separate the copper from the iron, will protect the iron, but as the zinc will then be rapidly eaten away, care must be taken that it is not used in such a manner that a leak would ensue in consequence.

Preservation from fouling.

The ready fouling of iron in sea-water is still a great drawback to its use. Many applications for this purpose have been proposed, but none seem yet to have been so thoroughly successful as to require any special mention as deserving of any decided preference.

Weight of iron.

The weight of a cubic foot of wrought-iron is 480 lb. The weight of a square foot of plate $\frac{1}{4}$th inch thick, is therefore 10 lb., and this gives a ready and easily remembered standard for calculating the weight of any surfaces of iron of different thicknesses.

PRACTICAL BUILDING.

There is, perhaps, no structure exposed to a greater variety of strains than a ship, and none in which greater risks of life and property are incurred.

Strains to which a ship is liable.

A consideration of the disturbing forces in action, either to injure or destroy the several combinations embraced in its structure, is therefore most important. And a thorough knowledge of their action is necessary to a practical builder to enable him to guard against them, in whatever form they may present themselves, and to dispose and arrange the materials at his command, accordingly, in the most judicious manner. Some of these forces are always in action whether the ship be at rest or in motion. She may be at rest floating in still water, or she may be cast on shore; and when there she may be resting on her keel as a continuous bearing, with a support from a portion of her side; she may be supported in the middle only, with both ends for a greater or less length of her body left wholly unsupported; or she may be resting on the ends with the middle unsupported: or under any other modification of these circumstances, and under all these the strains will vary in their direction and in their intensity.

If the ship be in motion, the same disturbing forces may still be in action, with others in addition, which are produced by, and belong only to, a state of motion. When a ship is at rest in still water, it has been before explained, that the upward pressure of the water upon its body is equal to the total weight of the ship, but it does not necessarily follow that the weight of every portion of the vessel will be equal to the upward pressure of that portion of the water directly beneath it, and acting upon it; on the contrary, the shape of the body is such that their weights and pressures are very unequal.

If the vessel be supposed to be divided into a number of laminæ of equal thickness, and all perpendicular to the vertical longitudinal section, it is evident that the after laminæ comprised in the overhanging stern above water, and the fore laminæ comprised in the projecting head also above water, cannot be supported by any upward pressure from the fluid, but their weight must be wholly sustained by their connection with the supported parts of the ship. The laminæ towards each extremity immediately contiguous to these can evidently derive only a very small portion of their support from the water, whilst toward the middle of the ship's length a greater proportionate bulk is immersed, and the upward pressure of the water is increased.

At some certain station from the middle of the length in each body, fore and aft, the upward pressure will therefore be equal to the weight of the superincumbent laminæ, and all the laminæ composing that portion of the body between these two stations will be subjected to an excess of pressure above their weight, tending to force them upward; which upward pressure will be the greatest at the laminæ having the greatest transverse area of section. Now, as the total pressure upward is equal to the total weight of the vessel, this excess of upward pressure to which the midship part of the body is subjected, must be equal to the excess of weight over the upward pressure in the parts of the vessel before and abaft those laminæ at which the pressure and weight have been supposed to be in equilibrio.

A ship, when at sea, is subjected to severer strains than when floating at rest, and if cast on shore it may be subjected to still greater strains. Its strength, therefore, as a fabric, should be considered with reference to the severest trial of strength which may be required of it under any circumstances.

A ship floating at rest under the view just taken of the relative displacement of different portions of the body, if the weights on board are not distributed so that the different laminæ may be supported by the upward pressure beneath them as equally as possible, may be supposed to be in the position of a beam supported at two points in its length at some distance from the centre, and with an excess of weight at each extremity.

At sea it would be exposed to the same strain; and if supported on two waves, whose crests were so far apart that they left the centre and ends comparatively unsupported, the degree of this strain would be much increased. The strain would be still more severe if the vessel got aground, and rested on two isolated points situated in the supposed positions in her length.

Under these circumstances, however, the strain would depend upon whether the weights in the middle or in the ends preponderated. The latter is the usual case; and then the whole of the upper portion of the vessel will be subjected to a tensile strain from the tendency of the ends to droop.

The more these two points of support approach each other, or if they come so near each other that the vessel may be looked upon as supported on one wave, or on one point only in the middle of her length, the greater will be the tensile strain on the upper portion, and the crushing strain on the lower portion of the fabric of the ship.

The importance, therefore, of so forming the deck and the upperworks that they may afford an efficient tie is apparent; and it is to be feared that this has been too much neglected, especially in many iron-ships.

If a vessel be weak in this respect, and touch the ground in the middle of her length, the consequences will necessarily be most disastrous, as she will open at perhaps more than one place, and her sides will tear down instantaneously after the tie of the deck and upperworks is gone. These results appear to accord with the accounts given of the manner in which several iron-vessels have broken up on their being cast ashore.

Hogging and arching.

A vessel whose weights and displacements are so disposed as to render her subject to a strain of this kind beyond what the strength of her upperworks will enable her to bear, will assume a curved form.

The centre is curved upwards by the excess of the pressure beneath it, and the ends drop, producing what is called

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"hogging." The main remedy for these evils, as before stated, is in the strength of the deck and upperworks, and their power to resist a tensile strain. There is seldom a want of sufficient strength in the lower parts of the vessel to resist the crushing or compressing force to which it is subjected. The decks of vessels should not, therefore, be too much cut up by broad hatchways; and care should be taken to preserve entire as many strakes of the deck as possible. The tensile strength of iron can be brought to bear most beneficially in this respect, and some continuous strakes of it laid upon the tops of the beams and below the deck-plank would add materially to the strength of all ships. Deck-planking has been sometimes laid diagonally at an angle across a ship, but it will be evident, from these remarks, that the value of the longitudinal tie is thereby much lessened, and there is no sufficient corresponding benefit of any other kind to justify the whole deck being laid in this manner.

Great sheer, or rising of the deck, fore and aft, is objectionable, from its lessening the strength of the longitudinal tie, though it is much practised, as it gives a lively appearance to a ship, and hides the defects of hogging if it should occur.

In the whole of the upper parts of a ship, as well as in the deck, every means should be taken to increase the power of resisting tension. In a wooden ship the upper part of the frame should be chain-bolted wherever the continuous range of bolts can be placed so as not to interfere with the in and out fastenings; and the shifts of the different wales, and other parts, which act as longitudinal ties, should be carefully attended to. The waterway-planks and shelf-pieces are also most important, and their continuity should be maintained throughout the length of the vessel, with as little diminution of strength as possible, at the junction of the different lengths.

In iron-vessels the parts corresponding to these are particularly important, as the plating exposes a very weak edge at the top, and is liable to be torn down if this edge be not well guarded and supported. To enable the lower part of the ship to resist the compression to which it is subject, the spaces between the frames in the best built wooden vessels are filled in solid, so as to make, as far as possible, an incompressible mass. The various abutments of this part of the body should be as closely fayed or fitted as possible. In iron-vessels, as the spaces between the frames cannot be filled in solid, the keelsons should be of great strength. The power of wrought-iron to resist compression, when it is prevented from buckling, is here of great value, as the fastening of the keelson to every frame as it passes gives stiffness and rigidity to it, and consequently great power to resist compression.

Though these are the strains to which a ship is most likely to be exposed, it by no means follows that there are no circumstances under which strains of the directly opposite tendency by recoil, when pitching and tossing, or otherwise, may be brought to act upon the parts. The weights themselves in the centre of the ship may be so great that they may have a tendency to give a hollow curvature to the form, and it is therefore equally necessary to guard against this evil. When this occurs, the vessel is technically said to be "sagged," in distinction to the contrary or opposite change of form by being hogged. The weight of machinery in a steam-vessel, or the weight or undue setting up of the main-mast, will sometimes produce sagging. The introduction of additional keelsons tended to lessen this evil, by giving great additional strength to the bottom, enabling it to resist extension, to which, under such circumstances, it became liable; and as the strain upon the deck and upperworks becomes changed at the same time, they are then called upon to resist compression. In iron-vessels, the waterway-planks and shelf-pieces are again, in this case, very important to aid in resisting this strain. The deck-planks may become shortened by the deck assuming a curved form in the middle of the length of the ship, the beams yielding and working with them; and a crushing strain is then brought to bear upon the plating of the topsides, which they are not calculated to sustain. Some light flat-bottomed river-steamers of iron with very full lines forward and aft, have given way from this cause. The best practical lesson upon the subject, and the most direct proof of the want of strength of iron-vessels at the topsides, if constructed without additional strengthening there, was given by the Nemesis when her topsides opened, as so well described by Captain Hall in his account of her voyage to India, and when he so judiciously strengthened her by attaching balks of timber longitudinally to the two sides.

A corresponding action to that described as hogging takes place in relation to the breadth of the vessel, but more particularly in the case of men-of-war, on account of the weight of the ordnance concentrated along the sides. The central portion of the body is subjected to an undue upward pressure, while the outer portions are strongly acted upon by the weight there tending to depress and immerse them. The effects of this action may be greatly modified by the form of the vessel; longitudinally, it produces the upward curvature previously referred to; and transversely, it tends to separation of the sides, except in three-decked or very lofty ships, in which, if the tumbling home be very great, the tendency is to produce a separation at the main breadth and below it, and a collapsing of the sides above it.

Horizontal pressure of the water.

Another force tending to alter the form of a vessel arises from the horizontal pressure of the water on the sides of the vessel. The sides are compressed or forced together, and the tendency produced is to add to the curvature of the deck amidships, and increase the hogging both longitudinally and transversely.

Forces which affect a ship in motion.

When a ship is in motion, if the surface of the sea be very uneven, so that her passage will be over the waves, the supports become very variable, and the opposing forces of upward pressure and gravitation will have a tendency to produce corresponding changes in the form of the body; and if the motion of the ship be violent, and thus produce any sudden shock or jerk, the strain upon the materials and upon the fastenings will become immeasurably increased.

Force of the waves.

When the ship is on a wind, the lee-side is subjected to a series of shocks from the waves, the violence of which may be imagined from the effects they sometimes produce in destroying the bulwarks, tearing away the channels, &c. The lee-side is also subjected to an excess of hydrostatic pressure over that upon the weather side, resulting from the accumulation of the waves as they rise against the obstruction offered by it to their free passage. These forces tend in part to produce lateral curvature. When in this inclined position, the forces which tend to produce hogging when she is upright also contributes to produce this lateral curvature. By experiments made on her Majesty's ship Genoa, in 1823, by Mr Moorsom, a member of the late school of naval architecture, he ascertained that this lateral curvature amounted to $1\frac{1}{2}$ inch on each tack, making an alteration of form to the extent of 3 inches from being on one tack to being on the other.

Tension of the rigging

The strain from the tension of the rigging on the weather side when the ship is much inclined is so great as frequently to cause working in the topsides, and sometimes even to break the timbers on which the channels are placed. Additional strength ought therefore to be given to the sides of the ship at this place; and in order to keep them apart, the beams ought to be increased in strength in comparison with the beams at any other part of the ship.

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It has been proposed to introduce tie-rods from the channels to the step of the mast, so as to render each mast and its supports a combination of struts and ties with the strains self-contained. This may be explained by the annexed figure.

Let AB represent the deck-beam, or beams of the ship at

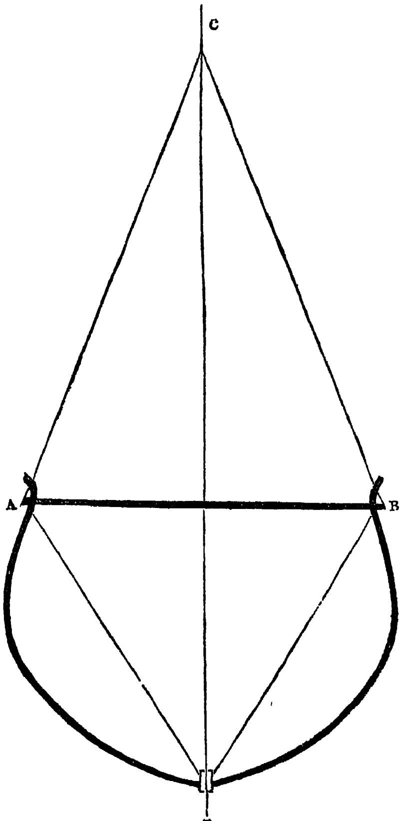

Fig. 28.

the channels, CD the mast, and AC and CB the shrouds. Now, if the ties AD and BD be introduced, it is evident that any additional strain brought upon AC or CB will be transferred to AD or BD, and resisted independently of any strength in the sides of the ship, so long as AB the beam, and CD the mast, are rigid and do not bend. By this system, also, any excessive strain is prevented from being brought upon the step of the mast at D, producing sagging, by setting up the rigging unduly. Though the ties AD and BD cannot conveniently be introduced in ships in direct lines, as shown in the woodcuts, the principle proposed may yet be brought into play by curved ties of sufficient stiffness not to straighten under the tensile strain to which they will be exposed.

General remarks on disturbing forces.

These are the principal disturbing forces to which the fabric of a ship is subjected; and it must be borne in mind that some of these are in almost constant activity to destroy the connection between the several parts. Whenever any motion or working is produced by their operation between two parts, which ought to be united in a fixed or firm manner, the evil will soon increase, because the disruption of the close connection between these parts admits an increased momentum in their action on each other, and the destruction proceeds with an accelerated progression. This is soon followed by the admission of damp, and the unavoidable accumulation of dirt, and these then generate fermentation and decay. To make a ship strong, therefore, is at the same time to make her durable, both in reference to the wear and tear of service and the decay of materials. It is evident from the foregoing remarks, that the disturbing influences which cause "hogging," commence their action at the moment of launching the ship, and are thenceforward in constant operation. As this curvature can only take place by the compression of the materials composing the lower parts of the ship, and the extension of those composing the upper parts as more particularly explained when treating of the strength of beams, the importance of preparing these separate parts with an especial view to withstand the forces to which they are each to be subjected cannot be overrated by the practical builder. The side of a ship is, however, in a somewhat different position from the plate or web of an ordinary plate-beam, or the sides of a box-beam, on account of the horizontal pressure of the water against it; and because in deep ships, with one or more intermediate decks, some of the strain is brought upon it in the middle of its depth. The position of the neutral axis or line between those particles exposed to a crushing and those exposed to a tensile strain, is therefore very difficult to determine; but from a consideration of the circumstances just mentioned, it must be higher in a ship than theory would place it if the ship were considered in the light of an ordinary beam exposed to strains brought upon it in the ordinary way.

Diagonal trussing as a means of resisting strains.

The importance of the system of diagonal trussing and bracing in ship-building appears to have been first fully appreciated by Sir Robert Seppings, and the principle on which it should be introduced to have been first explained by him. It is obvious that if four pieces of timber be put together, so as to form a square, or a rectangular parallelogram, with their ends connected by a round pin only at each corner, they may assume the form of any other parallelogram whose sides are of the same length, but that in so doing the length of the two diagonal lines will be altered; thus—

In both of the annexed figures, the sides are of the same length, but AC of fig. 29 is shortened into ac in fig. 30, and BD of fig. 29 is lengthened into bd in fig. 30. The introduction, therefore, of diagonals of a fixed or unalterable length into any piece of frame-work will tend to prevent alteration of form, and it will be perceived that the duty required of the two diagonals in resisting any change is different, the one being required to resist extension, and the other to resist compression. One diagonal only is sometimes considered sufficient, but in this case care must be taken that the material of which it is composed, and the manner in which it is applied, be such that it may be fit to resist either extension or compression, if the frame-work is liable to be alternately strained in either direction. In any piece of frame-work, however large, a straight wrought-iron bar is excellent as a tie, but as a strut it would be nearly useless on account of its liability to bend. Wrought-iron, however, is the material chiefly used in diagonal bracing; and it may be used with propriety for both diagonals, wherever on account of liability to a strain in both directions two are used, because each in its turn will resist extension, and that diagonal which is exposed to compression will be protected from injury by the resistance of the other to extension. The sides of a ship may be supposed to be divided into a number of pieces of frame-work of imaginary outlines or dimensions. Those embraced in the midship body may be supposed liable to be strained in both directions; but the upper portions of those composing

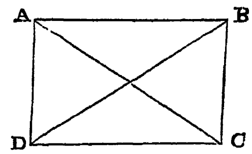

Fig. 29.

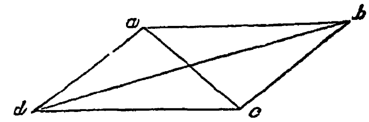

Fig. 30.

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the fore and after bodies will be inclined to fall forward and aft respectively; and if this tendency only is to be guarded against, the ties must be placed in different directions in the two bodies sloping up from below from amidships forward and aft in parallel lines, extension being the force which they will be called upon to resist. The system is not so much required in the bottom of a ship. In the decks diagonal trussing, placed diagonally across a ship, is advantageous as tending to prevent the ship working, by one side advancing or receding alternately with the other, and here the diagonals should be made to cross each other and lie in both directions.

Diagonal trussing, as used by Sir Robert Seppings, was introduced into some ships as a series of frame-work along the centre of the ship, from pillar to pillar, from the keelson to the decks, and he arranged these on the principle of depending upon struts and not upon ties. Wrought-iron was then much less used than in the present day, and timber forms an excellent material for a strut, weight for weight, in comparison with solid iron-bars, on account of its dimensions giving it stiffness. Struts are also convenient because they require comparatively little attention to the fastening of their ends. They abut against a surface, or into a corner, and their ends are easily prevented from shifting. With ties this is very different; their ends must be made sufficiently secure to resist a strain equal to their whole strength.

Before the introduction of this system, it was no uncommon thing to find ships hogged to the extent of from two to three feet. An instance is quoted in Portsmouth dockyard of an old ship, whose keel was curved upwards to the extent of two feet or more, and which was grounded in dry-dock on a set of blocks laid level. She straightened as she settled upon them, and diagonal trussing being then introduced, it was found to support her in a remarkable degree, when she was again floated. In this case the trussing was applied chiefly in midships, from pillar to pillar, from the keelson to the deck-beams.

In iron-ships diagonals are not so much required on the sides of the ship, because the plating being a connected surface of equal or nearly equal strength in all directions, it is incapable of motion in its parts, and the line of any supposed diagonal is incapable of extension otherwise than by a force sufficient to tear the plating asunder.

Comparison of iron with wooden vessels.

A general consideration of all the strains to which ships are subjected naturally leads to the question of selecting the material which is best adapted to resist them. In treating of the materials used in ship-building, especial reference was had to the various qualities possessed by each, which rendered them more or less valuable individually or collectively. It may perhaps be expected, that before leaving this part of the subject a more direct comparison should be drawn than has yet been done between the relative merits of wood and iron vessels, and that the points in their structure, in which they chiefly differ in strength and safety, should be pointed out. The advocates of either system will, no doubt, discover many errors and omissions in the remarks on this subject, which have been made, or which may now be made; but they are given as the results of close observation and experience for a period of upwards of twenty-five years of practical connection with both classes of vessels. It may at the same time be stated with respect to this treatise, that while the increase of steam-vessels, and the great alterations in the forms of ships since the publication of the previous edition of the *Encyclopædia Britannica*, had to be considered, much of the alteration from the previous very able article on this subject, by the late Mr Crueze, is caused by the necessity of now treating of iron-ships equally with those of wood. An endeavour has been made to introduce as much information respecting iron-vessels, in addition to as full information respecting wooden vessels, as the assigned limits would permit; and the substance of the article by Mr Crueze has been retained in many points, and free use has been made of it wherever desired, so as to form, as far as may be, a concise and consecutive treatise.

Basis of comparison.

If strength alone were to be assumed as the basis of comparison, without reference to weight or cost, it would probably be conceded that a stronger vessel could be built of iron than it would be possible to construct by any combination of wood. It will, however, be more practically useful to compare vessels of about equal weight, or equal cost or strength.

Frames.

An individual frame in an iron-vessel is formed with more continuity of strength throughout its length, than is the case in a wooden vessel, and greater opportunity is given of obtaining strength, no matter what may be the form of the body. By the variety of form into which iron can be rolled by the manufacturer, opportunity is also given to obtain the desired strength with less useless material.

Sheathing.

In the sheathing, whether internal or external, much greater difference exists. In wooden vessels the planks are laid side by side, and with few exceptions are not fastened or connected with each other; indeed they are forced asunder by the caulking required to make the joints between them water-tight. Their only connection therefore is by means of the fastenings which unite them to the frames. The plating of an iron-vessel, on the contrary, is made into one completely connected surface, and even if all the frames were removed, it would remain in shape, and would still form a vessel of great strength and stiffness. The fastenings, also, to the frames will not bear comparison, the power of iron to resist shearing across being so much greater than that of treenails or copper-bolts.

Resistance to bulging force by iron.

The power of iron-plates to resist a force similar to that to which they would be subjected if an iron-vessel took the ground on a hard bottom, with some projecting points of rock or stones, was also experimented on by Mr Fairbairn. The plates were placed upon a frame, leaving a space of 1 foot square, unsupported, and on the centre of this a bar of iron, 3 inches diameter, with its end rounded, was brought to bear. Plate $\frac{1}{4}$ inch thick was burst with a force of 16,779 lb., and a plate $\frac{1}{2}$ inch thick, bore a strain of 37,723. The plate of double the thickness, therefore, bears more than double the pressure. The power of timber to bear a similar strain was tested at the same time. Oak planks, 3 inches thick, were burst with a force of 17,933 lb., or only a little more than was required to burst the same surface of a plate $\frac{1}{4}$ inch thick. Oak planks, of $1\frac{1}{2}$ inch thick, were burst with 4406 lb. A plank of double the thickness, therefore, bore much more than double the pressure, the proportion being as the squares nearly.

by timber.

Beams.

Beams of iron are applicable to both classes of vessels, and their superiority is now becoming so generally acknowledged, that they are being largely used in wooden vessels in the merchant-service and in the French navy. It is, however, to the results of the combination of these materials as a whole that consideration must chiefly be given. Unfortunately there are no want of instances of both species of vessels going to pieces suddenly when cast on shore on rocks; and until iron-vessels are double-plated with an interior water-tight sheathing, wooden vessels, with solid bottoms of floors and futtocks, will probably give greater security in such a position for a short period of time if the sea be rough, and for a greater period if it be smooth; on a flat beach, however, iron-vessels seem undoubtedly to have the advantage. The Great Britain, lying for a whole winter on the coast of Ireland, and the Vanguard, lying ashore for several days on a rocky beach, are two notable instances of iron-vessels having come off comparatively uninjured, after having been exposed to strains which it is believed no wooden vessels could have undergone. There

General strength.

are, at least, no such instances on record with regard to them. As another direct comparison, the Demerara may be mentioned as a wooden vessel which, after being launched, grounded in the river at Bristol while being brought down, and she was so much injured that she was condemned; whereas the Australia, an iron-vessel, on first coming down the Clyde grounded in a similar manner, lying right across the river in one of its narrowest parts, but she came off quite uninjured. Another instance of strength, such as no wooden vessel has ever exhibited, may be quoted in the case of an iron-vessel which, on the occasion of her being launched, stuck on the ways which were upon a high wharf above the water, and more than one-third of the whole length of the vessel was left totally unsupported, overhanging the wharf, and yet she did not break or receive any damage.

The same elements of strength which enabled these vessels, especially the Great Britain and the Vanguard, to withstand the strain to which they were exposed, will also be efficacious in preventing a vessel straining at sea in a heavy sea-way, so as to become leaky and founder at sea from this cause. From a consideration of such facts as the foregoing, the general opinion appears to be, that iron-vessels, as a whole, are not only stronger than wooden vessels, generally speaking, but that they may be made of greater or equal strength, with considerably less weight of hull. The extent to which this saving of weight may be carried, without impairing the strength to an improper or unsafe degree, will always be a subject of inquiry to the iron ship-builder; but if he err in judgment and produce too weak a ship, the error must be attributed to him, and the material must not be considered to be in fault.

The power of fitting water-tight bulkheads to iron-vessels is also a great advantage, and will be a source of much greater security hereafter, when vessels are better built than they have hitherto been. Their importance, and the great additional safety which they impart, are evident, and the principle may be carried out to any extent, and this longitudinally as well as athwartship. In the after part of screw-ships, the passage alongside of the shaft to the propeller may be made water-tight, and communication with the engine-room may be cut off, if it be desired, and if proper arrangements be made for this purpose. These bulkheads also form a good protection against the very rapid spreading of fire, and in the case of any vessels particularly liable to this danger they might be made double, and water be admitted between them.

The durability of iron-ships has been already referred to, as far as regards ordinary tear and wear; but their superiority in the event of injury by collision, or by being on shore, is still more marked. If a few frames or floors are broken in a wooden vessel, the amount of work required to be entered into to replace them is very great, a large portion of the plank in the neighbourhood requiring to be ripped off. In an iron-vessel, on the contrary, a new piece of frame can be put in to replace the injured part, and the whole made as strong as before, by lapping pieces. And in the sheathing, an injured plate, or a piece of a plate, can be cut out and replaced without disturbing any of the other work.

on-vessels for rposes war.

For purposes of war iron-vessels have been pronounced by some as unfit, the reasons given being, that the iron when struck flies into innumerable small pieces, which would be most destructive to the men on board; and that in the event of a shot passing through the ship and striking the further side, the plates being no longer supported by the frames, but depending upon the rivets only, are apt to be torn off in large pieces. In some experiments made at the Royal Arsenal at Woolwich, in 1844, by the late General Dundas of the Royal Artillery, it was found that the splinters resulted equally whether the plates fired at were of the best Lowmoor iron or of common boiler-plate. A thickness of 12 to 15 inches of wood was found to stop almost the whole of the small splinters; and a less thickness of a material composed of a mixture of saw-dust and India-rubber effected the same object. With a shot fired with no greater velocity than would just enable it to penetrate the $\frac{5}{8}$ plates, the splinters were fewer; and at the edges of the hole through which the shot had passed, the plate was bent back with ragged edges. In some experiments in Portsmouth harbour, an iron target was fired at, with a screen of canvas behind it to show the splinters, and the same results were obtained. In both cases the plates were $\frac{1}{2}$-inch and $\frac{5}{8}$-inch thick. In iron-vessels, therefore, constructed for the purposes of war, if composed of plates of ordinary thickness, it would be judicious to line them with wood to prevent the men being exposed to the risk of such splinters. In ordinary gun-boats, or corvettes, where the men are above the hull of the ship when fighting the guns, this danger is obviated, and a portion of the ship might also be protected to any extent that might be considered desirable. The present changing state of the science of projectiles renders it difficult to provide against all contingencies; but plates of only ordinary thickness will stop all ordinary shells. This is a most important difference, as these, in their various forms, are now the most dangerous to a ship, and iron-vessels may therefore, on this account, lay claim to great consideration as adapted for warlike purposes. If the iron-vessel, then, be so constructed that it can be penetrated by solid shot only, it would become a question of a wooden vessel being burnt or destroyed by shells, or of an iron-vessel being sunk; and it is believed that many would prefer the latter risk. A shell bursting on board, or in the side of a wooden vessel, would cause greater injury and loss of life than the splinters from the shot in an iron-vessel, and these, as has been said, might be lessened in a large vessel, and avoided in the smaller vessels. It was the opinion of many naval officers respecting the effects shown by the experiments at Portsmouth, that if the same number of shots had been fired at targets of wood, the canvas screen would have been swept bodily away, and that such parts of the targets themselves as remained would have been reduced to a mass of fibres, without strength to sustain themselves or resist any strain or pressure whatever. If iron-vessels hereafter show such great superiority in strength and safety at sea, or when cast on shore, or in durability, as to make their introduction into the royal navy important on these accounts, it may then become a question whether a system may not be introduced of constructing the whole of the lower part of the vessel of iron, up to the neighbourhood of the water-line, and that the portion of the vessel above this, where the men would be exposed to the splinters, should be of wood. The iron-frames could be continued up for some distance alongside of the wooden frames, and there are no practical difficulties in such a system that could not be overcome.

PRACTICAL OPERATIONS.

Commencement of practical operations.

After the cursory view which has been taken of the strains to which ships are liable, and the general remarks which have been made on the points to be attended to in their construction, it is now proposed to give a short outline of the proceedings in the actual building of the vessel.

Laying off.

The term "laying off" is applied to the operation of transferring to the mould loft-floor those designs and general proportions of a ship which have been drawn on paper, and which have been previously referred to, and from which all the preliminary calculations have been made and the form decided. The lines of the ship, and exact representations of many of the parts of which it is to be composed, are to be delineated there to their full size, or the actual or real dimensions, in order that moulds or skeleton outlines may be made from them for the guidance of the workmen.

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These working drawings are made by projection, and are not views of the parts as they appear to the eye. In a projected drawing the eye is supposed to move and be directly opposite to each line, as it, in its turn, is represented by the draughtsman. Separate drawings must, therefore, be made for the different faces of any object which are at right angles to each other.

The delineation in this manner of solids of a complicated form is of itself a science, and one which is now attracting much more attention than formerly. It is very ably treated by the Rev. Dr Woolley in a work entitled *Descriptive Geometry*. Before the publication of this work the efforts in this direction in this country had been chiefly made by practical men, each showing the mode of delineating the more difficult objects in his own art. Architectural works showed the mode of delineating the mouldings and details of the columns of the seven orders of architecture. Books on carpentry showed the mode of working and laying off a geometrical or winding staircase, and works on ship-building included, at great length, the modes of laying off complicated and irregularly formed parts. To show the mode of delineating not only the frames, but all the pieces of varying form which are required in the bows or sterns of ships, would be far beyond the limits of this treatise. It is impossible to include either a complete treatise on drawing or a complete set of delineations of the modes of combining the whole of the various minute parts of which all classes of vessels of wood and of iron are composed.

A proper knowledge of the minutiæ of construction and of workmanship can only be obtained by practical experience upon the work itself; and the form and combination of the parts will continually vary with the variations in the form and outline of the bodies and of the heads and sterns of the ships.

Principal plans. The principal plans of a ship are the sheer plan, the body plan, and the half-breadth plan, and these have been already fully discussed, and their uses explained. In addition to these plans it is customary to furnish the architect with a profile of the inboard works, showing the disposition or distance apart, and the appearance of the timbers which constitute the frame, also the length or the heads and heels, and general arrangement of the floors and futtocks, the midship section, on which is described the moulding or athwartship size of the timbers, the thickness of the exterior and interior planking, the connection of the beams to the side, the dimensions of the waterways and shelf-pieces, and the forms and fastenings of the knees, &c. These, with a scheme of scantlings containing the dimensions and other particulars of the principal pieces which enter into the construction of the fabric, constitute all the preparatory information required by the builder. In private contracts very full information on all these points is generally included in the specification.

Fore and after bodies. A ship is generally spoken of as divided into fore and after bodies, and these combined constitute the whole of the ship; they are supposed to be separated by an imaginary athwartship section at the widest part of the ship, called the midship section or dead-flat.

Midship body. The midship body is a term applied to an indefinite length of the middle part of a ship longitudinally, including a portion of the fore-body and of the after-body. It is not necessarily parallel or of the same form for its whole length.

Square and cant bodies. Those portions of a ship which are termed the square and cant bodies may be considered as subdivisions of the fore and aft bodies. There is a square fore-body and a square after-body towards the middle of the ship, and a cant fore-body and a cant after-body at the two ends. In the square body the sides of the frames are square to the line of the keel, and are athwartship, vertical planes. In the cant bodies the sides of the frames are not square to the line of the keel, but are inclined aft in the fore-body, and forward in the after-body. The reasons for the frames in these portions of a wooden ship being canted, is that, in these parts of the ship, the timber would be too much cut away on account of the fineness of the angle formed between an athwart ship plane and the outline or water-lines of the ship. The timber is therefore turned partially round till the outside face coincides nearly with the desired outline, and it is by this movement that the side of a frame in the cant fore-body is made to point aft, and in the cant aft-body to point forward. This will be best understood by the annexed figure, showing an exaggerated horizontal section of a frame in the fore cant-body, the dotted line representing the extent to which the timber would have been cut away if it had been placed square to the line of keel, and if the

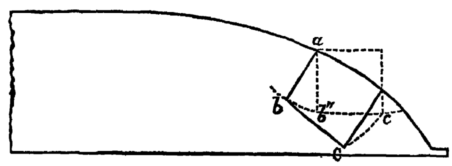

Fig. 31.

side $a\,b$ had not been "canted" aft, turning on the point or edge a.

In wooden ships the term "timbers" is sometimes applied to the frames only, but more generally to all large pieces of timber used in the construction. Timbers, when combined together to form an athwartship outline of the body of a ship, are technically called frames, and sometimes ribs. In iron-ships the frames are composed of iron-bars of various forms.

Moulding and siding. The terms moulding and siding are nearly synonymous with thickness and breadth, observing that the moulding of a piece of timber is the dimension of the side on which the mould is applied for determining its shape or curvature. For instance, the moulding of a beam is its length and thickness; its siding is its fore and aft dimension or breadth.

Room and space. Room and space is a certain distance determined by the fore and aft dimensions, or the siding of two adjacent timbers, together with the opening between them. It is generally defined as the distance from centre to centre of the frames, or from centre to centre of the spaces between them. The centre line between two adjacent frames is called the joint.

Shift. Shift in its general sense is applied to a certain arrangement among the component parts of a ship. Thus a shift of deadwood, or a shift of plank, means the disposition of the buts of the timber or plank with reference to the longitudinal distance of one joint from another, and this with respect both to strength and economy.

Bevellings. The bevelling of a timber is the angle contained between two of its adjacent sides. Bevellings are either acute angles, right angles, or obtuse angles. These three separate cases are denominated under bevellings, square bevellings, and standing bevellings.

Sirmarks. Sirmarks are certain points or stations marked on the mould of the timbers, at which the bevellings are applied, in order to cut the timber to the bevelling required at that spot. These sirmarks are determined, and their positions denoted in the body plan, by the various diagonal lines.

Water-lines and level-lines. Water-lines in the sheer plan, are lines drawn parallel to the surface of the water (Plate III.) Level-lines are similar to water-lines, except that they are drawn parallel to the keel instead of to the water (Plates V. and VI.) In the half-breadth plans, the water-lines or level-lines show the outline of the form of the ship at sections at the corresponding heights in the sheer and body plans.

Diagonal lines. Diagonal lines, as shown in the body plan and half-breadth plan (Plate III.), and marked 1 D, 2 D, 3 D,

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show the boundaries of various sections which are oblique to the vertical longitudinal plane, and which intersect that plane in straight lines parallel to the keel. In wooden ships, the position of the diagonal lines drawn in the body plan is not arbitrary, because it has reference to the different timbers of which the frame is composed, and also to the station of the ribands and harpins. The number of diagonals is increased in the deeper class of vessels. They are drawn to show the lengths of the floors and futtocks, together with the heights of their heads and heels above the keel, and are marked floor-head, &c. Diagonals, marked as 1st sirmark, 2d sirmark, 3d sirmark, &c., or 1 D, 2 D, 3 D, on the body plan (Plate III.), show the heights and situation of the harpins and ribands which are used to give support to the ship whilst in frame. In wooden ships they are always placed between the heads of the respective timbers.

Diagonals on sheer plan.

The following is the mode of setting off the diagonals in the sheer plan:—Take the perpendicular heights in the body plan, that is, the heights square to the upper edge of the keel of the intersection of the diagonal with each of the transverse sections, and transfer these heights to the corresponding section in the sheer plan. Through the points thus obtained draw a curve, which will be the line required.

Diagonal on half-breadth plan.

To transfer the diagonals to the half-breadth plan: observe the point of intersection of the diagonal on the body plan with each transverse section, and take the horizontal distance of each of these points from the middle line, and transfer it to the corresponding section in the half-breadth plan. Through the points thus obtained draw a curved line, which will represent the horizontal line of the diagonal. After these lines have been added to the sheer, body, and half-breadth plans on paper, the transference to the floor, where the ship is to be delineated to the full size, is easy.

It is the duty of the draughtsman in the mould-loft floor to fair the body, if any of the curves shown by the lines previously drawn on the paper do not appear of easy and good forms, when represented of their full size.

Every form to be drawn on the floor, and its beveling obtained.

On the mould-loft floor it is necessary, in iron-ships, to draw out every frame, so as to be able to give the particulars to the workmen; and it is not only necessary to give them the outline of the frame, but also the beveling or the angle which the outer surface makes with the side at each spot or sirmark. This is obtained from the half-breadth plan at the various points where the different level lines or diagonal lines cross each frame. A variety of modes are practised by different builders of iron-ships to convey this information from the mould-loft to the workmen, instead of using moulds, as almost universally practised by builders of wooden ships. Great accuracy in this respect is required in iron-ships, as in them no dubbing off or pairing the body by the adze is practicable.

Expanding the body.

Expanding the body so as to represent the whole of the planking or outer skin or surface of a ship, is another process connected with laying off; and it is particularly important to the iron ship-builder, as it enables him to obtain the necessary iron-plates from the rolling-mills of the exact widths and lengths that will be required. This is done by drawing a line, to represent the line where the plates meet the keel and stern-posts. On this line the station of any number of frames that may be necessary to give the desired degree of accuracy must be set off, and at these stations lines must be drawn of a length equal to the girt or outline of the frame at that station; this length will be obtained from the body plan. The number of strakes to be used in planking or sheathing the ship must next be determined and be set off accordingly, on the lines representing the different frames; and great art is necessary in this operation, as upon these lines much of the beauty of a ship depends to please the eye of a connoisseur. The shift or the distances between the ends of the different plates may also be determined and marked in this plan, and thus the length, width, and breadth of every plate may be accurately ascertained.

The circumference of the bottom being much larger at the midship part than toward the extremities—that is, at the bow and buttock—the lines for the strakes taper as they recede from midships. They also acquire an upward curve, called "Sny," which renders it difficult to work the plank. When the sny becomes too great, a strake is ended short of the others, and this is termed a "stealer," as it diminishes the sny for the succeeding strakes. Under the buttock it is often necessary to work some of the after-plank wider at the after-end, and this has the same effect of diminishing the sny of the following strakes. "Hang" is the exact reverse of "sny." It mostly occurs in working plank on the inner surface of the timbers, and outside above the main breadth.

"Sny."

With regard to the practical operations in building a ship, nothing more can be attempted here than a few general observations on the principal parts of a ship, and the mode of putting them together, to resist the various strains to which each part will be subjected. The practice in her Majesty's yard will be found very fully explained in Fincham's outlines of shipbuilding, and in a very excellent treatise by Mr Peake, now master-shipwright at Devonport. Some details of wooden ships of the ordinary system of construction will be first described.

The keel

The keel of a ship built in this country is generally composed of elm, on account of its toughness, and from its not being liable to split if the ship should take the ground, though pierced in all directions by the numerous fastenings passing through it. It is generally composed of as long pieces as can be obtained, united to each other by horizontal scarphs. These scarphs are made sloping up from the bottom to the upper surface, on which the floors rest. But the strain to which a keel is subjected has a tendency to curve it up or down, and not sideways. These scarphs should, therefore, be made vertical, in the same manner as scarphs of the beams, as there can be no doubt that the vertical scarph will give the greatest strength to resist a strain in this direction.

Rabbet of the keel.

The rabbet of the keel is an angular recess cut into the side to receive the edge of the planks on each side of it. In the government service this rabbet is made of greater breadth vertically, so that the plank to fill it is required to be of such great thickness that it altogether loses the character of a plank, and becomes a stout massive piece of timber. This arrangement was introduced by Mr Lang, and has been denominated Lang's safety keel. It gives great additional strength to the bottom of a ship, and great lateral support to the keel, when the ship takes the ground and rests on the edge, as the leverage to displace it sideways is thus reduced.

In the merchant service the rabbet is seldom carried so low down on the side, and the garboard strake or strakes are not so thick. The keel forward is connected to the stem by a scarph, sometimes called the boxing scarph, and aft to the stern-post, by mortice and tenon. The apron is fayed or fitted to the after-side of the stem, and is intended to give shift to its scarphs, the lower end scarphs to the deadwood. The keelson is an internal line of timbers fayed upon the inside of the floors directly over the keel, the floors being thus confined between it and the keel. Its use is to secure the frames and to give shift to the scarphs of the keel, and thus give strength to the ship to resist extension lengthways, and to prevent her hogging or sagging. The foremost end of the keelson scarphs to the stemson, which is intended to give shift to the scarphs connecting the stem and keel. The frames or ribs are composed of the strongest and most durable timber obtainable. By Lloyd's rules

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a durability of twelve years is assigned to frames composed of English, African, and live oak, East India teak, Morning Saul greenheart, morra or iron-bark; of ten years to mahogany of hard texture, Cuba, sabicu, and pencil cedar; of ten years for floors and first futtock, and nine years for second and third futtocks and top timbers, to Adriatic, Spanish, and French oak; of nine years to red cedar, angelly and Venatica; of nine years for floors and first futtocks, and seven years to second and third futtocks and top timbers of other continental white oaks, Spanish chestnut, stringy bark, and blue gum; of eight years and seven years respectively, as before, for North American white oak and American sweet chestnut; of seven years for larch, hackmatac, tamarac and juniper, and pitch-pines.

Floors.

The floors in the government service are carried across the keel with a short and long arm on either side alternately, so as to break joint, and between the frames the space is filled in solid.

Shelf-pieces.

Longitudinal pieces of timber are worked round the interior of a ship for the purpose of receiving the ends of the beams of the several decks; they are called shelves, and are of the greatest importance, not only for this purpose, but also as longitudinal ties and struts. In any system of diagonal bracing, properly carried out, they should form one side of the parallelogram or of the triangle, and those other timbers, or iron-bars, which form the diagonals or the other sides of the parallelogram or triangle ought to be firmly secured to them. A thick strake of plank used formerly to be worked between the shelf and the timbers or frames, but now it is generally worked home upon them. The shelf is generally supported by some thick strakes of plank worked immediately under it, and formerly it was also sometimes supported by chocks or triangular pieces, like brackets on the ship's side, brought out to be flush with the inner edge of the shelf, and on the face of this an iron-knee. This chock is now generally dispensed with, and the lower side of the shelf is bevelled off towards the ship's side, and the iron-knee is forged to fit under it accordingly. These fastenings will be referred to when treating of the means of securing the ends of the beams. The other fastenings of shelf-pieces are by numerous through-bolts. Timbers which are fayed to the inside of the frame, or upon the inside of the plank, longitudinally or diagonally, solely for the purpose of supporting the frame, are called riders.

The beams.

The beams of a ship prevent the sides from collapsing, and at the same time carry the decks. The beams are spaced, and their scantling settled upon, according to the strength required to be given to the decks, and to suit the positions of the masts and hatchways, and other arrangements connected with the economy of the ship. All beams have a curve upwards towards the middle of the ship called the round up. This is for the purpose of strength, and for the convenience of the run of the water to the scuppers. Wooden beams are single piece, two, three, or four piece beams according to the number of pieces of timber of which they are composed. The several pieces are scarphed together, and dowelled and bolted, the scarphs being always vertical. A scarph now very generally adopted was introduced by Mr Edye, late master-shipwright of Devonport dockyard, and is represented in the annexed figure.

Edye's Beam.

Fig. 32.

The beams of ships being supported at both ends, and one of the strains to which they are chiefly subjected being a downward pressure, the upper part of the beams will then be compressed, and the lower parts extended. It is therefore desirable that the lower part of the beams should not be wounded so as to cut the fibres across in that part. An incision above the line of the vertical axis is of less moment, and if an incision be made there for the purpose of introducing a carling, for instance, and if this be well fitted, and be of as hard wood as the beam, the strength of the beam will not be impaired, but may even be increased.

Connection of the beams to the sides of the ship.

The connection of the ends of the beams to the sides of the ship have been made in various ways. The points to be considered, with reference to this connection, are, that the beam is required to act as a shore or strut, to prevent the sides of the ship from collapsing, and also as a tie to prevent their falling apart; that the beam shall not rise from its seat, and that it shall not work in a fore and aft direction; that the beam may be an effective shore, nothing more is necessary than that the abutment of the end against the ship's side may be perfect.

In order that it may act as a tie between the two sides, it is generally dowelled to the upper surface of the shelf on which it rests; and the under surface of the water-way plank which lies upon it is sometimes dowelled into it. These dowels, therefore, connect it with the shelf and the waterway, and through this means it is thus connected with the sides of the ship. There is, also, in the ships of the royal navy, a plank called a side-binding strake, scored down over and into the beam-ends at some distance from the side, and bolted through the side between the beams. The scoring into the beams connects the in and out fastenings of this strake with the longitudinal tie of the beams, but the advantage does not seem to be commensurate with the labour.

Knees to beams.

The beams are also supported by knees below them. Wooden knees are chiefly used in America; and it is argued that they give a better support to the beam from their greater surface, and from their stiffness in the throat, or angle of the knee. The iron-knees used in the royal navy vary in form; they are made not only to support the beam from below, but sometimes with horns to clasp it sideways at a short distance from the side of the ship. The lower arms of these knees are so formed as to fit round the shelf; or sometimes, with a view to prevent the necessity of working the iron into this form, and at the same time afford additional support to the shelf, a chock is fitted under the shelf to receive the face of the knee. While the knee is instrumental in supporting the beam, it is also upon it that dependence is mainly placed to prevent the beam rising, or working in an upward direction. In these fastenings there appears a want of any very efficient means to prevent the beam straining in a fore and aft direction, or working upon the end as upon a pivot.

Strains which a beam must resist.

From the short outline previously given of the disturbing forces acting on a ship, it will be seen that the strain on the ends of the beams to destroy their connection with the side and loosen the fastenings, must be very great when the ship is under sail, either on a wind or before it—that is, either inclined or rolling. The principal action of these forces is to alter the vertical angle made by the beam and the ship's side—that is, to raise or depress the beam, and so alter the angle between it and the side of the ship above or below it. On the lee-side the weight of the weather side of the ship and all connected with it, and of the decks and everything upon it, as well as the upward pressure of the water, all tend to diminish the angle made by the beam and the ship's side below it, and consequently increase the angle made between them above it. The contrary effect is produced on the weather side, where the tendency is to close the angle above the beam and open that below it. If the beam when subjected to these strains, be considered as a lever, it will be evident that the fastenings to prevent its rising ought to be as far from the side as is consistent with the convenience or accommodation of the ship; and that while the support should also be extended inwards, the fastening to keep down the beam-end should be as close to the end of the beam, and consequently to the ship-side, as it can be placed.

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The annexed section of the side of a three-decked ship of the royal navy shows some of the modes that have been adopted for securing the ends of the beams.

Half-beams.

Beams which do not extend from one side of the ship to the other are called half-beams. They are introduced whenever the hatches or openings in the middle of the ship are such as to require the whole or unbroken beams to be so wide apart that the deck requires support between them. Their ends, towards the midships, are received by fore and aft pieces called carlings, which go from beam to beam; and any intermediate athwartship pieces between the carlings are called ledges.

Carlings and ledges.

Hooks.

The two sides of the ship at the bows are connected by hooks, which are either of timber or of iron. It is important to remember that the hooks above, and those below the surface of the water, are subjected to an opposite strain. The tendency of the pressure of the water on the bow is to make the sides collapse, and therefore the hooks below the water's surface should not only act as ties to the bow while the ship is grounded—as, for instance, when in dock—but should be formed more especially to resist the pressure of the water when she is afloat. Those hooks which are above the surface of the water act principally as ties, the rake of the bow and the weight of its parts tending to separate the two sides of the ship.

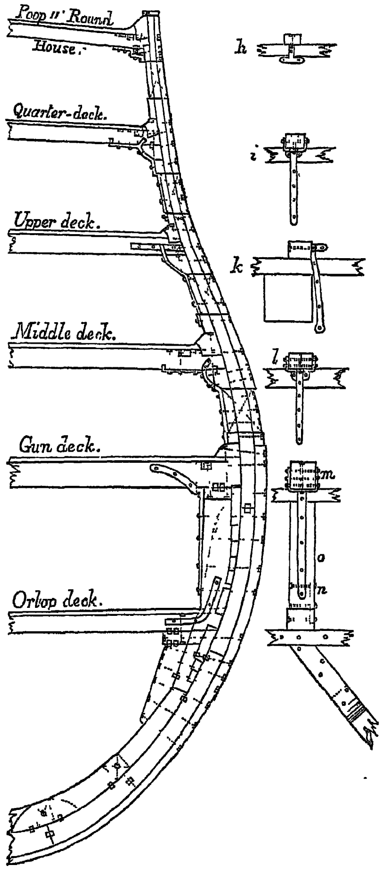

Fig. 33.

Planking.

The plank, or skin, or sheathing of a ship, both external and internal, is of various thicknesses. A strake of planking is a range of planks abutting against each other, and generally extending the whole length of the ship. A thick strake, or a combination of several thick strakes are worked wherever it is supposed that the frame requires particular support—for instance, internally over the heads and heels of the timbers; both externally and internally in men-of-war vessels between the ranges of ports; and internally to support the connection of the beams with the sides, and at the same time form a longitudinal tie. The upper strakes of plank, or assemblages of external planks, are called the sheer-strakes. The strakes between the several ranges of ports, beginning from under the upper-deck ports of a three-decked ship in the royal navy, are called the channel wale, the middle wale, and the main wale. The strake immediately above the main wale is called the black strake. The strakes below the main wale diminish from the thickness of the main wale to the thickness of the plank of the bottom, and are therefore called the diminishing strakes. The lowest strake of the plank of the bottom, and whose edge fits into the rabbet of the keel, is called the garboard strake.

Plank is either worked in parallel strakes, when it is called "straight edged," or in combination of two strakes, so that every alternate seam is parallel. There are two methods of working these combinations, one of which is called "anchor stock," and the other "top and butt." The difference will be best shown by the annexed figure. The difference in the intention is, that in the method of working two strakes anchor-stock fashion, the narrowest part of one strake always occurs opposite to the widest part of the

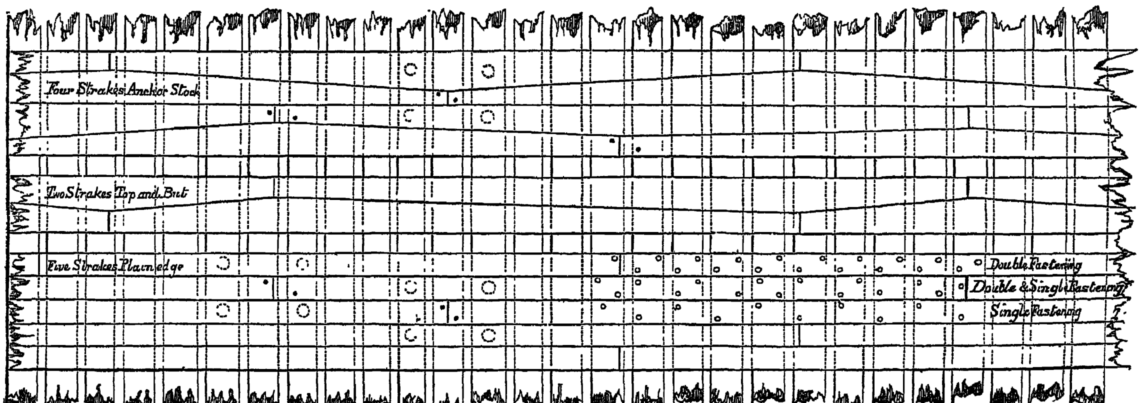

Fig. 34.

other strake, and consequently the least possible sudden interruption of longitudinal fibre, arising from the abutment, is obtained. This description, therefore, of planking is used where strength is especially desirable. In top and butt strakes the intention is, by having a wide end and a narrow end in each plank, to approximate to the growth of the tree, and to diminish the difficulty of procuring the plank. When the planking is looked upon as a longitudinal tie, the advantage of these edges being, as it were, imbedded into each other is apparent, all elongation by one edge sliding upon the other being thus prevented. The shift of plank is the manner of arranging the butts of the several strakes. In the ships of the royal navy the butts are not allowed to occur in the same vertical line, or on the same timber, without the intervention of three whole strakes between them.

Limber-strake.

Of the internal planking the lowest strake, or combination of strakes, in the hold, is called the limber-strake. A limber is a passage for water, of which there is one throughout the length of the ship, on each side of the keelson, in order that any leakage may find its way to the pumps.

Ceiling and internal planking.

The whole of the plank in the hold is called the ceiling. Those strakes which come over the heads and heels of the timbers are worked thicker than the general thickness of the ceiling, and are distinguished as the thick strakes over the several heads. The strakes under the ends of the beams

of the different decks in a man-of-war, and down to the ports of the deck below, if there be any ports, are called the clamps of the particular decks, to the beams of which they are the support, as the gun-deck clamps, the middle-deck clamps, &c. The strakes which work up to the sills of the ports of the several decks are called the spirketting of those decks—as gun-deck spirketting, upper-deck spirketting, &c.

Fastenings of the planks.

The fastening of the plank is either "single," by which is meant one fastening only in each strake, as it passes each timber or frame; or it may be "double," that is, with two fastenings into each frame which it crosses; or, again, the fastenings may be "double and single," meaning that the fastenings are double and single alternately in the frames as they cross them. The fastenings of planks consist generally either of nails or treenails, excepting at the butts, which are secured by bolts. Several other bolts ought to be driven in each shift of plank as additional security. Bolts which are required to pass through the timbers as securities to the shelf, water-way, knees, &c., should be taken advantage of to supply the place of the regular fastening of the plank, not only for the sake of economy, but also for the sake of avoiding unnecessarily wounding the timbers.

The planking in the royal yards is not usually fastened permanently till some time after it is trimmed and brought on to the bottom of a ship. It is thus allowed to season and shrink; and one strake in eight or ten is left out for the purpose of allowing ventilation, and to make good the shrinkage, and also to allow the strakes to be refayed. Without the latter provision there would be such an alteration of edge as would throw the holes made for the temporary securities out of the range of the strakes; but with this precaution it is very seldom that the alteration of edge is such as to require new holes, especially as the iron screw-eye bolts used for this temporary fastening are of much smaller diameter than the permanent treenail fastening, and therefore the holes for them through the plank can still be made good holes for the treenails. This method of securing the planks by a first or temporary fastening, to be afterwards substituted by a treenail, is also of advantage in enabling them to be brought into close contact with the timbers, in the saving of bolt fastenings, and in causing a good and regular seam to be given for the caulking.

The advantages and disadvantages of iron as a fastening for planking have been already discussed. The strength of treenails to resist a cross-sheering strain, as found by Mr Parsons, late of H.M. Dockyard Service, is shown in the following table:—

Experiments on fastenings.

"*Table of the Transverse Strength of Treenails of English Oak used as fastening for Planks of* 3 *and of* 6 *inches in thickness, and subjected to a Cross Strain.*

Number of the Experiment.	Diameter of the Treenails.							
	1 Inch.		1¼ Inch.		1½ Inch.		1¾ Inch.	
	Thickness of the Plank.							
	3 In.	6 In.	3 In.	6 In.	3 In.	6 In.	3 In.	6 In.
	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.
1	1 8	1 7	1 14	2 8	2 0	3 12	3 0	5 10
2	1 7	1 15	2 2	2 2	2 6	2 10	2 10	3 13
3	1 2	1 8	1 17	2 19	2 15	2 10	4 0	4 0
4	1 5½	1 8	2 2	2 2	2 4	3 12	2 8	3 8
5	2 12	1 3	2 2	1 15	2 18	2 5	3 10	4 0
6	2 2	1 7	2 9	2 10	2 6	2 5	3 10	5 8
7	2 4	1 10	2 8	2 10	3 7	2 5	3 5	3 12
8	1 6	2 3	2 7	2 0	2 5	3 0	3 5	3 13
9	1 8	1 8	2 12	2 10	3 0	4 0	4 6	4 13
10	1 2	2 3	2 10	2 15	3 0	4 10	3 8	4 0
11	2 0	2 0	2 7	2 0	3 9	2 18	4 0	3 8
12	1 8	1 7	2 10	2 0	4 2	3 0	4 10	5 0
13	1 16	2 8	2 17	2 0	3 2	3 18	4 2	5 5
Average	1 11	1 13	2 6	2 6	2 16	3 2	3 10	4 6

"In all these experiments on treenails, when the treenails were evidently good, they gave way gradually. In some of the rejected experiments, however, the treenails certainly did break off suddenly, but then they were evidently, on examination, either of bad or over-seasoned material. It has been asserted that the treenails made from the Sussex oak are much stronger than those made from the New Forest timber, or any other English oak. To ascertain the truth of this assertion, some experiments were made with Sussex and New Forest treenails of all sizes; and the result was, that there was not the least difference in them, the New Forest were, on experiment, quite as strong as the Sussex. In the experiments on treenails, the plank generally moved about half an inch previous to the fracture of the treenail."

The following useful tables were also drawn up by Mr Parsons from a series of valuable experiments carefully made by him, and show the longitudinal holding power of treenails. The first of these tables exhibits the adhesion of iron and copper bolts, driven into sound oak, with the usual drift, not clenched, and subject to a direct tensile strain. By drift is meant the allowance made to insure sufficient tightness in a fastening; it is therefore the quantity by which the diameter of a fastening exceeds the diameter of the hole bored for its reception.

"*Table of the Adhesion of Iron and Copper Bolts driven into sound Oak with the usual Drift, not clenched, and subjected to a direct Tensile Strain.*

Diameter of the Bolt.	Number of the Experiment.	Iron.		Copper.	
		Length of the Bolt driven into the Wood.			
		Four Inches.	Six Inches.	Four Inches.	Six Inches.
Inches.		Tons. Cwt.	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.
¼...	1	1 13	...	0 18½	...
	2	2 0	...	0 18	...
	3	2 2	...	0 19	...
	4	1 13	...	0 18	...
⅜...	1	2 6	2 12	1 7	2 2
	2	2 4	2 11	1 8	2 2
	3	2 4	2 16	1 10	2 2
	4	2 0	2 10	1 13	2 0
½...	1	3 2	3 12	2 10	2 15
	2	3 4	4 0	1 17	3 10
	3	3 0	4 0	2 2	3 1
	4	2 10	4 0	2 5	2 15
⅝...	1	3 2	5 5	3 0	4 5
	2	3 0	4 8	3 6	3 18
	3	3 1	4 8	3 6	3 15
	4	3 1	5 0	2 9	3 5
¾...	1	3 3	6 0	3 10	5 5
	2	3 2	6 0	3 10	5 5
	3	3 10	5 0	3 10	5 8
	4	3 10	6 0	3 18	4 18
⅞...	1	4 10	6 2	4 0	4 13
	2	5 12	5 10	4 0	4 13
	3	3 10	6 11	4 5	4 19
	4	4 10	6 4	4 2	4 19
1...	1	5 0	7 2	4 2	5 19
	2	4 7	8 1	4 8	5 0
	3	4 11	6 5	3 15	6 5
	4	4 0	7 0	4 10	5 0

"In Riga fir the adhesion was, on an average, about one-third of that in oak, and in good sound Canada elm it was about three-fourths of that in oak.

The following table exhibits the strength of clenches and of forelocks as securities to iron and copper bolts, driven six inches, without drift, into sound oak, either clenched or forelocked on rings, and subjected to a direct tensile strain. It gives the diameter of the bolt on which the experiment was made, as well as the number of the experiment:—

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" *Table of the Strength of Clenches and of Forelocks, as securities to Iron and Copper Bolts, driven six inches, without Drift, into sound Oak, either clenched or forelocked on Rings, and subjected to a direct Tensile Strain.*

Diameter of the Bolt.	Number of the Experiment.	Iron.				Copper.			
		Clench.		Forelock.		Clench.		Forelock.	
Inch.		Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
$\frac{1}{4}$...	1	1	16	0	16	1	0	0	8
	2	1	13	0	14	0	19	0	8
	3	1	9	0	20	1	0	0	7
	4	1	9	0	18	1	0	0	6
$\frac{3}{8}$...	1	3	0	1	15	2	10	1	4
	2	3	0	1	8	2	10	1	0
	3	2	16	1	9	2	5	1	2
	4	2	15	1	14	2	9	1	4
$\frac{1}{2}$...	1	4	15	2	11	3	10	1	18
	2	4	10	2	15	3	15	1	18
	3	4	5	2	10	4	0	2	4
	4	4	12	2	12	4	10	1	16
$\frac{5}{8}$...	1	5	18	3	15	6	0	2	13
	2	6	8	3	6	5	15	2	10
	3	6	8	3	0	6	5	2	16
	4	6	0	3	7	5	10	2	10
$\frac{3}{4}$...	1	7	10	3	10	7	0	...	
	2	7	10	3	15	7	0	...	
	3	8	0	3	10	7	5	...	
	4	8	15	3	15	7	8	...	
$\frac{7}{8}$...	1	11	11	5	1	7	16	...	
	2	11	15	5	10	7	16	...	
	3	8	11	4	6	7	12	...	
	4	8	6	4	15	7	5	...	
1...	1	12	0	5	18	7	1	...	
	2	12	3	6	18	7	1	...	
	3	11	3	5	12	7	14	...	
	4	11	1	5	2	8	14	...	

" In the experiments on the clenches, the clenches always gave way; but with the forelocks it as frequently occurred that the forelock was cut off as that the bolt broke; and in the cases of the bolt breaking, it was invariably across the forelock hole. According to the tables, the security of a forelock is about half that of a clench.

" It appears an anomaly that the strength of a clench on copper should be equal to that of one on iron. But, in consequence of the greater ductility of copper, a better clench is formed on it than on iron. Generally the thickness of the fractured clench in the copper was double that in the iron. With rings of the usual width for the clenches, the wood will break away under the ring, and the ring be imbedded for two or more inches before the clench will give way.

" With the inch copper-bolts, all the rings under the clenches turned up into the shape of the frustum of a cone, and allowed the clench to slip through at the weights specified.

" Experiments with ring-bolts were made to ascertain the strength of the rings in comparison with the clenches. The rings were of the usual size, viz., the iron of the ring one-eighth inch less in diameter than that of the bolt. It was found that the rings always carried away the clenches, but that they were drawn into the form of a link with perfectly straight sides. The rings bore, before any change of form took place, not quite one-half the weight which tore off the clenches. It appears that the rings are well proportioned to the strength of the clenches."

From these tables it will be seen how much the strength of a clenched or fore-locked bolt falls short of the strength due to the full diameter of the bolt where a tensile strain only is applied to it; and when exposed to a cross strain, it is also well known how much the strength is diminished when the ends are not fastened and held securely in position. An increased use of screw-bolts with nuts and larger plates or rings under the heads and under the nuts would therefore give great additional strength; and if a sufficient length of the bolt were screwed at the end to allow of as much as an inch being cut off when too long, the supply of sizes necessary to be kept in store would not be large. Economy also would be likely to result from the greater accuracy in the length required to be given for the bolt about to be drawn from the store for use.

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Screw-treenails of the annexed form have lately been introduced by Messrs Hall, the well known builders of the Aberdeen clipper-ships, and whose modes of construction will be more particularly referred to hereafter. The increased holding power of such treenails to prevent planks from starting needs no demonstration.

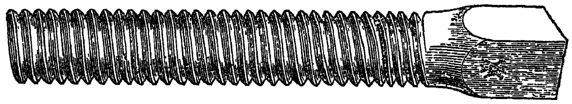

Fig. 35.

Decks.

The decks of a ship, as has before been stated, must not be considered merely as platforms, but must be regarded as performing an important part towards the general strength of the whole fabric. They are generally laid in a longitudinal direction only, and are then useful as a tie to resist extension, or as a strut to resist compression. The outer strakes of decks at the sides of the ship are generally hard wood, and of greater thickness than the deck itself; they are called the water-way planks, and are sometimes dowelled to the upper surface of each beam. Their rigidity and strength is of great importance, and great attention should be paid to them, and care taken that their scarphs are well secured by through bolts, and that there is a proper shift between their scarphs and the scarphs of the shelf.

When the decks are considered as a tie, the importance of keeping as many strakes as possible entire for the whole length of the ship must be evident; and it has already been stated that a continuous strake of wrought-iron plates beneath the decks is of great value in this respect. The straighter the deck, or the less the sheer or upward curvature at the ends that may be given to it, the less liable will it be to any alteration of length, and the stronger will it be. The ends of the different planks forming one strake are made to butt on one beam, and as the fastenings are then driven close to the ends, they do not possess much strength to resist being torn out. The shifts of the butts, therefore, of the different strakes require great attention, because the transference of the longitudinal strength of the deck from one plank to another is thus made by means of the fastenings to the beams, the strakes not being united to each other sideways.

Strain in caulking to be resisted.

These fastenings have also to withstand the strain during the process of caulking, which has a tendency to force the planks sideways from the seam; and as the edges of planks of hard wood will be less crushed or compressed than those of soft wood when acted on by the caulking-iron, the strain to open the seam between them to receive the caulking will be greater than with planks of softer wood, and will require more secure fastenings to resist it. It may also be remarked that the quantity of fastenings should increase with the thickness of the plank which is to be secured, for the set of the oakum in caulking will have the greater mechanical effect the thicker the edge.

Diagonally laid decks.

A deck, laid in a diagonal direction only, involves a great loss of strength longitudinally, and the advantages are not such as to compensate for this loss, and for the other inconveniences as to wear and tear, which result from such a system. Mackonochie proposed to lay decks in three layers, one diagonally from starboard to port, another from port to starboard, and an upper layer fore and aft. He also proposed a somewhat similar system for the outside planking, and vessels have been built on different modifications of this plan both in this country and in America.

Importance of securing the decks at the extremities.

At the two ends of a ship it is important that the strength of the tie of the deck should be maintained there, and while the continuation and connection of the shelf-pieces and waterway-planks are duly attended to, with any necessary hooks and crutches, additional strength to sustain the projecting bows and raking sterns may be obtained by a judicious connection of several beams to the extreme ends. This may be done by long bolts passed through the beams and secured by nuts and screws at their ends, or by pieces of timber fore and aft, underneath the beams, and bolted to them. These beams should have several ranges of carlings let down between them to diffuse the strain.

Dowelling and scoring down.

In all such connections of wood with wood, dowelling is much to be preferred to scoring down. The latter is objectionable on account of its wounding and weakening the parts in a greater degree, and the joint is subject to become loose or open by the shrinkage of the materials, and it also requires much more care and skill on the part of the workman for its perfect execution. It should therefore be discontinued wherever practicable.

Partners.

The frame-work of timbers which is formed round the mast-holes in each deck is called the mast partners. "Partners" generally are the principal timbers in a framing formed for the support of anything passing through a deck, as the masts and capstands.

Steps.

The pieces of timber to receive the heels of the several masts are called steps, as the main, fore, or mizen steps.

Coamings and head ledges.

Coamings are pieces generally faying on carlings, and rising higher than the flat of the deck, to form the fore and aft sides or boundaries of openings, such as hatch or ladder-ways; head ledges forming the athwartship boundaries to the same openings.

Caulking.

When the planks are fastened, the seams or the intervals between the edges of the strakes are filled with oakum, and this is beaten in or caulked with such care and force that the oakum, while undisburbed, is almost as hard as the plank itself. If the openings of the seam were of equal widths throughout their depth between the planks, it would be impossible to make the caulking sufficiently compact to resist the water. At the bottom edges of the seams the planks should be in contact throughout their length, and from this contact they should gradually open upwards, so that, at the outer edge of a plank 10 inches thick, the space should be about $\frac{10}{16}$th of an inch, that is, about $\frac{1}{16}$th of an inch open for every inch of thickness. It will hence be seen that if the edges of the planks are so prepared that when laid they fit closely for their whole thickness, the force required to compress the outer edge by driving the caulking-iron into the seams, to open them sufficiently, must be very great, and the fastenings of the planks must be such as to be able to resist it. Bad caulking is very injurious in every way, as leading to leakage and to the rotting of the planks themselves at their edges. It frequently happens, however, that the caulking is blamed when the leakage and the attendant evils have been caused by the edges of the planks sliding upon each other through the working of the deck or of the ship.

Marine glue.

Instead of pitch for closing the seams above the oakum, Mr Jeffery introduced a mixture of shellac and caoutchouc, combined with naphtha. This is at first more expensive, but its decided superiority and greater durability, preventing the necessity of so frequently re-caulking, will counterbalance this in due time, so as to be to the advantage of the ship-owner, though this will not make it economical to the ship-builder who builds and completes a vessel by contract. It is insoluble in water, and impervious to it; it is also elastic, and yet of sufficient solidity to fill up the joint and give strength; and it is also powerfully adhesive, so as to connect the planks together at their edges.

The mode of applying diagonal trussing to strengthen the side of a ship constructed in accordance with the foregoing outline, will next be considered.

Diagonal trussing.

In the system of building which was superseded by that termed the diagonal system, the whole of the interior surface of the frame was planked, and a second series of internal frames was worked upon this planking, agreeing in direction with the timbers of the ship. Riders were also introduced in various parts, but not diagonally, and those in the hold were no doubt necessary when it was the custom to "ground" ships on a beach for repair; a large quantity of timber was thus massed together, having the appearance of great strength; but, in fact, from its weight, injudicious combination, disposition and fastening, much of it was, if not injurious, at least useless. The idea of diagonal trussing was not an entire novelty at the time when Sir Robert Seppings introduced it as a system. There is evidence, in the representation of a vessel under repair in the fifteenth century, of some pieces of timber having been used diagonally in her construction, as also in some other isolated instances. The credit, however, of calling the attention of ship-builders to the principles on which the advantages of diagonal trussing depend, is entirely due to Sir Robert Seppings, and no ship is now ever built without the principle being brought into action in a greater or less degree.

He described his system in a paper communicated by him to the Royal Society, and which is printed in their *Transactions* for the year 1814. In that paper, after supposing the frames for a two-decked 74 gun-ship to be in place, and the spaces between the frames filled-in solid, he proceeds as follows:—

"In this state the diagonal timbers are introduced, intersecting the timbers of the frame at about the angle of 45°, and so disposed as that the direction in the fore is contrary to that in the after part of the ship, and their distance asunder from 6 to 7 feet or more; their upper ends abutting against the horizontal hoop or shelf-piece of the gun-deck beams, and the lower ends against the limber strakes, except in the midships, where they come against two pieces of timber placed on each side of the keelson (called additional keelsons), for the purpose of taking off the partial pressure of the main-mast, which always causes a sagging down of the keel, and sometimes to an alarming degree. These pieces of timber are nearly as square as the keelson, and fixed at such a distance from it that the main step may rest upon them. They may be of oak or pitch-pine, and as long as can be conveniently procured. Pieces of timber are next placed in a fore and aft direction over the joints of the frame-timbers, at the floor and first futtock-heads; their ends in close contact with, and coaked or dowelled to, the sides of the diagonal timbers. In this state the frame-work in the hold presents various compartments, each representing the figure of a rhomboid.

"A truss-timber is then introduced into each rhomboid, with an inclination opposite to that of the diagonal timbers, thereby dividing it into two parts. The truss-pieces so introduced into the rhomboid are to the diagonal frame what the key-stone is to the arch; for no weight or pressure on the fabric can alter its position in a longitudinal direction, till compression takes place at the abutments, and extension of the various ties.

"This arch-like property of the diagonal frame not only opposes an alteration of position in a longitudinal direction, but also resists external pressure on the bottom, either from grounding or any other cause, because no impression can be made in its figure in these directions without forcing the several parts of which it is composed into a shorter space."

The trussing here proposed for the hold of the ship was undoubtedly with the intention of introducing the principle of the inverted arch or dome; and it must be remembered, that the general form of the vessels to which Sir Robert

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Seppings was accustomed approached that of a hemisphere at their midship section, and was very different from the comparatively flat or plain surfaces now common. Any lower ranges of riders and trusses brought on the floors and first futtocks could have little effect in preventing arching beyond that which arises from the additional resistance they offer to deflexion by their rigidity. In men-of-war with several decks above the lower deck, the object aimed at seems to have been to obtain a firm base on which to ground a new and upper series of diagonal ties and struts. It will be evident from these remarks, that it is not considered that the bottom of a ship, if filled-in solid, and made as little compressible as possible by this means, and by the introduction of additional or sister keelsons, requires any great expenditure of material or labour, in order to adapt a system of diagonal trussing to it. The position for its most beneficial application is undoubtedly the sides of the vessel, but whether struts or ties be used, there must be a proper starting point for their ends. In wooden vessels of ordinary construction, this would, perhaps, be found to be in the sister keelson, nearest the wing, or in the thick strakes or riders brought on at the head and heels of the floors and first futtocks. The importance of these last in resisting any strain, if the ship takes the ground and rests on her bilge, is also evident; and it would therefore be advantageous to increase their strength with this view, even if there existed no other reason. Having determined a base or starting point for the lower ends of the diagonals, the next point to be attended to is to determine a strong line of work to which to attach their upper ends. Where intermediate decks occur the diagonals must either be carried past them in one continued line, or a new system be commenced and carried on from that line. In this case the strain on the parts may become such that the direction of the ties and struts may require to be changed. While diagonals are useful as a means of firmly connecting the adjacent pieces of timber, it must be remembered that this is a small portion of their value, and that full advantage will not be ensured from them without due consideration being given to keep up an unbroken system of sides and of diagonals, with their ends firmly united. It is immaterial whether parallelograms or triangles be used, if the last side of the one be always made the first side of the next. A triangle is a valuable form in structures of this kind, because it is a figure which admits of no alteration in its form; its angles are invariable as long as the sides remain the same, that is, as long as they are neither elongated nor shortened.

These principles are becoming more and more appreciated every day, and the strength of ships is consequently becoming much increased.

Diagonal trussing in Government vessels.

In the government service the diagonals, which extend over the surface of the side of the ship, are of iron-bars, varying according to the size of the ship, and also of wood. The annexed wood-cuts represent and show portions of the side of a two-decked ship, the diagonal riders of iron passing up between the ports (figs. 36 and 37). They commence under the thick strakes over the first and lower futtock-heads, and run up unbroken to the shelf of the upper-deck. On the turn of the bilge, where it is most rounding, and where the ship would rest if she took the ground, there is a system of wooden trusses introduced to stiffen the vessel at that spot, which has before been stated to be so desirable an object.

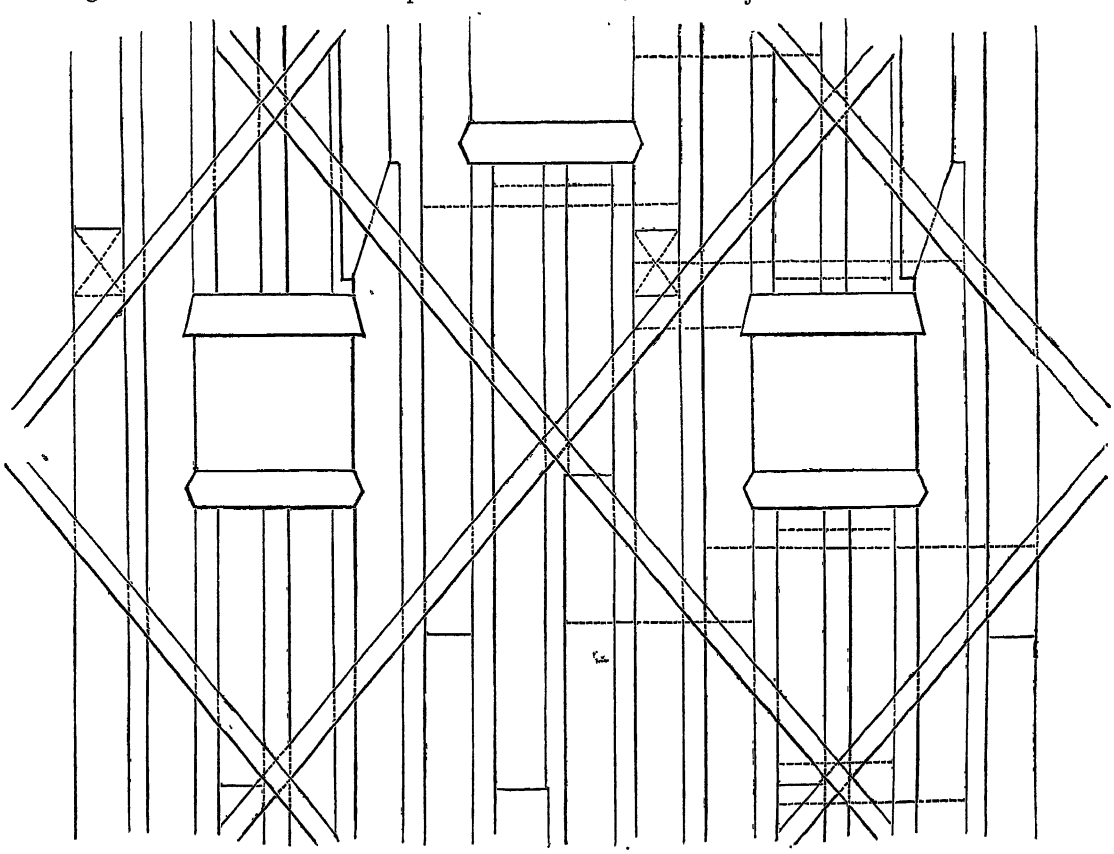

Fig. 36.

In other vessels the iron-bars are laid upon, and sunk into, the frames in one direction, while a series of wooden diagonal riders are placed upon the surface of the internal sheathing, crossing them in the other direction. In the fabric, as a whole, there appears a want, to the eye of an engineer, of a due consideration to the fact, that the strength of a box-girder, or tubular bridge, to which the mind naturally reverts as the simplest form of a long body to sustain

such weights and strains as those to which a ship is liable, lies mainly in the top and bottom, and not in individual portions of the sides. A lattice, or trellis girder, is nothing without the top and bottom bars uniting the lattice or trellis works. If a weight is to be supported by ties, there must be something to carry their upper ends without yielding; and if it is to be supported by struts, there must be a sound and unyielding foundation for them to rest upon, and from which they may rise.

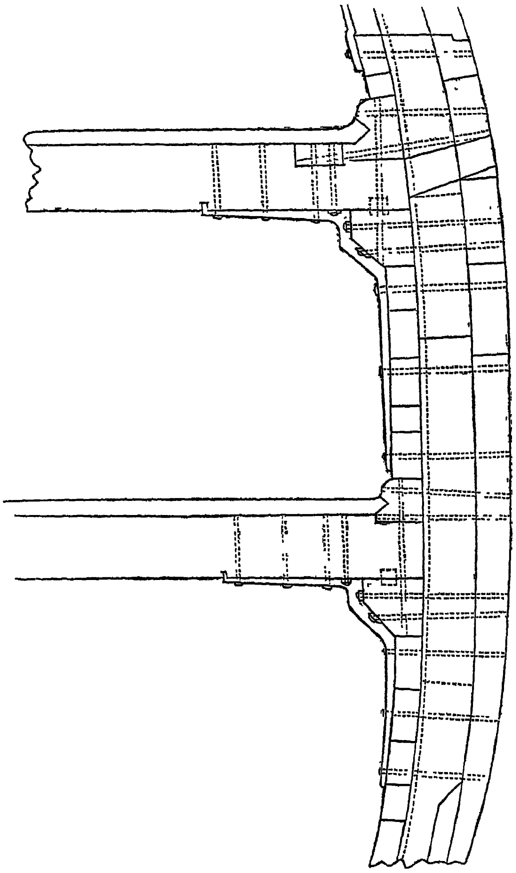

Fig. 37.

Details of ship Schomberg, by Messrs Hall and Co., of Aberdeen.

Messrs Hall and Co., of Aberdeen, carry out the principle to a great extent in the vessels built by them.

The following is a general description of the Schomberg (Plate III.), as built by them, in 1854, for James Baines and Co., of Liverpool, and many valuable hints may be gained from the practice of these eminent builders. She was expressly designed for an Australian passenger-ship, and every attention was paid to render her ventilation complete:—

Sheathing.

Her register measurement was 2400 tons; her frames were of British oak, $4\frac{1}{2}$ feet from centre to centre, close-jointed and bolted, and her sheathing consisted of four thicknesses of $2\frac{1}{2}$ inch Scotch larch, first two courses worked diagonally at an angle of 45° passing under the bottom of inside keel, and up the opposite side; the third course also passed under the keel, and was laid on transversely, same as the frames; there was a similar course worked inside between the frames, each course having a layer of felt, and a coat of Archangel tar, between them. The outside longitudinal planking averaged 6 inches in thickness, and the whole mass was combined by screw treenails of African oak, $1\frac{3}{8}$ inches diameter, put through the whole, there being one treenail at every foot in each strake of plank.

Beams.

She had three tiers of malleable iron-beams, there being one attached to each frame on each side of the three decks, as shown in the transverse section (Pl. III.) These beams were laid on pitch pine stringers, which were in two depths, and were attached to the sides by iron staple knees, a piece of plate-iron passing betwixt the beam end and the frame, and these plates being connected with the knees by the throat-bolts passing through them, and thus forming a lodgment for the iron beam ends. There was also a malleable iron-plate, $16 \times \frac{1}{2}$ inches, riveted to the top angle-irons on the beams; to this plate the water-ways were secured, besides being bolted horizontally. The sizes of the beams were:—

Upper deck,	$7\times\frac{1}{2}$ width,	$2\frac{1}{2}\times2\frac{1}{2}$	inches in single iron.
Middle deck,	$8\times\frac{1}{2}$	3	inches angle iron.
Lower deck,	do.	do.	do.

The beams were in one length; the lower edge with a bulb, and upper edge with angle-irons, back to back. They were supported by three tiers of iron stanchions, riveted to the beams, and bolted to the keelson and sister-keelsons.

For ventilation, the spaces, 3 feet wide, between the frames, were boarded up, and formed excellent ventilators from the various decks and hold, leading up to a space immediately under the main rail, which was fitted all round with venetians. She was also fitted with large funnels, and with a fanner for forcing the air down to the keel, besides scuttles on every six feet on the middle deck. The saloon was on the upper deck, and was fitted with a double roof for causing a current of air, with orifices all round under the cornice outside.

The vessel having a great rise of floor, it was levelled off inside to the 5 feet water-line, by having a fourth deck laid from end to end, and under this deck tanks were fitted to hold 300 tons of fresh water. Along the upper deck, from saloon forward, there was a range of houses for live stock, cook-house, and accommodation for the crew. This vessel sailed from Liverpool for Australia in 1854, drawing 21′ 6″ forward and 24′ 6″ aft, and on the eighty-fourth day was lost on Cape Otway, on a fine moonlight night. No favourable opportunity occurred during the passage to test her speed for any continued length of time; but she attained, on one occasion, a speed of sixteen knots for a few hours. This ship, complete, cost L.45,000.

The annexed figures are further illustrations of the details of construction adopted by the same builders.

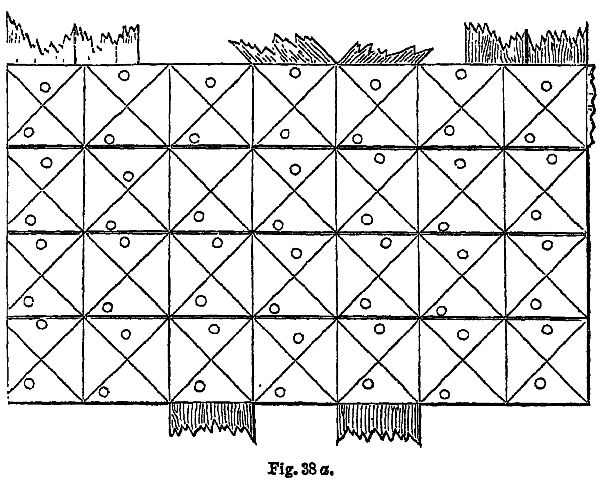

Fig. 38 *a*.

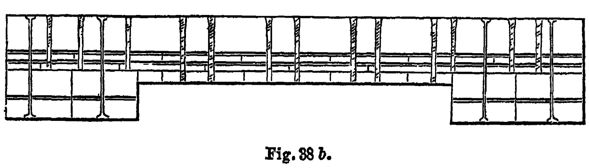

Fig. 38 *b*.

A section of a clipper ship, of 700 tons burthen, The Vision, of Liverpool, built in 1854, is given in fig. 39. The larboard side represents the bolting in the frames,

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which are 4⅔ feet asunder from centre to centre. The starboard side shows the application of the screw-treenails in connecting the various layers of plank, which consist of two thicknesses of 2-inch larch worked diagonally, as shown

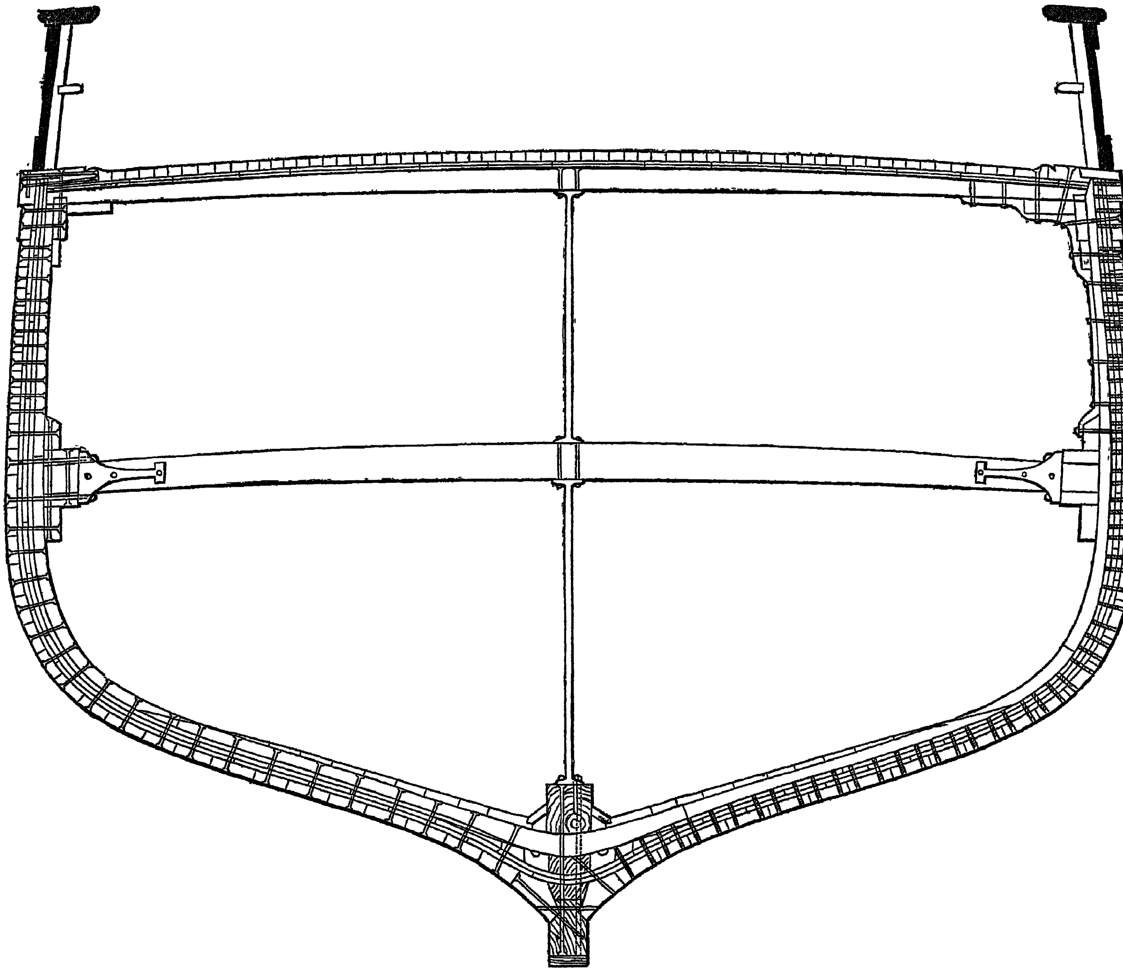

Fig. 39.

in figs. 38 *a* and 38 *b*, one thickness of larch worked vertically, and one outside, of an average thickness of 4½ inches, worked longitudinally, the sheer-strakes of East India teak, top sides Dantzic red pine, Wales, and to light water-line of

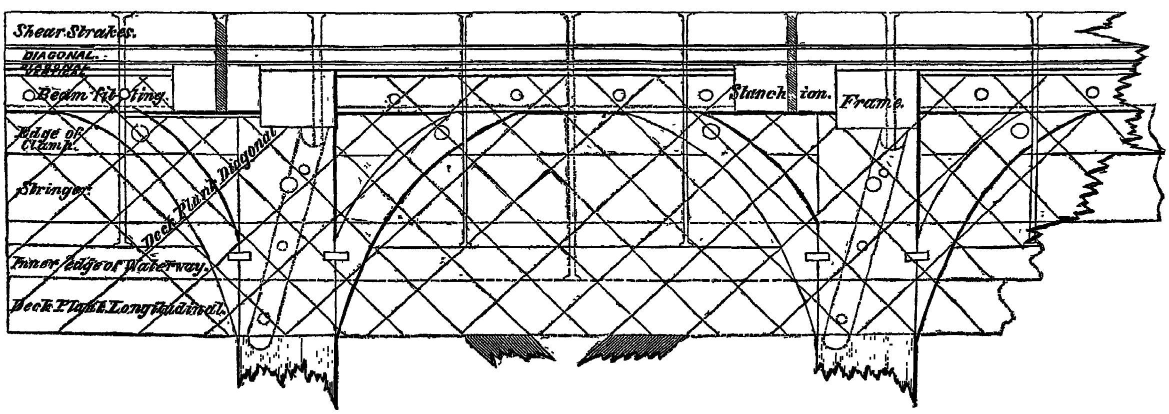

Fig. 40.

Dantzic imported plank, from thence to the keel-strakes of Dantzic red pine, with two complete layers of hair felt between the planks, which are all coated with vegetable tar.

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Fig. 38 *a* represents an outside longitudinal section of the side planking fastened with screw-treenails; and fig. 38 *b* represents a vertical section of the same, with the felt between and the metal bolting in the frames.

Fig. 40 represents the mode of laying the diagonal planking of the deck under the longitudinal upper-deck planks.

Details of iron-ships.

A cursory view will now be taken of a few of the leading features in the construction of iron-ships, and of the mode of forming and uniting some of the principal parts; and the specifications, in full, to which two first-class steamships have been built, will then be given.

Keel.

The keel is sometimes formed of a single bar, with the floors crossing above it, and united to the floors by being riveted to the garboard strake. It is more frequently formed of a plate, sufficiently deep to form both the keel and the centre plate of the keelson, or of a box form. Specimens of these forms of keel will be found in the engravings. A box-keel may also be made thus (fig. 41):—

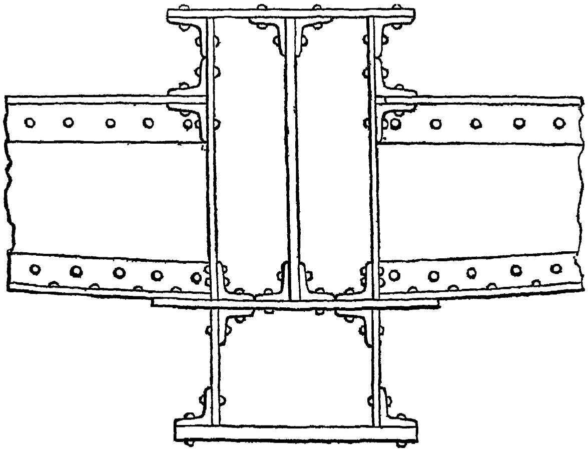

Fig. 41.

The points, in addition to general strength, which require attention, are, that if the keel be injured by the vessel taking the ground, it shall cause as little damage as possible to the vessel itself. A keel should also be capable of being varied in strength, so that it may be made stronger at the heel of the stern-post, where the bottom of the rudder is attached to it. It will be observed that this latter point is particularly attended to in the vessel for the Peninsular and Oriental Company.

In the keel, according to the sketch shown above, it will be observed that the plating is carried right across it, so that it might be very much injured, and probably even torn away in parts, without causing any leak into the ship, its edge being made purposely weaker than the bottom plate to which it is attached. Cross-plates with flanges, or with angle-iron, may be riveted across it, at any distance that may be desired, so as to stiffen it; and the plates can be made thicker, or additional strengthening plates may be added inside or outside the side-plates, at the stern-post, or at the forefoot.

Keelson.

The keelson is generally formed in one or other of the manners shown on the sections; and the floors may be carried across the bottom of the vessel, and the keelson be placed upon the top of the floors, following the same arrangement as in wooden vessels. In the latter case the side-plates of the keelson should be the whole depth of the floors, in addition to the height of the keelson above them, a space for each frame being cut out of the lower part of the plate to allow it to pass down between the frames, and be attached to the bottom by short pieces of angle-iron, as specified for the side keelsons of the Australasian, and shown in the section of that vessel at HH. There does not appear to be any particular advantage gained by the floor being made continuous across the bottom of the vessel; and as additional height is occupied by placing the keelson above them, there does not appear to be sufficient grounds for adopting this system in preference to the other.

Side or sister-keelsons.

With any side or sister-keelsons this is different, as it would be inconvenient to break the floors or frames again. In cases where such sister-keelsons are to be used as engine or boiler bearers, it would much improve their strength, and they would be better fitted to receive any such weights to be bedded upon them, if the plates were double, and they were brought up above the top of the floors, and formed into a box-keelson, thus (fig. 42). The

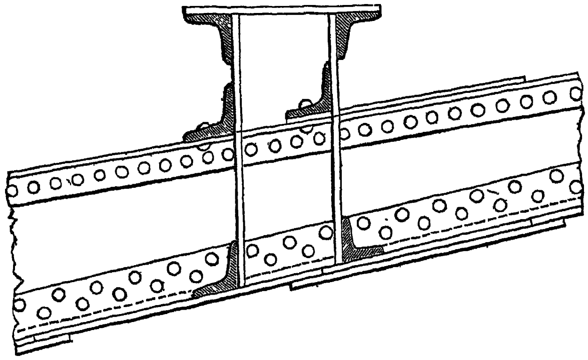

Fig. 42.

angle-irons of the keelson lying on the floors, and attached to them as they pass, stiffen them, and will tend to prevent their buckling or bending sideways when a great strain from the outside is brought upon them.

Where the floors abut on each side of the centre keelson, there is no reason why they should be the same height as the top of the keelson; and if the top or covering plate of the keelson be put on with external angle-iron (as shown in the above sketch) for a sister-keelson, great facilities are given for taking off the plate at any time for repair, or to renew any of the rivets. Indeed, there is no reason why different lengths of the covering plate should not be put on with screw-bolts, care being taken that the bolts fill the holes correctly.

Floors.

The floors are generally composed of an angle-iron, to which the external plating is attached, and a plate of any depth that may be desired, with single or double angle-iron on the inner edge of this plate. For the frames two angle-irons riveted back to back are generally sufficient. A T-shaped iron is also sometimes used, and if made with the centre web very deep, so as to be similar to the bulb-iron used for deck beams, it would be suitable for vessels of great strength, and, in some cases, for the floors with a single or double angle-iron on its inner edge.

Beams.

Some of the forms of beams have already been described. Beams formed of bulb-iron, with two angle-irons, are decidedly the most convenient, as there is no difficulty in welding them up in a common smith's fire to any length that may be required; and the top edge may be cut so as to vary the depth, and this even in the same beam if desired. By doing this the lower edge of the beam might be made straight, so as not to follow the round-up of the deck and of the upper edge; and thus any slight elongation of the beam, when brought down or straightened by any weight or strain, and the pressure to force out the sides of a ship consequent upon this, as dreaded by some, would be obviated.

The forms of bulb-iron, as generally rolled, do not give nearly so large a proportion of iron in the bulb as would be desirable. It is not consistent with the proper proportion of the flanches of beams, in reference to their depths, as laid down by Mr Fairbairn and other authorities on the subject.

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For beams 8, 12, 18, and 24 inches deep, proportions may be adopted according to the annexed four figures. The

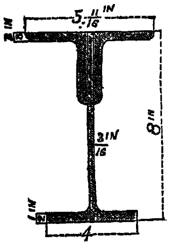

Fig. 43.

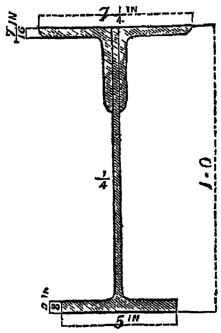

Fig. 44.

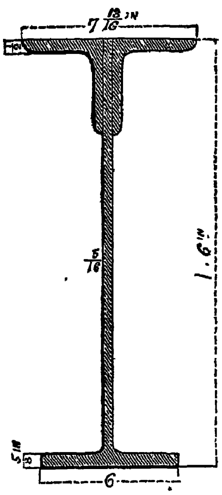

Fig. 45.

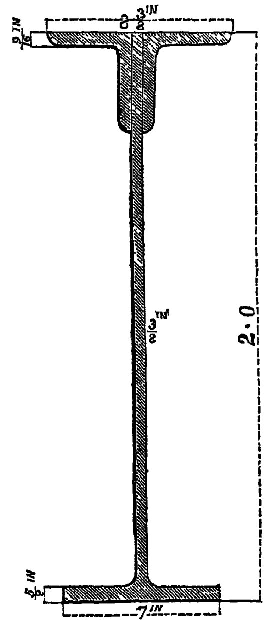

Fig. 46.

breaking weights of these beams, at the distances of 10 feet, 15 feet, 20 feet, and 30 feet between the supports, are respectively 10, 15½, 21, and 22 tons. The thickness of the webs may be considered by many to be too thin, but a beam of the annexed figure (fig. 47) is given by Mr Fairbairn as one much used by him, with a distance of 30 feet between the supports, and it may therefore be taken as a standard pattern. Where a saving of depth is a great object, the proportions may be varied. The relative strengths and weights of such beams, in comparison with ordinary wood beams, may be easily obtained by the rules which have been given.

Of the desirability of introducing iron-beams into wooden vessels there can be no doubt. Their durability alone ought to be a sufficient inducement.

Beams are now being welded up to any lengths by a process patented by Mr Bertram, late of Woolwich dockyard. The edges to be welded are brought together, and two jets of gas are made to play upon both sides at the same time till the iron is brought to a welding heat, when it is united in a most perfect and satisfactory manner.

Sheathing or plating.

An increase of thickness in the plates of iron-vessels adds to the safety and general strength of the vessel in a much more important degree than putting the additional weight into the frames to strengthen them. A large surface of unequal strength in different parts is objectionable; it will be sure to yield at the line where the weak and the strong parts meet, and probably a rupture may take place along that line; but if the surface be all of nearly equal strength, and a pressure be then applied, as may be the case on the exterior of a vessel, it may yield, and the indentation may be extensive without any rupture.

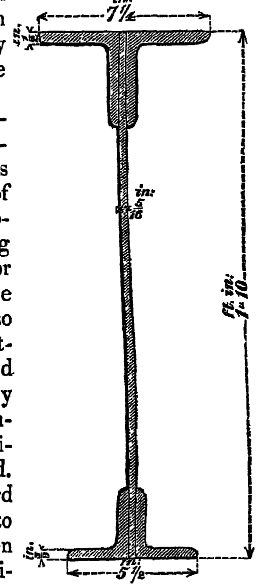

Fig. 47.

Riveting.

The subject of riveting has already been fully treated, when giving the details of Mr Fairbairn's experiments on the strength of riveted joints. Mr Bertram's process, as adapted for the welding of beams, and by which one or more experimental boilers have already been constructed, is also proposed for the purpose of uniting the plates of iron-ships, and there do not appear to be any reasons to prevent it from becoming available after more experience in its use has been obtained. The same remarks, with regard to decks, apply to iron-ships as to wooden ships; but iron has been more used as diagonal and longitudinal stringers under the deck-planks in the former than in the latter class of vessels.

In the accompanying sections of a vessel constructed to the design of Mr Bowman of London (fig. 48), the iron-plating below the deck-planks is shown, and it is laid complete over the whole surface beneath the deck-planks. The water-ways, or pieces for forming the run of the water at the sides to the scuppers, it will also be observed, are of iron, which is not usual, but it is an important improvement, and a step in the right direction of greater deck-strength. At the risk of its being considered a repetition, reference is again made here to the importance of this point, as the strength of an iron-vessel may be compared more easily than that of a wooden one, with the strength of iron tubular bridges. As has been before observed, the severest strain to which a vessel is likely to be exposed is when it is supported in the middle, and the two ends are left unsupported. As a familiar illustration of the mode of dealing with this subject, a vessel in this position may be looked upon as a beam supported at the middle, and weighted at the two ends, or, which is the same thing, as a beam pushed up in the middle and prevented from rising by the weights, or by being fixed at the two ends. And if this beam be now supposed to be turned upside down, or reversed, and then to be subjected to the same strains upon it as before, it becomes equivalent to a beam supported at the two ends and weighted at the middle, and all the calculations for beams or tubular bridges so weighted immediately become applicable. It will thus be seen that the bottom of the ship has to bear a strain of compression as due to the top, or top flanche of the tubular bridge, and the deck has to bear a strain of extension as due to the bottom or bottom flanche. The keel and keelsons, and the internal and external plates of the bottom, supported, or rather stiffened and kept in the direct line of the strain, by being attached at such short intervals to the floors, duly meet the case of the top flanche, and give the requisite strength; and the deck of the ship, and the strengthening pieces connected with it, must be made equal to meet the strain of extension, to which the bottom flanche of the beam is subjected. Let a vessel be supposed to be of the length of 300 feet, with a depth of 30 feet, and the weight of fittings, machinery, and everything which she has to carry to be 1500 tons, which may be assumed to be nearly correct for a passenger screw steam-ship of this length,—and let it be

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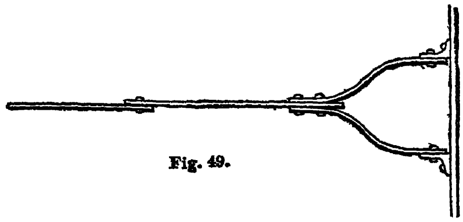

Fig. 49.

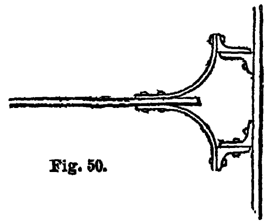

Fig. 50.

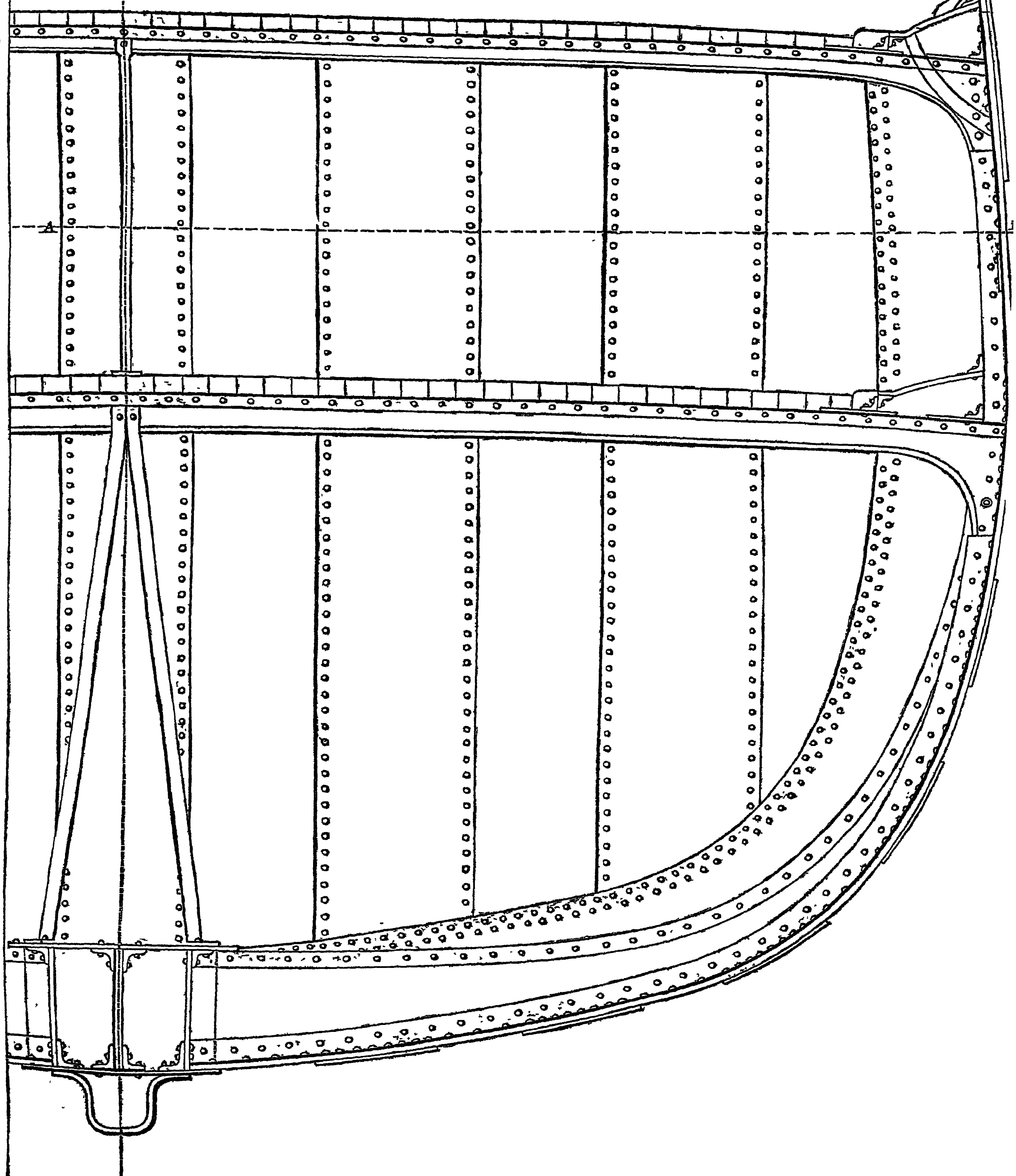

Fig. 48.

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further supposed that the weights are equally distributed over her length, then the strain would require to be the same as for a tubular bridge, or girder, to carry a weight of 750 tons at the middle. Now, if the ordinary rules be applied, it will be found that the sectional area of the bottom flanche of a box-girder of these dimensions, and whose breaking weight is 750 tons, would be 94 square inches; and doubling this for the excess of strength necessary in practice, will give an area of 188, or say 200 square inches of iron. The strength of the deck, therefore, at the middle, should be equal to the strength of iron-bars or plates of this sectional area, and towards the ends it may be diminished to about two-thirds of this strength, on the same principle and in the same manner as the flanches of a beam may be diminished.

An explanation of the theory of the strength of girders is not within the province of this article. It will be found very fully treated in the works of Tredgold, Hodgkinson, Barlow, Fairbairn, Latham and others, as also in some papers in the *Transactions* of the Institution of Civil Engineers, and in a paper in the *Transactions* of the Royal Society, by Mr Barlow, "On the position of the Neutral Axis."

Water-tight bulkheads.

While the advantages of iron water-tight bulkheads are unquestionable, nothing can be worse than that the sheathing should be weakened in one direct transverse line by a series of rivets, placed so close together as to lessen the strength of the plates in an undue degree at that line. The Board of Trade insist upon the bulkheads being attached to two frames, but it is not apparent how the difficulty is got over by this means alone, because on one or other of these frames the rivets must be sufficiently close to make the joint water-tight. This would be advantageous if the bulkhead were made to run home to the side of the ship, and be made water-tight there by an additional angle-iron, while the two frames on either side are united together through the bulkhead, so as to prevent the vessel separating along the line of weakness between them. In this view the inner line of plates uniting the frames to the bulkhead should be kept as close as possible to the ship's side, and therefore as much as possible in the direct line of the strain to be resisted.

The following is a specification of an iron screw-steamship for the Peninsular and Oriental Steam Navigation Company:—

Principal Dimensions.

Length between the perpendiculars	335 feet.
Length of the keel for tonnage	To be according to the approved design.
Breadth, extreme	39 feet.
Depth amidships (from top of keel)	31 „
Burthen in tons, Nos	2520. $\frac{8}{94}$ O. M.

Keel.—To be formed of plates, as shown in figs. 51 and 52, the centre through-piece to be 3 feet 6 inches deep from bottom of keel to top of floors, and $\frac{11}{16}$ thick right fore and aft. The plate on each side to be 10 inches deep by $1\frac{1}{2}$ inches thick. The fore and aft plate shown on top of floors to be $\frac{3}{4}$ in. thick, and 2 feet 6 inches wide, worked so as to fit on top of floors, and connected to centre through-piece by two angle-irons $4 \times 4 \times \frac{8}{16}$. The after-end of keel to have an angle-iron 6×4 on each side, and a plate $\frac{7}{8}$ in. thick on the bottom, to run for 50 feet from the aftermost stern-post.

Stem.—To be made of plate in exactly the same manner as the keel, the plate on each side the centre through-piece to gradually taper to $9\frac{1}{2}$ inches deep at the top, and all the bow-frames to be riveted to it.

Breast-hooks.—As may be required.

Stern-posts.—15 inches broad by 7 inches thick, and a heel left on the after-side to bear the rudder, with eyes for the pintles, and turned so as to form a knee forward on the keel. The screw-port to be forged in one piece to suit the drawing, or as the engineer may require.

Frames.—Of angle-iron, $5\frac{1}{2} \times 4 \times \frac{10}{16}$, and 20 inches from centre to centre. In engine and boiler spaces, the frames to be doubled in the bottom, and a reverse angle-iron on every frame, $4 \times 3 \times \frac{8}{16}$, from floor to gunwale, the whole length of the vessel.

Plates.—Garboard-strake, $\frac{17}{16}$ plates, as broad as can be procured, or worked; bottom-plates $\frac{13}{16}$, next plates up to the wales $\frac{12}{16}$, from the wales to gunwale $\frac{10}{16}$, except two plates, 2 feet 6 inches wide, $\frac{14}{16}$ thick, or one plate equal to this to form the wales; the sheer

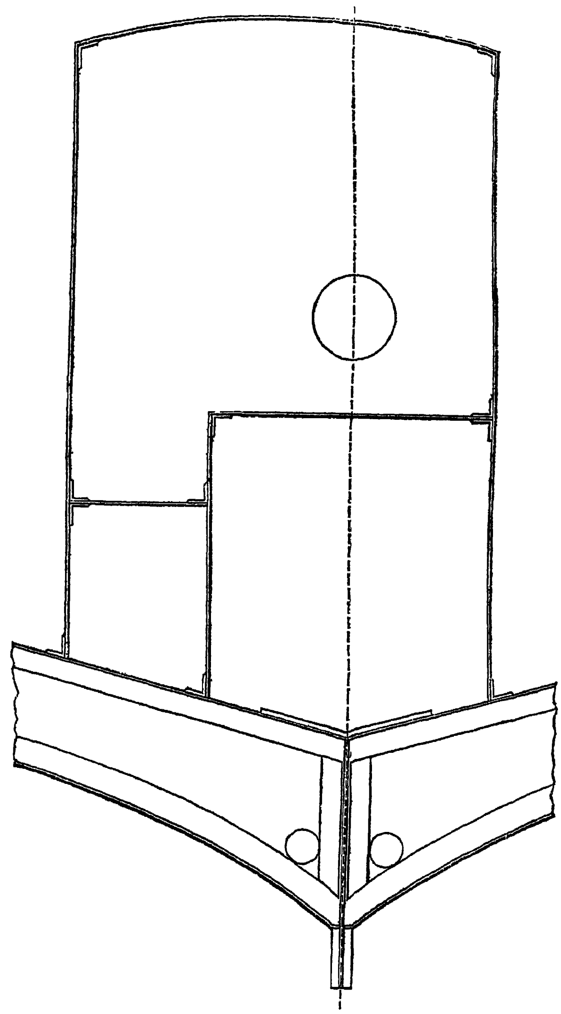

Fig 51.

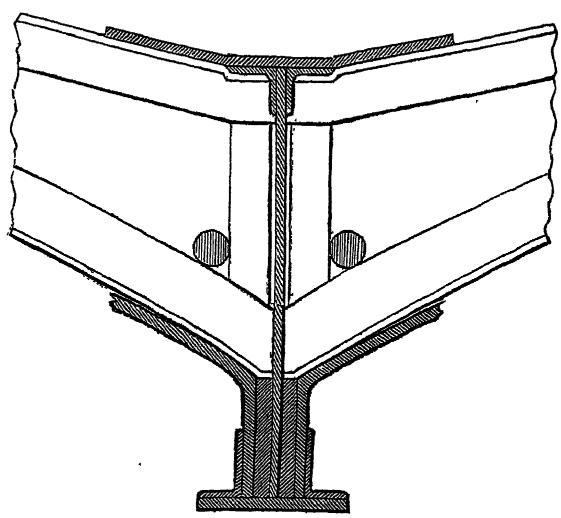

Fig. 52.

strake, $\frac{14}{16}$ thick, to be doubled right fore and aft, and butt-straps inside, as in single plates, all double riveted from keel to gunwale, and all butts to be flush; the upper or sheer-strake to go 12 inches above top of water-way, as per sketch. All spaces formed by the projections of the plates to be fitted with liners, so as to avoid small

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pieces and rings being used, except in the case of the sheer and upper wale-strakes, which will be doubled, and the inner strake will necessarily form the liner. The butts to be perfectly close as well as the seams, as no pieces will be allowed to be put in and caulked over. The counter-sinking to be carefully done and all rivets to be full and smooth outside plates, and to be chipped down while hot. The greatest care to be taken in the punching, to prevent unfair holes.

Floors.—30 inches deep in engine and boiler spaces of $\frac{12}{16}$ plates, with angle-iron, $4\frac{1}{2} \times 3 \times \frac{7}{16}$, on each side, on top of every floor, to run from 14 to 16 feet up the turn of bilge. The floors in after-hold, 30 inches deep, $\frac{10}{16}$ thick, with single angle-iron on top, $4\frac{1}{2} \times 3 \times \frac{7}{16}$. The floor-plates to run 6 feet up the turn of bilge on each side of frames in one piece.

Keelsons.—As may be required, and to suit the engineer's drawings, to run right fore and aft as far as the form of vessel will allow.

Pillars.—In holds between keelsons and beams, to be $3\frac{1}{2}$ inches in diameter amidships, tapering to $2\frac{1}{2}$ at the ends. One on every beam, or as may be directed. Pillars on main-deck, one on every other beam, arranged so as to suit the cabin plan.

Bulkheads.—Water-tight; one in fore-peak, two before the engine, one abaft the boilers, and one in after-hold; to be in accordance with the Board of Trade regulations in every respect. To have iron-bulkheads, or floors, on every frame from stern-post for 40 feet, and on every frame from stem for 20 feet, the after ones $\frac{5}{8}$ inch thick, the foremost $\frac{1}{2}$ inch. Those abaft the aftermost water-

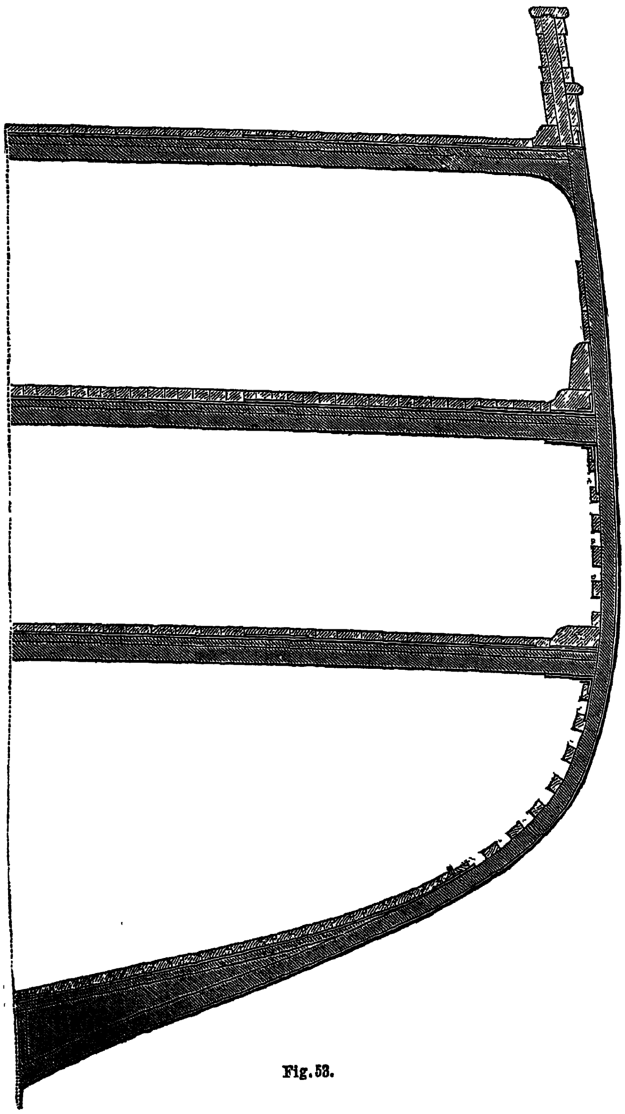

Fig. 53.

tight bulkhead to run up to the lower-deck water-way plate, and an angle-iron on the top of each, with a water-tight deck, riveted to the same. The lower-deck water-way plate will run through these bulkheads, as well as the water-way forming part of the deck. Proper man-holes, cut through each floor above the shaft, and sufficient water-tight man-hole doors, fitted to the holes in the iron-deck. The floors before the water-tight bulkhead to run up as far above the shaft as may be required. Every other bulkhead, the length of screw-shaft, to have a forged iron-rim, 3 inches wide, 1 inch thick, riveted round shaft-space. The hole for shaft to be drilled from after-end through all these by the engineers. All water-tight bulkheads to be fitted with approved brass sluice-valves. The space below the screw-shaft, abaft the aftermost water-tight bulkhead, to be filled-in solid with bricks and cement. Iron-tie bulkheads to be placed, as directed, between main and spar-decks, about 20 feet apart.

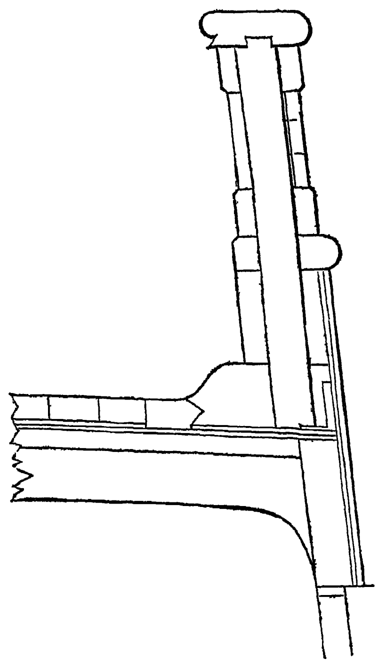

Fig. 54.

Beams.—Of plate, $10 \times \frac{7}{16}$, with two angle-irons on top, $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{7}{16}$. Beams not to be turned at the ends, but to have a vertical and horizontal plate, riveted to under side of beams and side-frames, with an angle-iron in the angle, and to be finished on the lower edge, with half-round iron, as may be required. An angle-iron on each alternate frame, for main and lower decks, with as many in the engine and boiler spaces as the position of the machinery will allow. To have orlop-beams and a deck to allow of such accommodation for stores as may be required (fig. 53). Engine-beams as the engineers may direct. Eight of the foremost beams to be made of an elliptical shape, turned down 2 feet 6 inches to strengthen the bow, and likewise for the hawse-pipes to pass through. The plate to be twice the thickness of the other beams.

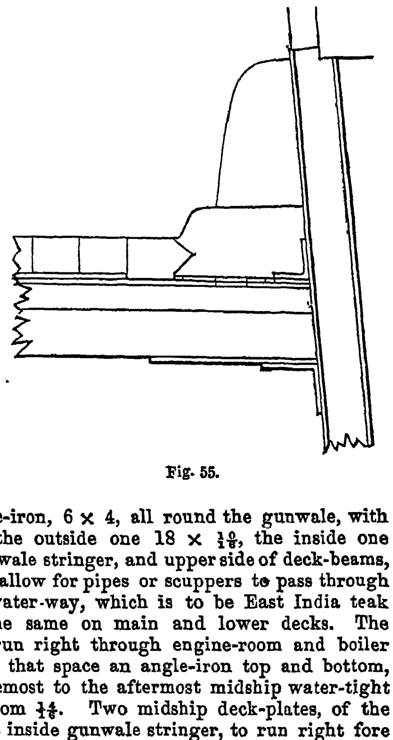

Fig. 55.

Stringers.—An angle-iron, 6×4, all round the gunwale, with two covering plates, the outside one $18 \times \frac{12}{16}$, the inside one $24 \times \frac{12}{16}$, riveted to gunwale stringer, and upper side of deck-beams, and 6 inches apart, to allow for pipes or scuppers to pass through the first plank from water-way, which is to be East India teak (figs. 54 and 55). The same on main and lower decks. The lower-deck plates to run right through engine-room and boiler space, and to have in that space an angle-iron top and bottom, and to be from the foremost to the aftermost midship water-tight bulkhead in engine-room $\frac{12}{16}$. Two midship deck-plates, of the same dimensions as the inside gunwale stringer, to run right fore and aft, full length of vessel, on each side of engine-room skylight, and riveted to upper side of deck-beams. To have at least 6 diagonal spar-deck plates, $12 \times \frac{1}{2}$, riveted on top of all these stringers, to tie the sides of the vessel together, to be placed as may be required (fig. 56). The butts of all these fore and aft stringers to be placed so that the whole of them come on beams, and to have a butt-strap to each butt 12 inches in width, and a row of rivets on each side of the edge of the beams. A vertical stringer, 2 feet 2 inches wide, $\frac{12}{16}$ thick, to run round the main-deck at back of spirketting, and to be connected to side deck-plate, or horizontal stringer, by

an angle-iron, $6 \times 4 \times \frac{10}{16}$. All these fore and aft stringers and deck-plates to run fore and aft, and not to be disconnected or cut through anywhere, and all water-tight bulkheads, beams, or any athwartship work to be cut round them, and all to terminate at each end in plate-breasthooks of $\frac{1}{8}$ in. thicker plate than the stringers, and to run out as far from either end as may be required. A bilge-stringer, formed of two angle-irons, $6 \times 4 \times \frac{10}{16}$, with a plate at back $18 \times \frac{9}{16}$, fastened to frames to run right fore and aft the ship. All stringers, vertical and horizontal, water-way plates, &c., to be doubled for 30 feet in way of cargo gangways.

Riveting.—The vessel to be all double riveted with $\frac{7}{8}$ rivets, except in keel and stern-post, which must be $\frac{1}{4}$th inch thicker than the plates they pass through.

Other Iron Work.—Iron casing round boiler space and stoke-hole, between main and upper-decks, likewise all coal-bunker bulk-heads (except what forms part of the engineer's contract). Coal-shoots and deck-plates for them, flat in bunker-bottoms, casing of bunkers, engine-beams, screw-tunnel, iron gratings over stoke-hole on upper deck, ash-bucket pipe from stoke-hole to spar-deck, with revolving cap on top, to be furnished by the contractors. A water-tight slide, at foremost end of screw-tunnel, to be fitted in accordance with the Board of Trade regulations. Preparation to be made for a lifting-screw on the most approved principles. The engineer to furnish all slides and lifting apparatus.

Topgallant Forecastle.—To be in accordance with the drawing given both in length and height, to be plated up from sheer-strake to top with $\frac{3}{8}$ iron-plates, and to be fitted up inside as may be directed. A manger, 3 feet deep, to be fitted forward, with 4 hawse-pipes, bucklers, plates, and all complete, as may be required by the company. The deck to be 3 inches thick, with iron-stancheons, and rails round the top-beams, $8 \times \frac{7}{16}$, bulb-iron, with 2 angle-irons on top, $3 \times 3 \times \frac{6}{16}$. A water-closet on each side, the aftermost end outside, with pumps, and all complete for the crew.

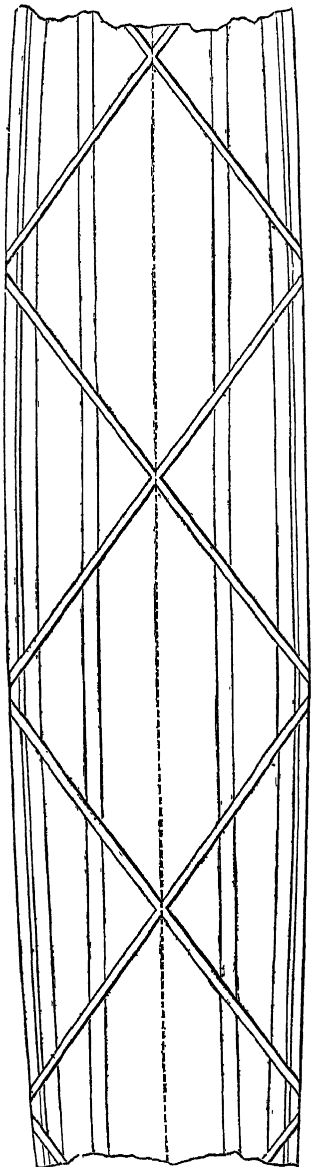

Fig. 56.

Inside Cement.—The vessel to be filled up solid to the limber-holes with Portland cement.

Quality of Iron.—Garboard-strake, sheer-strake, and longitudinal stringers, of Staffordshire B. B., of an approved maker, all the other plates of Staffordshire B., except curves, which are to be the best Lowmoor, or of iron made from best picked scrap equal to this.

Wood Work and General Outfit.

Upper or Spar Deck.—East India teak $3\frac{1}{4}$ inches thick, secured to beams by two $\frac{5}{8}$-inch galvanized iron bolts and nuts, let in $\frac{3}{4}$ths of an inch below the surface, and dowelled with wood. The mid-ship's deck-strakes to be 1 inch thicker, and to run fore and aft, or as may be required.

Main Deck.—Yellow pine 6×5, caulked and secured with iron bolts and nuts as upper deck.

Lower Deck.—Yellow pine $9 \times 3\frac{1}{2}$, caulked and secured with iron bolts and nuts as above.

Stancheons.—Teak or British oak 6×5. Stern timbers of the same 7×6, and to run well down, to give strength to the stern. All the other stancheons to run down on top of spar-deck, water-way plate through covering-board, and the space between under-side of covering-board, and top of water-way to be filled in solid and caulked, and a piece of teak-spirketting inside of stancheon, bolted through and through, from outside of iron sheer-strake, except in those stancheons which come in way of boats' davits, which will have an angle iron knee to turn under water-way, inside of bulwarks, well riveted to water-way plate. Oak or teak spirketting 18×9, to run right round the main-deck inside, on top of water-ways.

Awning Stancheons.—Of iron, all round the vessel.

Water-ways.—Upper or spar deck, and main deck, to be East India teak 18×9, and, if required, to be fitted over the angle-iron stancheons.

Ceiling of Hold.—Flat of floor laid with 3-inch American elm, and from that to be ceiled with yellow pine, room and space to the main deck beams. The remainder to be 2-inch close futline, caulked, payed, and beaded over seams, as will be pointed out.

Bulwarks.—Yellow pine $3 \times 2\frac{1}{2}$ thick, and to have a panel grooved in the centre.

Main-Rails.—Teak, $12 \times 4\frac{1}{2}$; to have copper or yellow metal along the edge outside, fore and aft.

Gangways.—To be where shown on plan—viz. four cargo-gang-way ports with all doors, brass scuttles, hanging platform to turn outside or inside as may be required, between main and upper decks, lined in sill and edges, with twenty ounces copper or yellow metal. Two passenger gangways on upper deck, fitted with the most approved accommodation-ladders complete, with all necessary fittings. Four coaling gangways on upper deck, fitted with doors complete; also hanging brackets riveted on ship's side, to carry stage when required. The ends of rough-tree-rail and gang-ways to be capped with a casting of brass.

Catheads.—British or African oak, 18×16, mounted with all stoppers, cleats, &c., as may be required.

Bitts.—Of British or African oak, 22×22, stepped on keelson. Towing bitts, topsail-sheet bitts, belaying pin-racks, cleats, eye-bolts, timber-heads, &c., to be fitted as and where required.

Bridge.—To be 5 feet 6 inches wide, to be supported with sufficient iron stancheons, and fitted with ladders, lamp-boxes, hand-rails, and all complete, as may be required.

Masts.—Lower mast and bowsprit of iron or steel as may be approved, and a provision to be made for cutting them away if required, the other masts and spars to be of black spruce or red pine, to be rigged according to plan.

Rigging.—Standing rigging of wire-rope, the rest of best hemp, with all requisite blocks. All blocks to be brass-bushed, or patent leather bushes, as may be preferred; all dead eyes, both upper and lower, to be made of lignum vitæ; if required the vessel to be fitted with Cunningham's patent self-reefing topsails.

Storm-House.—To be built at after-end of upper deck, with two two-berth cabins on each side of wheel, with a water-closet in each, and fitted up inside in every respect as first-class cabins. The top of this house, as well as those of all other cabins and offices on the upper deck, to be double; the upper one teak, the lower one pine, covered with canvass.

Companions and Skylights.—To be built according to plan. The tops of all of them on the upper deck to be made of East India teak.

Boats—To be in accordance with the Board of Trade regulations, and to be fitted complete, with masts, sails, oars, boat-hooks, breakers, gratings, davits for ship's sides, and all necessary fittings as may be required; brass rowlocks to mail-boat; life-boats to be according to Lamb and White's plan.

Fowl-Coops.—Twelve; 12 feet by 2 feet 4 inches high.

Sheep Pens.—To hold forty sheep.

Scuppers.—Eight on each side on each deck, to be placed where shown.

Fish-Davits.—For fishing anchors to be fitted, as will be shown.

Anchors and Chain Cables.—In proportion to tonnage of vessel, the anchors to be patent, or as required by the Board of Trade regulations.

Winches.—Two; if steam, the difference in price to be paid by the company.

Sails.—One suit of sails complete.

Tarpaulins.—One for each hatch and scuttle.

Awnings.—A complete set, fore and aft.

Pumps.—One copper chambered pump 8 inches in diameter, with brass bucket and lead pipe, fitted in every compartment, and a 7 inch and a 5-inch Downton, fitted as may be directed.

Wheels.—Two of mahogany, brass-mounted, hide-rope, fitted with patent steering gear complete.

Fenders.—With chains, &c., complete.

Ports.—Of East India teak, 21 inches square, with a 5-inch brass

scuttle fitted in the centre of each, hung with strong iron hinges, brass-bushed, and copper pins, except where shown round in plan, as in water-closets or other deck-offices, where scuttles must be fitted, 7 inches in diameter, of the best manufacture.

Water-Closets.—Tylor's of Newgate Street to be fitted where shown on plan, with cisterns, pipes, valves, and all necessary fittings.

Baths.—Hot, cold, and shower, to be fitted where shown on plan.

Tanks.—For 12,000 gallons of water, with all requisite cocks, pumps, pipes, and all necessary fittings.

Binnacles.—Two, with adjusted compasses and lamps complete.

Brass Bell.—18 inches in diameter, with vessel's name engraved thereon.

Cook-Houses.—Two of iron, with all necessary fittings complete.

Cooking and Baking Apparatus—With all necessary utensils complete, as may be required to be furnished by the company.

Colours.—A complete set as may be required.

Life-Buoys.—Six of such description as may be required.

Lanterns.—Signal-lanterns and fittings to be fitted where required—viz., 2 bridge, 1 mast-head.

Buckets.—Twelve wash-deck and twelve leather buckets, with the company's crest and ship's name painted thereon.

Hose.—Leather fire-hose and canvass-hose for washing decks, with the necessary couplings complete.

Capstans.—Two; the foremost, or main capstan, to be one of Brown's patent double-headed capstans, to work on top of topgallant forecastle, with all the bitts, stoppers, &c., fitted complete on spar-deck. The after one to be Brown's patent double-power capstan for warping the ship, and to be fitted complete.

Meat-Safe and Vegetable Locker.—One of each to be made and fitted, as will be shown.

Butcher's Shop.—To be where shown on plan, slate-tanks, and all complete.

Cabins.—To be fitted according to plans furnished by the company, arranged generally as the "Pera" and "Candia." The contractors to find everything complete, except saloon and fore-cabin tables, seats, chairs, sideboards, sofas, bed and sofa mattresses, curtains, camp-stools, glass, earthenware, plated goods and cutlery; cabin-lamps and looking-glasses; pantry, steward's and store-keeper's utensils; but the contractor will find all the furniture and fittings for all the cabins and offices in the ship, including first and second class passengers, officer's, engineer's, steward's, and any other cabin in the ship, such as chests of drawers, washstands with marble tops, tables, toilet-shelves, or any other fittings that may be required; likewise all the different offices on deck, as shown in plan, to be fitted complete, such as surgery, lamp-room, baker's shops, scullery, or any other office not named here, but shown on plan. All the cabins in the ship to be fitted with Robinson's patent ventilating bulkheads, as per elevation.

Painting.—All the wood-work to have four coats. The main-deck cabins, from the main hatch forward, to be grained oak in the very best style. The main saloon to have at least six coats of paint and two of best varnish, and the whole of the gilding to be of the very best quality.

Mail-Room.—To be where shown on plan. Space for sixty tons of mail, and to be lined with zinc all over. The bottom to have ledges of wood, $3 \times 2\frac{1}{2}$, 12 inches apart, secured to deck.

Sail-Room.—To be where shown on plan, and to be covered over with zinc.

Purser's Store-Rooms.—To be where shown on plan, and to be fitted up inside as may be directed.

Boatswain and Carpenter's Store.—To be where shown on plan, and to be fitted up as shall be directed.

Finally.—The whole of the material and workmanship to be of the very best quality, and the vessel (with the foregoing exceptions) to be entirely fitted and ready for sea at the cost of the contractors, notwithstanding any omission in this specification, and subject to the approval of the managing directors, or of such surveyor or surveyors as they may appoint to inspect the work.

The following is a copy of the specification of an iron screw-steamship, built for the European and Australian Royal Mail Company. The Australasian was built in 1857, by Messrs J. and G. Thompson, of Glasgow, under the inspection of Mr Bowman, of London, who has kindly permitted its publication here. The strength of this vessel, and the soundness of the principles on which she is constructed, were well proved by her grounding in the Clyde, on her first passing down the river after being launched, when she came off, as before stated, quite uninjured.

Specification of an Iron Screw-steamship to be built for the European and Australian Royal Mail Company.

Principal Dimensions.

	Ft.	In.
Length of keel	310	0
Breadth of beam	42	0
Depth of hold to spar-deck	29	9
To have three decks, with full poop and full topgallant-forecastle		
Height of poop	8	0
„ topgallant-forecastle	6	3
„ from main to spar-deck	8	6

Keel and Keelson.—The keel to be formed of three thicknesses of plate; the centre plate to be 1 inch thick, and 45 inches deep; forming, at same time, the main keelson and centre of keel; these plates to be in as long lengths as possible, to be put together, butt-jointed, with straps of same thickness, and double-riveted above that part which forms a portion of the keel; the plates to run the entire length of the vessel, and for 10 feet up the stem. The keel side-plates to be 12 inches $\times 1\frac{1}{8}$ inch; to be in as long lengths as can possibly be obtained; to be all scarphed on to each other, scarphs 6 inches long; these three thicknesses of plate, to be partially riveted together before the garboard-strake is fitted on; the garboard-strakes to be double-riveted to the keel with $1\frac{1}{4}$th inch rivets; all the holes to be runneled out perfectly true before riveting; the butt of the keel-plates and garboard-strakes to be carefully shifted and caulked, and made water-tight. (Section AB, fig. 59.)

Stern-post.—To be of best hammered scrap-iron in one piece, the after-post to be 12×5 inches, the inner-post to be 12×7 inches; the lower portion, uniting the two posts, to be 12×8 inches; and to have about 8 feet of keel attached to it, and with corresponding scarph for riveting to keel. The keel portion to be planed out into a groove, 1 inch wide and 6 inches deep, into which the keelson plate is to be worked, and double-riveted through and through. The end of the keelson-plate to be secured to the inner post by two vertical bars of angle-iron secured to it by rivets, and to the post by tapped bolts (fig. 57). The inner post, at the line of the lower

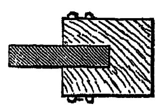

Fig. 57.

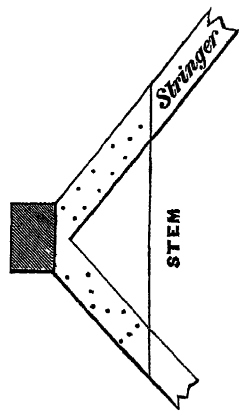

Fig. 58.

deck-stringer, to have a palm welded to it, which is to be firmly riveted to the stringer, so as to give security to the post (fig. 58). To be formed in the same way as the keel, from iron of the same dimensions, and riveted together in the same way; the keel, keelson, floors, stem, and stern-post to be according to sketch to be furnished.

Frames.—To be spaced throughout the vessel 18 inches apart from centre to centre, of angle-iron, $4 \times 3\frac{1}{2} \times \frac{5}{8}$th inch, to have a reverse angle-iron on every frame, $4\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{2}$ inch, riveted along the top of the floor-plates, and up the frames, to the height of the upper deck-beams, by $\frac{3}{4}$th inch rivets, 6 inches apart (every alternate frame from main-deck may be left without reverse iron, a piece being put in underneath the clamp-plate). Where desired, in wake of boilers and engines, the frames and reverse bars to be worked double.

Floors.—The floor-plates at keelson or amidships to be 33 inches deep $\times \frac{5}{8}$th inch thick; to be carried up past the turn of bilge, say to the 6 feet water-line, and riveted to the frames and reverse angle-irons. The end of each floor, which butts against the keelson, to have a vertical angle-iron, $5 \times 3 \times \frac{1}{2}$ inch, riveted to the floors and to the centre keelson, (section CD, fig. 59). Along each side of the top of keelson-plate there will be angle-iron $5 \times 5 \times \frac{5}{8}$ths. riveted on a level with the top edge of keelson-plate and floors. A

Practical Building.

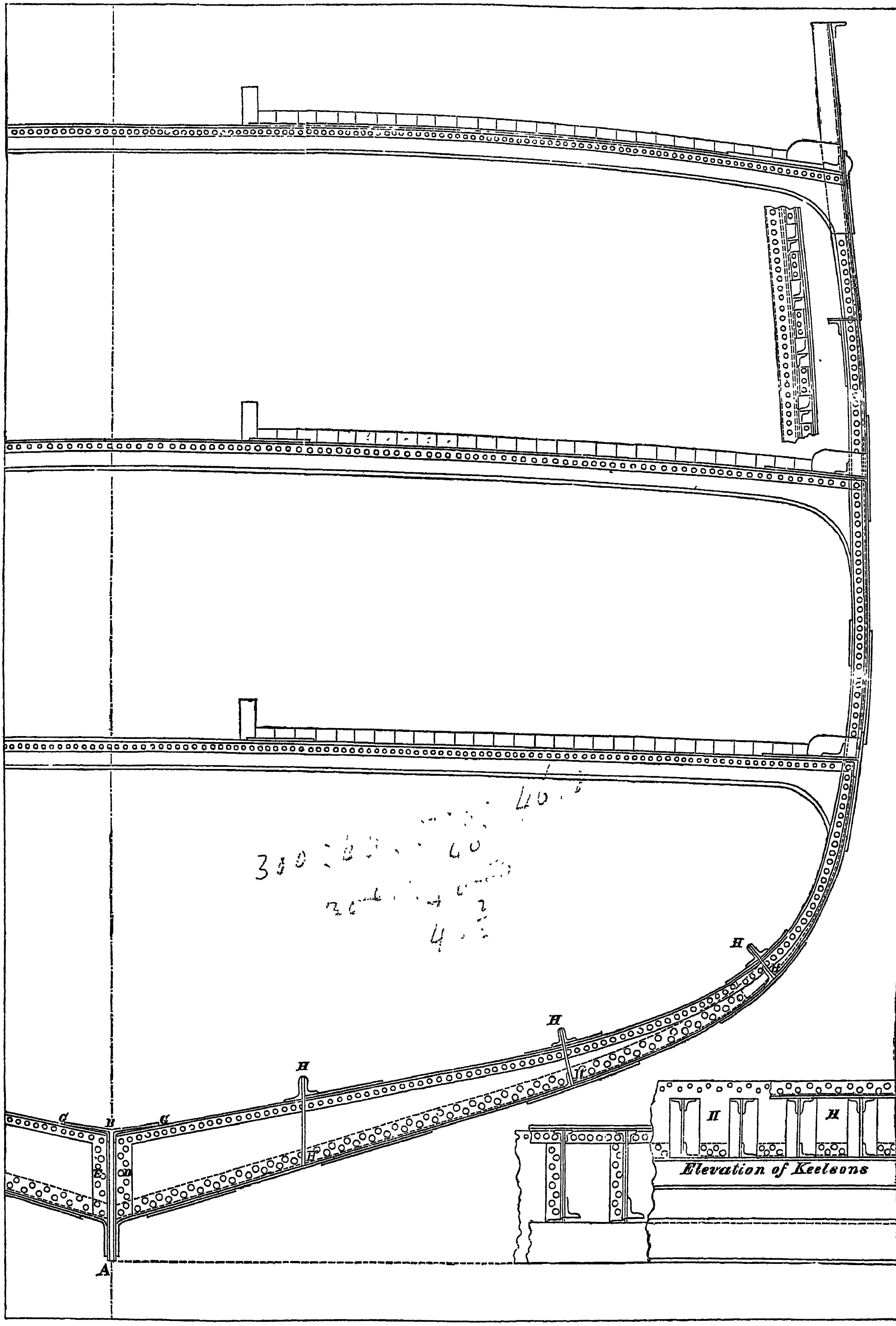

Fig. 59.

Practical Building.

plate 36 × $\frac{7}{8}$th inch in engine-room, and 36 × $\frac{13}{16}$ths at ends of vessel, in long lengths, will run the whole length of the vessel, and be riveted to the angle-iron on top of keelson, and to the reverse angle-irons of the floors; these plates to be built jointed, and double riveted, section GG.

Keelsons—To have two side and two bilge keelsons, to be formed of plates 30 inches broad × $\frac{5}{8}$th inch, riveted to the reverse frames. On the centre of these plates there will be double angle-iron 6 × $3\frac{1}{2}$ × $\frac{5}{8}$th, riveted back to back, and to the plates. From betwixt these angle-irons there will pass down to the skin-plate $\frac{5}{8}$th inch thick, the breadth regulated by the distance apart of the frames and reverse angle-irons; these plates to be riveted at the foot to short pieces of angle-iron, secured to the skin, and at the top, betwixt the floor angle-irons, section H. H., &c., &c.; to have intermediate keelsons for about 150 feet amidships, to be double angle-iron 6 × $3\frac{1}{2}$ × $\frac{5}{8}$th inch, riveted back to back, and to the reverse angle-irons on the floors, and to be connected to the outer skin, same as the other keelsons, section H. H. The whole of the stringers, main, bilge, and other keelsons, to pass unbroken through the bulkheads, and to be made water-tight by strong brackets, riveted to them, and to the bulkheads.

	Fd.	200 feet Mid.	Aft.
Plating.—Garboard-strake to be fitted close up to the frames.........	$\frac{7}{8}$	1 in.	1 in.
Next strake to garboard (to garboard).....................................	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$
Thence to bilge....	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{11}{16}$
Bilge-strake..............................	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{11}{16}$
Thence to wales..........................	$\frac{9}{16}$	$\frac{5}{8}$ & $\frac{9}{16}$	$\frac{1}{2}$
Wales in two strakes.................	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$
Thence to sheer-strake...............	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{7}{16}$
Sheer-strake at least 36 in. broad	$\frac{7}{8}$	1	$\frac{7}{8}$

The plating from keel to gunwale to be lap-jointed horizontally with vertical flush-butts, with an internal strap of corresponding thickness to the respective plates, 8 inches wide. The butt-straps of the sheer, wale, or garboard-strakes to be cut across the thread of the iron from plates, and to be $\frac{1}{16}$th thicker than the plates to which they are respectively fitted. All the plates which end on screw-frames, and the next adjoining them on every strake, to be not less than $\frac{13}{16}$ths thick, and double riveted, with very great care, to the stern-frame.

Riveting—The keel, stem, stern-post, and all the longitudinal seams of the plates, up to the spar-deck, to be double riveted. All the butts throughout the ship to be double riveted. Double riveting to have about eight rivets to the foot. The bar-rivets, through frames and plates, to be spaced 6 inches apart, and the plating to be wrought out and in fashion; the space between each alternate strake, and the frame being filled with a solid sliver-piece closely fitted; all the rivets of keel, stem, and stern-post, to be $1\frac{1}{4}$th inch diameter; those passing through inch plates to be 1 inch; through $\frac{7}{8}$th plates, to be $\frac{13}{16}$ths; through $\frac{3}{4}$th plates, $\frac{7}{8}$th inch; remainder, $\frac{3}{4}$th inch.

Caulking.—The whole of the seams and butts to be caulked in the most careful manner, and made perfectly water-tight; and on no account is any canvass, or red-lead, or like substance, to be inserted in the seams, but all to be caulked throughout, metal to metal.

Beams.—Main-deck beams, of patent bulb-iron, 10 × $\frac{5}{8}$th inch; upper and lower deck-beams, of patent bulb-iron, 9 × $\frac{1}{2}$ inch, all to be spaced on alternate frames; the upper, main, and lower deck-beams to have double, 3 × 3 × $\frac{1}{2}$ inch angle-iron, securely riveted on top edge, with rivets 8 inches apart; all the beams to have suitable knees, solid, 18 inches deep, for securing them to the frames, formed by bending round the ends of the beams.

Stringers.—On the upper-deck, of plate, 42 × $\frac{5}{8}$ths amidships, and $\frac{9}{16}$ths at end, with angle-iron 8 × $3\frac{1}{2}$ × $\frac{5}{8}$th inch riveted to it, and to the deck-beams, and double riveted to the sheer-strake on the main and lower deck, of plate 36 × $\frac{5}{8}$ths amidships, and $\frac{7}{16}$ths at end with angle-iron, 5 × 3 × $\frac{5}{8}$th inch, firmly riveted to the main and lower deck-beams, and reversed angle-irons, 2 feet below the main and upper deck-beams, to have a clamp-plate 18 × $\frac{5}{8}$th inch, running the whole length of the vessel, and securely riveted to the reverse angle-irons on the frames, by rivets spaced 4 inches apart. All the butts to be double riveted.

Deck Trussing.—On the upper and main deck, on each side of the hatches, to have a plate $24\frac{1}{2}$ inches, carried right fore and aft, worked in lengths of 15 feet, with double-riveted butts, the whole riveted to the beam angle-irons with ten rivets in each; the whole space from the outside edge of this to the inside edge of gunwale stringer on the upper-deck to be filled in with plate, wrought in long lengths, not less than 18 inches broad and a $\frac{1}{2}$-inch thick (these plates may be $\frac{3}{8}$-inch, and cover a space equal in weight to those plates specified).

All butt-jointed longitudinal straps single riveted, thwart straps double riveted; the whole riveted to the beam angle-irons with rivets spaced 4 inches apart.

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Hold Stancheons.—From keelson to lower deck beams to have $3\frac{1}{2}$ inches round iron stancheons, riveted securely to the keelson-plate and the beams; above these from lower deck to main deck to have 3 inches round iron stancheons, firmly secured to both tiers of beams where necessary

Bulkheads.—To have the number of water-tight bulkheads that may be required by the company, fitted between double frames and over keelson and stringers, supported by suitable bars of angle-iron 4 × 3 × $\frac{1}{2}$, spaced 30 inches apart.

Bulkheads to be carried to main deck, and to be fitted in every respect in accordance with the Board of Trade regulations. Between the aftermost bulkhead, to which screw-propeller pipe is attached, and the stern-post, to have fitted on every frame, up to the height of lower-deck beams, a series of bulkheads formed of $\frac{1}{2}$-inch plate, and firmly riveted to the frames, and secured on the top with double angle-iron; at this line breast-hooks, specified afterwards, are to be worked forwards to the pipe bulkhead, so as to form an iron deck above these bulkheads specified, and to be riveted to the double angle-iron on them. The hole for passing stern-pipe through to be carefully arranged, so that no more than necessary space is cut.

Rudder.—The stock to be $7\frac{1}{2}$ inches diameter, with turned pintles, of best hammered scrap-iron, in one piece with the frames, and plated with $\frac{5}{8}$ths plate.

Breasthooks and Crutches.—To be fitted at each deck, fore and aft the ship, at the junction of the stringer plates; bilge and side keelson formed by riveting triangular plates about 9 feet long to these fore and aft ties, so as to firmly unite the two sides of the ship.

Mast-Partners.—On the various decks to be formed of materials similar to the beams, and to be securely riveted to them.

Gunwale Moulding.—To be formed of 6-inch half-round iron in length, securely riveted to the upper edge of wale strake by rivets about 8 inches apart.

Water-ways.—On main and lower deck of red pine $4\frac{1}{2}$ inches thick, and on the upper deck of East India teak 18 inches broad by 9 inches thick, both securely bolted to the stringer plates by two rows of bolts and nuts.

Decks.—To have three decks. Upper deck throughout where exposed to be of best East India teak $3\frac{1}{2}$ inches thick, to be secured to the beams by bolts and nuts at every third beam, and with a wood screw of best form on both sides of the alternate beams, the whole to be planed true on the edges, top, and bottom before being laid, and thoroughly caulked and payed with resin or pitch, as may be directed by the company, and made perfectly water-tight; main-deck to be of best seasoned Quebec yellow pine $3\frac{1}{2}$ inches thick, thoroughly secured to the beams by wood screws with bolts in the butts, thoroughly caulked, payed and made water-tight; lower-deck of 3 inches yellow pine to be similarly fitted.

Rails.—The rails to be of best East India teak of suitable breadth, firmly bolted to stancheons, to be covered on the outside and inside edge with 18 oz. yellow metal, firmly nailed; to have a netting all round of best cordage, firmly secured to galvanised iron rods on rail and water-way.

Bulwark Stancheons.—To be of East India teak, and to be fitted into sockets formed of angle-iron, 7 × 3 × $\frac{1}{2}$; these to be riveted to the stringer plates at proper intervals for the stancheons, one bolt through each socket and stancheon.

Hatch Coamings.—On main, upper, and lower decks, of East India teak, of dimensions to suit the size of the hatches, and securely bolted to the iron carlines; to be protected by iron plates on sides and top, and fitted with iron battens, cleats, and cutbands; on upper decks to have teak skylights on the hatches.

Ceiling.—In flat of floor in holds of $2\frac{1}{2}$-inch elm, thence to hold beams of 2-inch red pine from hold beams to main-deck beams, and cabins and store-rooms of 1-inch yellow pine close seamed; the ceilings to be bolted to reverse angle-irons with galvanised screw-bolts.

Ports.—To have four gun-ports on each side, with flaps properly arranged in netting, and fitted with ring-and-eye bolts as required.

Capstands.—To have one of Brown's patent capstands of suitable size, placed forward, with patent chain-stoppers, and four riding bitts complete for working cable; in addition, to have a cast-iron working capstand, with brass top on quarter-deck poop, both complete, with all necessary bars.

Catheads.—Of British oak, with anchor stoppers, and all usual fittings.

Bitts.—To have at least five cast-iron mooring timber-heads on each side, of suitable strength, properly bolted through water-ways and stringer plates, with heavy chocks of hard wood timber below.

Hawse-pipes.—To have a strong cast-iron hawse-pipe on each bow,

of size to suit chains, firmly secured to the skin of the ship; also stern and side mooring pipes of cast-iron where required, and firmly secured.

Chain-Lockers.—To be built of wood where required.

Anchors and Chains.—To have anchors and chains; the chain cables of best best iron, and to be tested to the government test. Hemp-warps according to Lloyd's rules.

Anchor-Davits.—To have two strong anchor-davits, with blocks and falls complete for lifting anchors.

Pumps.—To have a pair of 6-inch Redpath's patent pumps in each compartment, with lead-pipes and roses, and all the necessary iron gearing for working.

Scuppers.—To have sufficient lead scuppers on upper and main deck, well secured to ship's side and water-ways.

Tanks.—To have suitable iron tanks made of quarter plates, capable of containing 10,000 gallons of water, with two fixed copper pumps with brass boxes, lead pipes, and iron gearing complete for working, and placed where required.

Masts and Spars.—To be rigged as a ship, with one complete set of masts and spars according to plan; lower masts and bowsprit of yellow, red, or pitch pine in one stick, or built and hooped if necessary; topmasts, lower and topsail yards, and jibboom to be of red or pitch pine, the remainder of black spruce; to be all according to plan, and complete with all usual iron work of best quality.

Rigging.—All the standing rigging to be of galvanised wire, the running rigging to be of the best St Petersburg or Manilla hemp and chain where required, chain of best best iron.

Blocks.—To have a complete set of iron and rope stropped blocks of suitable sizes, the lower and topsail yards brace blocks, topsail peak and throat haulyards, catblocks, &c.; to have Dalton's patent roller bushes in the sheaves, the standing rigging to be set upon lignum vitæ dead eyes of proper size; to have all necessary snatchblocks, catblocks, watch-tackles, and belaying-pins of greenheart.

Sails.—To have one complete suit of sails, the topsails to be fitted with Cunningham's patent reefing apparatus according to plan, of Gonvock extra canvass, with suitable Nos. complete, ready for bending with sail covers as required.

Iron Work.—All the small iron work of the hull to be furnished complete of the best quality.

Boats.—To have at least six boats, according to Act of Parliament, complete with strong iron davits, tackle falls, &c., as usual. The boats to be supplied with ash oars, rudders, tillers, and boathooks, and the four largest to have masts and sails.

All the boats to be supplied with canvass covers and gripes as required; the four midship boats to be carried inboard on beams of proper strength, and properly supported on iron stancheons from the rail, and to be fitted with patent lowering apparatus to a plan to be furnished.

Gangways.—To have properly-fitted gangways opposite to each hatch for receiving cargo; to have on each side a passenger-gangway, with suitable accommodation-ladders, davits for lifting, iron railings, and man-ropes.

Coaling-Ports.—To have fitted along ship's side, between upper and main decks, the number of coaling-ports that may be afterwards found necessary, properly hinged, so as to be perfectly water-tight when closed, and fitted with strong iron shoots inside, communicating, by grated openings, with the upper-decks and with coal-boxes.

Painting.—The outside of the ship to receive three coats of the best oil paint, the inside two coats, except the bottom, which is to be coated with patent cement. The woodwork on deck to receive three coats, and to be grained in imitation oak. Masts and spars to receive two coats of paint or varnish. Cabins and internal fittings to be painted in the best manner, as may be afterwards directed.

Winches.—To have three double-power cargo winches, with derricks and chains complete, for working cargo.

Side Lights.—To have two brass side lights in each state-room on main-deck and spar-deck, all securely riveted to ship's side, and made water-tight.

Bells.—To have a ship's bell and belfry, with name engraved on it, and binnacle-bell.

Binnacles.—To have two brass and one mahogany binnacle, with lamps.

Figurehead.—To have a handsome full-length figurehead, with trail-boards, stern and quarter carving, as may be required to suit name, all handsomely relieved with gilding.

Flags.—To have one ensign, one burgee, one union-jack, one blue-peter, one private signal, and one set of Marryatt's signals with chest and book.

Signal Lanterns.—To have complete set of Admiralty signal lanterns (brass, of large size).

Guns.—To have two brass 4-pounder, and four iron 9-pounder guns, with breechings, rammers, and sponge complete, with all the usual complement of muskets, pistols, and cutlasses.

Steering Apparatus.—To have a handsome double-steering wheel of E. I. teak, fitted with right and left handed screw-steering gear, brass nuts, malleable iron crosshead, connecting-rods, and screw. To have two portable tillers fitted to rudder-stock; wheel to be covered by a substantial house, with glass front.

Cook-House.—To have a spacious galley of iron fitted on main or spar-deck, near funnel, with the most improved form of cooking apparatus and baking ovens for crew and passengers; the woodwork of the galley to be lined with 5lb. lead and felt, and the floor to be covered with fire-tiles, and to have proper ventilators on sides and top.

Poop.—To have a poop to extend from after-part of vessel to after-part of after-hatch, about 90 feet long; in forming the poop, every alternate frame of the vessel to be carried up, to which are to be joined the beams of the poop, same size of iron as the frames. The sides and after-end of the poop to be rounded over and plated with $\frac{3}{8}$ plates, the poop-deck to have teak water-ways, 12×5; teak decks, $3'' \times 5''$. The whole fastened to the beams with bolts and screws, every butt to have a screw-bolt. Stancheons of galvanised iron to be carried round the poop, with a teak rail on top. The poop to be fitted with suitable skylights, made of teak, fitted in the best style for light and ventilation; also to have round or square side lights in state-rooms, as may be required; to have side stairs, with brass rails, from the upper deck. The inside of poop to be fitted up in first style for passenger accommodation, and in accordance with a plan to be approved; to have two bath-rooms; also a water-closet for every eight passengers, side state-rooms, ladies' sitting cabin, captain's cabin and steward's pantry, with all the necessary furniture and fittings; the whole of the very best description of workmanship and material, as usual in large passenger steamers of the first-class.

Main-Deck.—On the main-deck a dining-room, to be entered by a spacious stair, either from inside of poop or from upper-deck, to be fitted with all the necessary furniture; a full set of dining-tables, sofas, settees, and chairs covered with morocco; to have mirrors, carpets, sideboards, stoves, lamps, swinging trays, &c., &c., and to have side state-rooms for first-class passengers, with carpets, curtains, sofas, wash-stands, &c., the whole arranged to a plan to be approved of.

Second-Class Accommodation.—To be fitted on main-deck forward for 100 passengers, with a water-closet for every 12 passengers, bath-room, &c. Saloon under spar-deck, of polished E. I. teak, with tables, settees, &c. The steward's bar and other conveniences all in the best manner.

Deck-House.—To have a strongly-fitted deck-house, as large as possible, consistent with other deck arrangements; to be constructed with iron-frames and beams, made fast to strong teak coamings, bolted to the deck-beams. The deck of the house to be of $2\frac{1}{2}$ inches yellow pine, with a side covering board to form moulding, of E. I. teak; the sides and ends to be of $1\frac{1}{2}$ inch yellow pine, half checked or feathered, and grooved; the house to be fitted according to a plan to be arranged and approved.

Officers' Accommodation.—To have accommodation for the officers, engineers, stokers, and stewards, with a sufficient number of water-closets and other conveniences, fitted on main-deck, between the first and second-class cabins, with separate ladder-ways, all as may be afterwards arranged.

Topgallant Forecastle.—To extend from the back of the figurehead of vessel to the fore side of the fore-hatch, being about 68 feet in length, and in height about 6 feet to 6 feet 6 inches; every alternate frame of the vessel at forecastle to be carried up to deck of forecastle, with reverse angle-irons, $4 \times 3 \times \frac{1}{2}$ inches, by piecing the present frames; to have an angle-iron stringer, $4 \times 4 \times \frac{1}{2}$ inches, with plates $18 \times \frac{1}{2}$ inches. The beams to be of bulb-iron, $7 \times \frac{1}{2}$, placed on every frame; these beams to be turned down at ends, to form knees, same as the other beams of the vessel; the beams to have an angle-iron, $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ inches, riveted on each side, for fastening down decks; to have two beam-ties riveted on top of plates, $12 \times \frac{1}{2}$; and that part of the forecastle deck where capstan comes through, to be all plated between the beam-ties; same to extend a sufficient length for strengthening that part of capstan; plating to be $\frac{7}{16}$ths thick, and to extend from gunwale of vessel to top of forecastle, and the whole length of forecastle with double riveted butt-joints. The decks to be of teak, $5\frac{1}{2} \times 3$ inches, with teak water-ways, $12 \times 4\frac{1}{2}$, well fastened down, caulked, and made water-tight; the part of deck at capstands to be well fastened and strengthened with teak planks, of increased thickness to those on deck; the top of forecastle to be fitted with all the necessary chocks, &c., required for a vessel of this class. The capstand for anchors to be double, and wrought on topgallant forecastle; but the stopper and riding-bitts to remain on spar-deck, as originally intended. The front of fore-

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castle to be neatly closed in and panelled, equal to bulwarks of vessel. The interior to be fitted up for crew, as may be directed by owners, with suitable brass side lights for ventilation.

Forecastle.—The crew to be accommodated in forecastle, under spar-deck, with berths, mess tables, &c., as may be required.

Lower-Deck Fittings.—The lower-deck, forward and aft, to be fitted with bullion-room, mail-room, wine-cellar, store-rooms, &c., as may be directed, all in the most approved manner.

On the main-deck, forward of second-class cabin, the remaining space to be fitted with butcher's shop, cabin for petty officers, and other necessary fittings, as may be directed.

Skylights.—The second-class cabin to be lighted and ventilated by skylights, fitted on cargo hatches, with suitable gratings, and other particulars as required.

Sundries.—All the locks, hinges, hat-hooks, &c., to be of brass, and fitted as required, and of the best description; to have complete sets of lamps for all the cabins, locks and bars for all the hatches and store-rooms; hen-coops, sheepfold, pig-sty, sets of

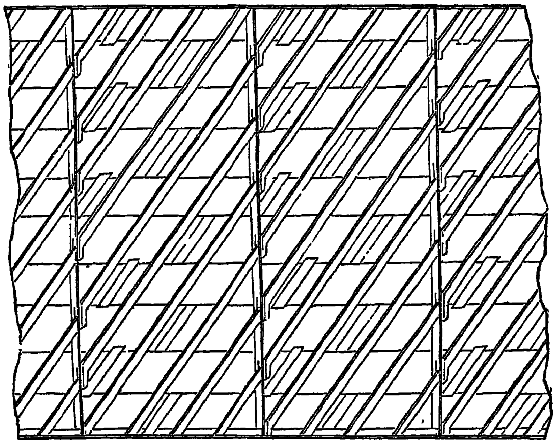

Fig. 60.

capstand bars for both capstands; four 60-gallon water-casks, four harness-casks, twenty-four buckets, twenty-four mess kids; four water-funnels, six breakers, four deck-tubs, and four tar-buckets; awnings for quarter-deck, with iron stancheons, binnacles, and bell-covers; skylight-covers and tarpaulines as required; iron bell-mouthed ventilators, and windsails for engine-rooms where required.

Taylerson's diagonal framing.

Messrs Taylerson and Company, of Port-Glasgow, have patented a diagonal arrangement of the frames of iron vessels. They substitute diagonal framing in the place of the ordinary vertical framing, or intersperse diagonal with vertical frames. The annexed figure shows the latter system of arrangement. No addition of strength, however, to the side of a ship will obviate the necessity for strength in the bottom and in the deck. If rupture were to take place at the top edge of the side, it may be doubted whether the diagonal frame would do more than divert the line of rupture into the sloping line between itself and the next frame. The same builders use a remarkably strong form of keel and keelson (fig. 61); and a representation of this is annexed, showing at the same time their mode of attaching the water-tight bulkheads; they introduce a piece of timber at each bulkhead, where it is attached to the ship's side, and fasten this by screws from the outside, with a view of lessening the number of rivet-holes. This most desirable object is no doubt attained, but great care must be taken that corrosion of the fastenings does not take place.

Arman's mixed system of wood and iron.

Mr L. Arman, of Bourdeaux, has constructed ships with diagonal iron framing inside a framing of wood of very light scantling, the sheathing of the ship being of wood. Inside the vessel, and attached to the iron frames, he introduced a series of horizontal stringers of plate-iron at intervals from the deck to the keelson, which is also of iron. This system imparts great strength to the framework of the vessel, and it is believed that it has, upon the whole, been very successful. Altogether the combination of wood with iron has been carried much further in France than in this country. Iron beams are being much used in their vessels, and iron rudder-pieces, the latter being very advantageous in men-of-war, from their smaller size.

Effects of Lloyd's register in ship-building.

Before closing these remarks, the influence or effects exercised upon the practical construction of ships by the rules of Lloyd's register require to be noticed, as they form a code of instructions to which all merchant-builders of this country are compelled to adhere. These rules are stated to be compulsory, because if a builder deviates from them, or ventures to differ in any point from the opinions of the surveyor, his vessel loses caste, either by being excluded altogether from the first class, or by being put on it for a less term of years. This does not suit the purchaser, and as there is no appeal from the decision of the surveyor, the builders must submit. In the first place,

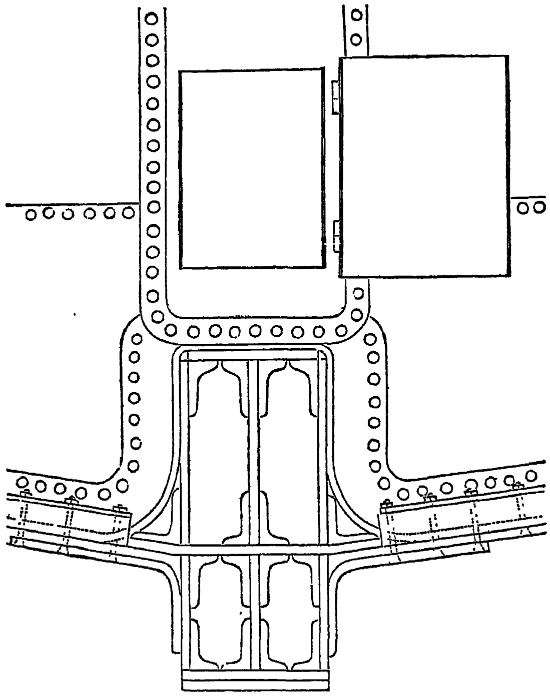

Fig. 61.

it may be remarked, that there is but one table of scantlings, &c., for ships of the same tonnage, while it is evident that the same rules as to scantling, &c., cannot be correct for the sharp long ship intended for carrying light cargoes, such as tea, wool, &c., and also for those which are intended for heavy dead-weights. Nor is any difference permitted in the scantlings of the timbers at the bow and at the stern of full or sharp ships. The rules do not directly interfere with the forms of ships, but in some respects they have undoubtedly indirectly militated against the production of fast-sailing vessels.

The supporters of Lloyd's register claim to themselves the credit of having improved the British mercantile marine; but, in the opinion of many experienced persons, its effect has been to produce a dead and spiritless mediocrity. That the construction of many very bad ships is greatly prevented is true, but there is no actually compulsory law to force every ship to be inspected and classed at Lloyd's, and many ships are sailed independent of any such inspection: its action in this respect, therefore, is not complete. On the other hand, it is equally true, that men of skill and talent are restrained from introducing improvements in the combination of materials. That this is the effect produced is well known; and as an instance, it may be mentioned, that on the first proposal being made to introduce iron beams into a wooden vessel, leave was refused unless the vessel was put into a lower class; and this improvement,

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which is now fully admitted by Lloyd's, was kept back for many years. It is natural that the general feeling of servants of the government, or of large public or joint-stock companies, should be against taking responsibility upon themselves by introducing or permitting changes; but it is much to be deplored if this spirit is brought into such a position as to be a drag upon the talent and energies of the whole nation. Shipowners who are not themselves practically acquainted with ship-building, take the natural course of adopting Lloyd's register as their standard. They contract for a ship to be built in such a manner that she may be put into the first class at Lloyd's, and they thus declare themselves ready to pay the cost of the builder's adherence to Lloyd's rules.

The ship-builder knows, perhaps, that he could introduce improvements, but he is unwilling to subject himself to the risk of a refusal by Lloyd's surveyors, and as the purchaser for whom he is working is satisfied, he builds accordingly. The want of encouragement by Lloyd's rules to increase the durability of ships has been before noticed. Under the existing rules, then, there seems to be reason to fear that the tendency of Lloyd's register has been to some extent to cause increased expenditure, to restrain improvement, and to uphold a dead and stagnant mediocrity. It is to be hoped that care will be taken to guard against the possible existence of such evils for the future.

On Launching.

Launching.

Ships are generally built on blocks which are laid at a declivity of about $\frac{5}{8}$ths of an inch to a foot. This is for the facility of launching them. The inclined plane or sliding plank on which they are launched has rather more inclination, or about $\frac{7}{8}$ths of an inch to the foot for large ships, and a slight increase on this for smaller vessels. This inclination will, however, in some measure, depend upon the depth of water into which the ship is to be launched.

While a ship is in progress of being built, her weight is partly supported by her keel on the blocks, and partly by shores. In order to launch her, the weight must be taken off these supports, and transferred to a movable base; and a platform must be erected for the movable base to slide on. This platform must not only be laid at the necessary inclination, but must be of sufficient height to enable the ship to be water-borne, and to preserve her from striking the ground when she arrives at the end of the ways.

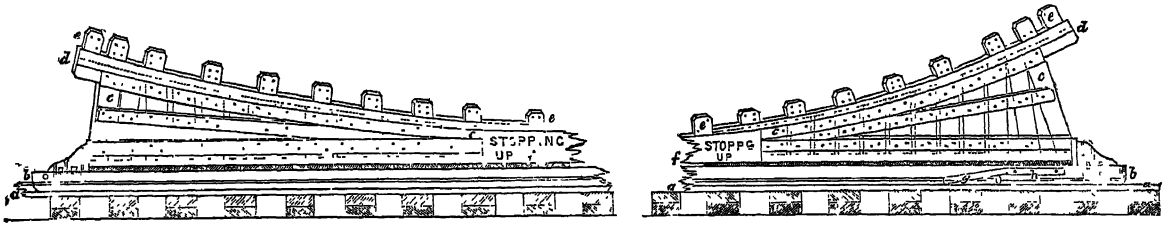

Fig. 62.

For this purpose, an inclined plane, *a*, *a* (figs. 62 and 63), purposely left unplaned to diminish the adhesion, is laid on each side the keel, and at about one-sixth the breadth of the vessel distant from it, and firmly secured on blocks fastened in the slipway. This inclined plane is called the sliding-plank. A long timber, called a bilgeway, *b*, *b*, with a smooth under surface, is laid upon this plane; and upon this timber, as a base, a temporory frame-work of shores, *c*, *c*, called "poppets," is erected to reach from the bilgeway to the ship. The upper part of this frame-work abuts against a plank, *d*, temporarily fastened to the bottom of the ship, and firmly cleated by cleats, *e*, *e*, also temporarily secured to the bottom. When it is all in place, and the sliding-plank and under side of the bilgeway finally greased with tallow, soft soap, and oil, the whole framing is set close up to the bottom, and down on the sliding-plank, by wedges, *f*, *f*, technically called slivers or slices, by which means the ship's weight is brought upon the "launch" or cradle.

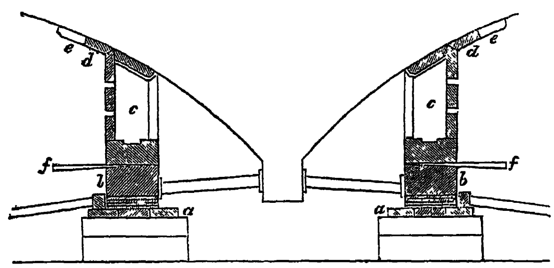

Fig. 63.

When the launch is thus fitted, the ship may be said to have three keels, two of which are temporary, and are secured under her bilge. In consequence of this width of support, all the shores may be safely taken away. This being done, the blocks on which the ship was built, excepting a few, according to the size of the ship, under the foremost end of the keel, are gradually taken from under her as the tide rises, and her weight is then transferred to the two temporary keels, or the launch; the bottom of which launch is formed by the bilgeways, resting on the well greased inclined planes. The only preventive now to the launching of the ship is a short shore, called a dog-shore (*g*), on each side, with its heel firmly cleated on the immovable platform or sliding-plank, and its head abutting against a cleat (*h*), secured to the bilgeway, or base of the movable part of the launch. Consequently, when this shore is removed, the ship is free to move, and her weight forces her down the inclined plane to the water. To prevent her running out of her straight course, two ribands are secured on the sliding-plank, and strongly shored. Should the ship not move when the dog-shore is knocked down, the blocks remaining under the fore part of her keel must be consecutively removed, until her weight overcomes the adhesion, or until the action of a screw against her fore-foot forces her off.

Launching on the keel.

A much less expensive mode of launching is now much practised in the merchant-yards of this country, and has been long in use in the French dockyards, allowing the keel to take the entire weight of the vessel. The annexed figure represents this method (fig. 64). The two pieces (*a a*), which are shown in the figure as being secured to the ship's bottom, are the only pieces which need be pre-

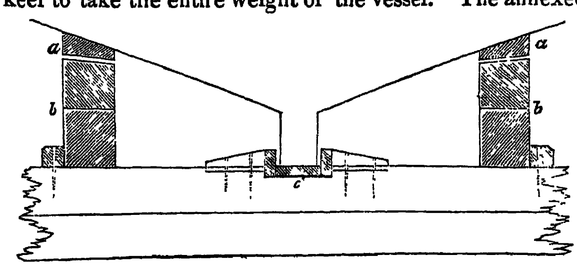

Fig. 64.

pared according to this system for each ship, the whole of the remainder being available for every launch. A space of about half an inch is left between them and the balk timber placed beneath them, as it is not intended that the ship should bear on these balk timbers in launching, but merely be supported by them in the event of her heeling over. The ship, therefore, is launched wholly on the sliding-plank (*e*), fitted under the keel. Messrs Hall of Aberdeen launched a vessel of 2600 tons in this manner without a single cleat upon her bottom or riband of any kind, and avoided all the making-up of the side-ways, except for about 60 feet in midships for keeping the ship upright. The centre-way was hollowed, and a round sliding-way fitted in it, and the keel was thus supported from end to end. This may, therefore, be considered to be the safest, cheapest, and easiest mode of launching long sharp ships.

If a ship is coppered before launching, so that putting her

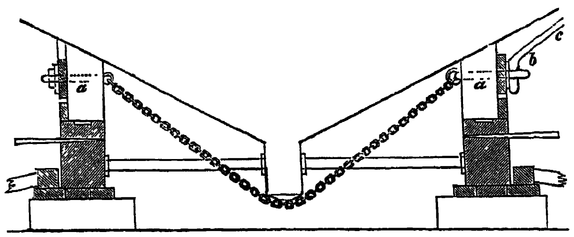

Fig. 65.

into a dry-dock for that purpose becomes unnecessary, it is then desirable that she should be launched without any cleats attached to her bottom. This method of fitting the launch, as represented in figure 65, is then adopted for this purpose. The two sides of the cradle are prevented being forced apart when the weight of the ship is brought upon them by chains passing under the keel. Each portion of frame-work composing the launch has two of these chains attached to it, and brought under the keel, to a bolt *a*, which passes slackly through one of the poppets, and is secured by a long forelock *b*, with an iron handle (*c*), reaching above the water-line, so that when the ship is afloat it may be drawn out of the bolt. The chain then draws the bolt *a*, and in falling trips the cradle from under the bottom. There should be at least two chains on each side secured to the fore-poppets, two on each side secured to the after-poppets, and two on each side to the stopping up, and this only for the launch of a small ship: in larger ships the number will necessarily be increased according to the weight of the vessel and the tendency that she may have, according to her form, to separate the bilgeways. This tendency on the part of a sharp ship by a rising floor, or by her wedge-shaped form in the fore and after bodies, is great, but there is not much probability of a ship heeling over to one side or the other.

It is recorded that upon one occasion of our sailors having taken possession of an enemy's arsenal, and finding a vessel on the stocks nearly completed, they removed the shores from one side, and tried to upset her by wedging up the shores on the other side, but were unable to do so. There appears, therefore, to be no valid objection to the cheaper and more ready method of launching on the keel. (A. M—Y.)

SHIRAZ, a city of Persia, formerly capital of the whole country, and now of the province of Fars, 115 miles E.N.E. of Bushire. It stands in a wide plain, 25 miles long by 12 broad, enclosed by bare limestone mountains. The greater part of the plain is stony and barren; but a large portion has been brought under cultivation. The immediate vicinity of Shiraz is celebrated for its beauty and fertility, and is occupied with extensive suburbs and gardens. The town itself is encircled by walls $3\frac{3}{4}$ miles in circumference; and entered by six gates, each flanked by two towers. Formerly there were here a large palace, numerous mosques, colleges, bazaars, and caravanserais; but the aspect of the place has been entirely changed by the earthquake which took place in April 1853, by which nearly the whole town was laid in ruins. Previous to this earthquake there had been others nearly equally destructive in 1812 and 1824. Besides these, and other natural disasters, the town has suffered very much from the oppression of its rulers, so that it is now reduced to a very wretched condition. One of the gates is named after the poet Sadi, who was born here in 1149 A.D., and died here also at the age of one hundred and twenty. He is buried in a mausoleum, 22 miles to the N.E. of Shiraz. About half a mile N.E. of the Ispahan gate of the city is the tomb of Hafiz, the Anacreon of Persia, also a native of Shiraz. The most remarkable commodity of the place is wine, of which there are two kinds. Its seal-engravers are very famous in Persia; and it has also manufactures of silk and cotton goods, firearms, cutlery, and earthen-ware. Its trade, too, is very considerable, as it stands on the routes from the port of Bushire to Kerman, Yezd, and Ispahan, in the interior. According to Persian legends, Shiraz was built by Janshid; but history makes Hadji bin Yusuf its founder, A.D. 697. The principal mosque was built by Atabah Sad Zanzi, A.D. 1226; but the greatest benefactor of the town was Kerim Khan, who lived towards the end of the eighteenth century. Since that time the place has gradually declined. In the vicinity lie the remains of many splendid ancient buildings; and about 25 miles N.E. are the ruins of Persepolis. Pop. 30,000, including about 400 families of Jews.

SHIRE (Anglo-Saxon *Scyran* to divide, whence also to shear, shears, sheer, shore, shirt, skirt, &c.), a territorial division, cut off or divided from the surrounding country. As ordinarily applied now-a-days, it is synonymous with COUNTY (which see); but certain districts in England still preserve traces of the original meaning of the word. For example, Richmondshire, in the North Riding of Yorkshire; and Hallamshire, which is nearly co-extensive with the parish of Sheffield.

SHIRLEY, JAMES, a successful English dramatist, was born in London on the 13th September 1596. He had his education at Merchant Taylors' School, London, and at St John's College, Oxford, where he gave signal marks of future distinction. The duration of his residence at this university cannot now be ascertained, as the public records of Oxford do not mention his name. He next proceeded to Catherine Hall, Cambridge, where he took his degree. His earliest publication was a poem, entitled, *Echo, or the Infortunate Lovers*, which appeared in 1618, and which was in all probability the same as the *Narcissus* of 1646. Having finished his academical course, he adopted the ecclesiastical profession, and was appointed to a living in or near St Alban's, Hertfordshire, which he shortly resigned, from his having become a convert to Roman Catholicism. Resigning the clerical profession, he taught for some time during the years 1623 and 1624 in the Grammar School of St Albans. Disliking the drudgery of tuition, he went up to London, lived in Gray's Inn, and devoted himself to the composition of plays. *Love Tricks, or the School of Complement*, was his earliest production. It was published in 1631, but had been licensed five years earlier. It was evidently a youthful production, but it gave good promise of future excellence in the peculiar walk which he had chosen. Of the thirty-three regular dramas which flowed from his exuberant invention, there are great varieties of

Shirvan. excellence. Unquestionably his highest effort was the *Traitor*, licensed in 1631 and published in 1635. "Assuredly, since his decease," says Dyce, "no tragedy of equal excellence has graced the British stage." The truth and vigour which waited on his pen in the composition of this drama must have disliked the work, for they seem in a great measure to have deserted him on its completion. This play was plagiarized by one Rivers in 1692, and has been frequently revived. It was partly recast by Richard Sheil, in his *Evadne, or the Statue*, which was acted with success at Covent Garden in 1819. Shirley, however, who should have been a good judge of the quality of plays, esteemed his *Cardinal*, which was published in 1652, as "the best of his flock."

In September 1642, an order went forth from both Houses of Parliament for the suppression of stage plays throughout the kingdom; and Shirley, who was a monarchist, gave in his adherence to his munificent patron, the Duke of Newcastle, whom he had assisted largely in the composition of his plays. The King's cause declining, and the dramatist's prospects being of the gloomiest description, he retired obscurely to London, where he contrived, by industriously pursuing his former occupation of a teacher, to support his wife and family for the remainder of his days. He was solaced by the intimate friendship of Thomas Stanley, author of the *History of Philosophy*, and of Sir Edward Sherburne, now principally remembered by his translation of a portion of *Manilius*. Of Shirley's competency for this office, he has left us a pledge in his excellent grammatical treatises. With the exception of giving occasional assistance to John Ogilby in his literary undertakings, Shirley seems to have henceforward renounced the use of his pen. The restoration of Charles II. could not prevail upon him to break his resolution, and while the degenerate race of playwrights hurried eagerly forward to hold up their bombast and obscenity to that licentious age, the gentle and modest old Shirley wore out the remainder of his days away from the corruption of the court and the dissolute practices of his compeers. Shirley was burned out of his house in Fleet Street by the great fire of London in 1666, and being obliged to withdraw to the suburbs, he and his wife, overcome with fright and fatigue, both died in the same day (October 29), and were buried in the same grave. The orphan children of the dramatist were most probably thrown destitute on the world. In Anthony à Wood's day, one of his sons held the office of butler at Furnival's Inn. *Sic transit gloria mundi!*

Dryden has satirized Shirley in his *MacFlecknoe*, but he possessed much greater merits than his appearance there would imply. His language is always correct, and his invention sometimes successful; but he has only a limited stock of the objects of fancy to draw upon. His humour, however, is broad and genial; his wit is sometimes sprightly, but more frequently strained; his characters are well drawn, although he never rises into any of the nicer shades which discriminate one personality from another. He delineates passion well, yet he is better at the description of it than he is in making us feel the thing itself. His plays, although many of them well worth reading, are no longer acted. He had not the anticipatory genius, enabling him to delineate with words the passions of men throughout all times. This prerogative was given to Shakspeare alone of all our English dramatists. The best edition of Shirley's *Dramatic Works and Poems* is that of Gifford and Dyce, 6 vols. 8vo, London, 1833.

SHIRVAN, a province of Asiatic Russia, in the country of the Caucasus, bounded on the north by the province of Daghestan, from which it is separated by the Caucasus, E. by the Caspian, S. by Persia, and W. by Georgia. It lies between N. Lat. 40. and 41.; E. Long. 48. and 49. 30. A range of mountains traverses the province from N.W. to S.E., separating the valley of the Kur, which forms the southern frontier, from that of the Terek. The northern portion is level, fertile, and well wooded; watered by numerous affluents of the Kur. The climate is warm, especially about the delta of the Kur, where the soil is very fertile, and would produce, if properly cultivated, many tropical plants. Rice, silk, wine, cotton, and tobacco are the principal productions of Shirvan. On the coasts of the Caspian there are valuable fisheries. The chief manufactures are those of silk at Shamaka, the largest town in the province. In the mountainous regions arms and other metal fabrics are made. The inhabitants are almost all of the Tartar or Turkish race, with a slight mixture of Arabs and Persians. The majority are Mohammedans, but there are also some Jews and Armenians. The language is the Turkish, which is also used in Azerbijan. Shirvan formed until the sixth century a part of the monarchy of Armenia; but was afterwards conquered by the Persians, and made a part of that empire under Khosroo Nooshirvan, who called this country after his name. But at a subsequent period it was governed for some time by independent princes, who in the ninth century acknowledged the supremacy of the Caliphs. The rulers of Shirvan, however, long retained much power, and carried on many wars with Persia, over which country they repeatedly gained great advantages. Finally, in the end of the fifteenth century, it was completely brought under the Persian sway. The Russians gradually invaded the country; and it was ceded to them in 1812. Under their dominion it first formed the Caspian province, but was divided in 1847 into the governments of Shamaka and Derbent; the former of which in 1851 had 603,006, and the latter 453,284 inhabitants.

Shishkoff. SHISHKOFF, Alexander Semenowitsch, a Russian author, admiral, and statesman, knight of several orders, and president of the Russian Academy, was born in 1754, and was educated at the Naval Cadet Corps. Having entered the naval service, he subsequently visited, both professionally and privately, Sweden, Denmark, England, Germany, Italy, and Turkey. He began his career of authorship while a cadet in the navy, by executing translations, poems, and dramas. In his later years he devoted his attention exclusively for long years to the benefiting of persons connected with the naval service of Russia. His *Naval Service*, St Peterburg, 1793; his *Marine Lexicon*, St Petersburg, 1795; his *Collection of Journals during Voyages at Sea*, St Petersburg, 1800; and his *Historical Records of the Navy*, published some time after, all belong to this class. After an estrangement of twenty years, he returned to pure literature, the darling of his early years. His effective, but too hasty book, *Considerations on the Old and New Styles of the Russian Language*, appeared in 1802, and has been frequently reprinted. His *Additional Remarks* to this volume appeared in 1804, and the *Essays of La Harpe* in 1808. A tart review of this work occasioned a series of replies and retorts, which wound up with *The Easiest Way of Replying to a Criticism*, 1811, from the pen of the reviewer, and is acknowledged to be one of the most acute works of a polemical nature in the Russian language. In 1811 appeared Shishkoff's *Dialogues on Literature*, and in 1812 he was made secretary of state, in which capacity he accompanied the Emperor Alexander, and gleaned the materials of his *Memoirs of the War in* 1812, published in 1816 at St Petersburg. The latter work is perhaps the best which he has written. It overflows with patriotism and zeal for the glory of Russia, and is written in a strain of high-wrought, fervid eloquence. In 1818 appeared his prose translation of Tasso's *Gierusalemme Liberata*, which closed his public career of authorship. Many of his later writings are reported to be still in manuscript; and if one can trust to the intelligence which rumour conveys, they had better remain so. Shishkoff

died in 1841, and his works appeared in 14 vols. in 1823–34.

SHITOMIR. See JITOMIR.

SHOA, or SHWA, a state of Abyssinia, in the south-east of that country, lying between N. Lat. 8. 30. and 11., E. Long. 38. and 40. 30., and extending from the river Hawash, which separates it from the country of the Gollas on the south, to its affluent the Berkona, and to the Wanshit, a tributary of the Abai, which separate it from Amhara on the north. The country is very elevated, and attains on the south and east a height of 9000 or 10,000 feet above the sea. Towards the south the land gradually declines to the broad plain watered by the Hawash; towards the east the descent is much steeper; while the centre and west of the country is occupied by the valley of the Jamma, sloping by degrees to the height of about 3000 feet, which that river has at its confluence with the Abai. Both on the north and on the south of this valley there are high mountains, rising 4000 or 5000 feet above its surface. The Jamma is the principal river in the land, and receives many affluents from the south. These divide the table-land through which they flow into a number of narrow ridges, since many of them flow through deep ravines, interrupted by numerous cataracts. The loftier parts of the country are in many places well cultivated, producing large crops of wheat and barley, and are studded with numerous villages and trees; but there are also extensive regions used only for pasturage. The climate is cool and healthy, sometimes exceedingly cold. In the lower ground, where the temperature is higher, cotton is largely grown. Many of the valleys of Shoa are exceedingly beautiful, with a luxuriant and even gigantic vegetation; but the climate here is very hot and unhealthy. Among the mineral productions of the country coal is the most important; some metals have also been found, as well as sulphur, nitre, and alum. The vegetable productions include dyewoods, drugs, indigo, and coffee, besides those already mentioned. Almost the only manufacture is a coarse kind of cotton cloth, which is made in large quantities at every farm. A considerable trade is carried on, chiefly through Zeila, which is the nearest port, not far from the Strait of Bab-el-mandeb. The exports comprise the produce of the surrounding countries, as well as of Shoa itself, such as ivory, spices, and gold-dust. The country is governed by a king, and the population amounts to 1,500,000, including heathens, Mohammedans, and Christians.

SHOE, a covering for the foot, usually of leather. Shoes among the Jews were made of leather, linen, rush, or wood; those of soldiers were sometimes of brass or iron. They were tied with thongs, which passed under the soles of the feet. To put off their shoes was an act of veneration; it was also a sign of mourning and humiliation. To bear one's shoes, or to untie the latchets of them, was considered as the meanest kind of service.

Among the Greeks, shoes of various kinds were used. Sandals were worn by women of distinction. The Lacedæmonians wore red shoes. The Grecian shoes generally reached to the middle of the leg. The Romans used two kinds of shoes; the *calceus,* which covered the whole foot, somewhat like our shoes, and was tied above with latchets or strings; and the *solea,* or sandal, which covered only the sole of the foot, and was fastened with leathern thongs. The calceus was always worn along with the toga when a person went abroad; sandals were put on during a journey and at feasts, but it was reckoned effeminate to appear in public with them. Black shoes were worn by the citizens of ordinary rank, and white ones by the women. Red shoes were sometimes worn by the ladies, and purple ones by the coxcombs of the other sex. Red shoes were put on by the chief magistrates of Rome on days of ceremony and triumphs. The shoes of senators, patricians, and their children, had a crescent upon them, which served for a buckle; and these were called *calcei lunati.* Slaves wore no shoes, and hence they were called *cretati,* from their dusty feet. Phocion also and Cato of Utica went without shoes. The toes of the Roman shoes were turned up in the point; and hence they were called *calcei rostrati.*

In the ninth and tenth centuries the greatest princes of Europe wore wooden shoes, or the upper part of leather and the sole of wood. In the reign of William Rufus, a great beau, Robert, surnamed the Horned, used shoes with long sharp points, stuffed with tow, and twisted like a ram's horn. It is said that the clergy, being highly offended, declaimed with great vehemence against the long-pointed shoes. The points, however, continued to increase, till in the reign of Richard II. they were of so enormous a length that they were tied to the knees with chains, sometimes of gold, sometimes of silver. The upper parts of these shoes were in Chaucer's time cut in imitation of a church-window. The long-pointed shoes were called crackowes, and continued in fashion for three centuries, in spite of the bulls of popes, the decrees of councils, and the declamations of the clergy. At length the parliament of England interposed by an act passed in the year 1463, prohibited the use of shoes or boots with pikes exceeding two inches in length, and forbade all shoemakers from making shoes or boots with longer pikes, under severe penalties. But even this was not sufficient. It was necessary to denounce the dreadful sentence of excommunication against all who wore shoes or boots with points longer than two inches. The present fashion of shoes was introduced in 1633, but the buckle was not used till 1670. The customary shoe of the American Indians, known as the moccasin, is generally made of deer-skin or other soft leather, and is without a sole, but ornamented on the upper side.

SHOLAPORE, a collectorate of British India, in the presidency of Bombay, lying between N. Lat. 16. 10. and 18. 34., E. Long. 75. and 76. 28.; bounded on the N. and E. by the Nizam's dominions, S. and S.W. by the collectorates of Belgaum and Sattara, W. and N.W. by those of Poona and Ahmednuggur. Its length from N.W. to S.E. is 170 miles; greatest breadth, 50; area, 4991 square miles. The country is undulating, presenting a series of hills and valleys, with comparatively few trees. Its chief rivers are the Kestnah, which washes the southern border, the Bheema and the Seena. The soil is admirably adapted for the growth of cotton, which is the principal crop raised. There is a great want of internal communications, as there is no good road in any part of the country; while the rivers Bheema and Seena, when swollen at the time of the monsoons, offer serious impediments in the way of travelling. Considerable care has been bestowed on agriculture; but as European implements have not yet been generally introduced, there are still great deficiencies, both in the cultivation of the soil and in the mechanical arts. Sholapore was acquired by the East India Company in 1818, after the fall of the Peishwa. It was at first included in the collectorate of Poona, but in 1838 formed into a separate collectorate. Pop. 675,115.

SHOLAPORE, the capital of the above collectorate, stands in a level tract near its eastern extremity, 165 miles S.E of Poona and 220 S.E. of Bombay. It is a place of no natural strength, but has been so strongly fortified as to be of much importance in a military point of view. It is oblong in form, surrounded by a substantial stone wall, and a broad deep ditch, outside of which, on the north and east, is a suburb, also fortified; while on the south the ditch expands into a tank, with a mound on three sides of it. A church has been built here, but there are no other important edifices. Sholapore has frequently changed masters in the early periods of Indian history. It was taken by escalade in 1818, by a British force under General Pritzter.

SHOOTING.

The pursuit and destruction of wild animals for security, food, clothing, or pastime, have been amongst the occupations of men in all ages, since the primeval *bruerè* overspread the earth,

> And wild in woods the noble savage ran.

Before the more refined arts are introduced into any country, the chase is a necessity, and the chief business of life. The stronger and more noxious animals are destroyed for individual safety; the weaker for food. It is not until civilization and her handmaid luxury have seated themselves, that the chase becomes a pastime. It does not appear when the sportsman first sprang into existence. There is no corresponding word in any ancient language, since that could not be called a sport which was a necessity. It is probable that in the earliest ages of society the dog was the sole agent employed by the hunter. Afterwards various weapons, manual, missile, and projectile, as the club, the dart, the arrow, were used by the hunter and fowler. Then would follow springes, traps, nets, and all that class of devices for the capture of beasts and birds *feræ naturæ*, comprehended in the term toils. As dogs were employed to hunt quadrupeds, so, in process of time, hawks were trained to bring down birds for the service of their master. The arbalest, or cross-bow, preceded the matchlock, which, however, could scarcely be called an implement of the chase, but which, in the order of succession, brings us down to the rifle, and original fowling-piece with its long heavy barrel and flint and steel lock; and, lastly, we arrive at the double barrels and detant locks of the modern shooter.

In the days of the Saxon and Norman kings, and long previously, the Britons were famous for their skill in archery, both in war and in the chase. The feats of the bow were often introduced into the songs of the bards of the ancient Britons, and into the ballads of the Troubadours.

Archery.

Archery is now confined to shooting at the target. Ladies not unfrequently contend for the prize in this elegant amusement. Their bows, however, are not such as were used by the amazons of yore, nor are those of the gentlemen of the archery clubs such as decided the battle of Cressy.

Falconry.

Falconry, coeval with, and subsequent to the decline of archery, occupied that rank in British field sports which is now enjoyed by shooting. Falconry is of high antiquity; but at what time hawks were first trained to the sport does not appear. Aristotle informs us that "there was a district in Thrace, in which the boys used to assemble at a certain time of the year, for the sake of bird-catching; that the spot was much frequented by hawks, which were wont to appear on hearing themselves called, and would drive the little birds into the bushes, where they were caught by children; and that the hawks would even sometimes take the birds and fling them to these young fowlers, who, after finishing their diversion, bestowed on their assistants part of their prey." Martial has the following epigram on the fate of a hawk:

> Prædo fuit volucrum, famulus nunc aucupis, idem
> Decipit, et captas non sibi, mœrit, aves.

There is no record of trained hawks previous to the time of Ethelred. Under the Welsh laws of Hoel Dha, (A.D. 940), "the falconer has a privilege, the day that the hawk shall bill a bittern, or a heron, or a curlew. Three services shall the king perform for the falconer on such a day; hold his stirrup whilst he dismounts; hold the horse whilst he goes after the birds; and hold his stirrup whilst he mounts again. Three times shall the king that night compliment him at table." Shakspeare often uses the language o. falconry. It is chiefly employed in a scene in the second part of Henry VI., wherein the king, queen, lord protector, and cardinal, are the chief speakers; which goes to prove, that the falconer's terms were, at one time, household words at the English court.

Shooting.

Hunting and archery.

Hunting and archery, which were then almost synonimous terms, (for the sport was somewhat similar to what deer-stalking now is, the rifle being substituted for the bow,) were in high repute with the Danish, Saxon, and Norman kings, whence arose the forest laws. Wolves and boars, which formerly infested the forests, were nearly exterminated in king Edgar's time, when that monarch prohibited the killing of deer and game in his woods. The punishment depended upon the will of the king, until the celebrated forest laws of Canute, which defined the rights and privileges of the monarch and others; but those laws were little regarded by succeeding kings, whose arbitrary will afterwards regulated the laws of the forest. "Besides other prerogatives of the Saxon kings," says Selden, "they had a franchise for wild beasts for the chase, which we commonly call forest, being a precinct of ground, neither parcel of the county, nor the diocese, nor the kingdom, but rather appendant thereto." And these prerogatives, he quaintly observes, were maintained, "that the world might see the happiness of England, where beasts enjoy their liberty as well as men." Another old writer says, that "the Saxon kings and the Danish king Canute made no new forests, but were contented with the woods that were their own demesnes, and were never granted to, or possessed by the subject; but the kings of the Norman race, not being satisfied with sixty-eight old demesne woods or forests, depopulated well-built towns and villages, to make to themselves places appropriated to their own diversion only. William the Conqueror laid waste thirty-six towns in Hampshire to make a forest, which still retains the name of the New Forest; and his forest officers exercised such arbitrary rule, as to abridge even the great barons of the privileges they enjoyed under the Saxon and Danish kings, not at all regarding the liberties given to the subject by Canute's forest laws. His son William Rufus is recorded in history for the severity of his proceedings against all that hunted in his forests, inflicting the punishment of death upon such as killed a stag or buck in his forests, without any other law than that of his own will." The killing of deer was punished with loss of sight by William the Conqueror.[1] William Rufus "did so severely forbid hunting a deer, that it was felony and a hanging matter to have taken a stag or buck."[2] In Cœur de Lion's time, the law was very severe against offenders taking the king's venison; it was even unlawful to carry a bow, or take dogs through a royal forest. "Qui arcus vel sagittas portaverint vel canes duxerint sine copulâ per forestam Regis, et inde attaintus fuerit, erit in miserecordiâ Regis."[3]

The forest laws professed to be for the protection of "vert and venison." *Vert* was whatsoever bore green

[1] John Selden. [2] William of Malmsbury. [3] England's Epinomis, p. 34.

leaves, and afforded food or cover to the deer; and *venison* signified such beasts of the forest or the chase as were the food of man. When reading old books, it is necessary to keep in mind this acceptation of the word venison.

This state of things continued until by the Charta de Foresta the forest laws were better defined and the penalties mitigated. The vast importance attached to the Forest Charter may be inferred from the fact, that although granted by king John at Runnymede, at the same time as the Great Charter, it was not incorporated in it, but was made the subject of a separate and distinct document. The Forest Charter was likewise confirmed by Henry III., contemporaneously with the Great Charter. On the latter occasion the Forest Charter was counter-signed by sixty-four bishops, abbots, and barons; and sentence of excommunication against all persons who should violate it was, with great ceremony, denounced in Westminster Hall, by the archbishop, in the presence of the king, bishops, and nobles, the bishops being robed and bearing torches.

The oath administered, at twelve years of age, to every young man dwelling within the precincts of a royal forest, was in the following rhymes:

> You shall true liege-man be
> Unto the King's Majesty:
> Unto the beasts of the FOREST you shall no hurt do,
> Nor to anything that doth belong thereunto:
> The offences of others you shall not conceal,
> But to the utmost of your power, you shall them reveal
> Unto the OFFICERS of the FOREST,
> Or to them who may see them redrest:
> All these things you shall see done,
> So help you GOD, at his HOLY DOOM

After the Forest Charter was granted any one was allowed to kill game, except in the royal and other forests, and certain other privileged places,[1] until the reign of Richard II., when a landed qualification of forty shillings per annum became necessary to entitle a person to keep "any greyhound, hound, dog, ferret, net, or engine, to destroy deer, hares, conies, or any other gentleman's game." The qualification required was increased with the improved value of land, from time to time, until, in Charles the Second's reign, it was enacted, that persons not having L.100 per annum arising from freehold, or L.150 from leasehold property, or not being of the degree of esquire, or otherwise privileged, should not keep or use "any guns, bows, greyhounds, setting dogs, ferrets, coney-dogs, lurchers, hays, nets, lowbels, hare-pipes, guns, snares, or other engines for taking or killing game."

It was not until the early part of the reign of George III. that killing game was taxed as a luxury, and made a source of revenue to government. A tax of two guineas was first imposed on all persons who should go out in pursuit of game; but the price of the certificate was afterwards raised to three guineas, and subsequently to three and a half guineas. The property qualification is abolished, and now any person who has taken out a certificate and obtained permission from the owner or tenant of the land, in which soever the right at the time may happen to be, is privileged to kill game at all seasonable times. During a long period the sale of game was prohibited, which gave a peculiar value to it, as it was not attainable by any but qualified and certificated persons and their friends, except by indirect means. It is now publicly sold by persons taking out licences for the purpose, and such licenced persons are liable to penalties, and are incapacitated from renewing their licences, should they purchase game from any but duly certificated sportsmen. The licenced dealers are, however, largely supplied by poachers, notwithstanding the penalties to which they subject themselves by trading with uncertificated persons.

Falconry fell into dissuetude in the days of the Georges. It is now scarcely known but by name, although the honorary distinction of hereditary Grand Falconer of England is still extant. As falconry fell into disuse, another kind of sport, which is now considered as disreputable, and practised only by poachers, was pursued by the country gentlemen; the capturing of birds of the game species by means of nets and setting dogs. The dogs were trained to lie down when near to game, and to suffer the net to be drawn over them, so that both dog and birds were entangled in the toil. In this manner partridges are still frequently taken by poachers in the night. A poacher's dog is sometimes known by his habit of crouching when close upon game, and this circumstance not unfrequently leads to a detection of the practices of his master. Netting was considered as a fair mode of taking game until the fowling-piece came into general use.

On the accession of the house of Hanover to the throne of Great Britain, falconry, netting, and shooting, were contemporary amusements. The number of shooters was very limited, the inferiority of the guns and ammunition being such as not to induce their general adoption; hawking was going out of favour; and, of the three sports, netting was the most commonly practised, until the beginning of the reign of George III., after which time it was no longer deemed the sport of gentlemen. At what time the fowling-piece first came into use is uncertain. We learn from Pope that pheasant shooting was in vogue in Windsor forest during the reign of Anne.

Shooting, as practised with guns to which flint and steel locks were attached, may be said to have risen and fallen with the Georgian era. During the latter part of that period, great improvements were made in all the implements and materials of shooting. Double barrels came into use, horse-nail stubs were employed in the manufacture of

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[1] The places privileged were of four descriptions, viz. a forest, a chase, a park, and a warren. To these may be added a decoy for water-fowl, which had also peculiar privileges.

"A *forest* is a certain territory of woody grounds and fruitful pastures, privileged for wild beasts and fowls of forest, chase, and warren, to rest and abide there in the safe protection of the king for his delight and pleasure; which territory of ground so privileged is meered and bounded with unremoveable marks, meers, and boundaries, and replenished with wild beasts of venery or chase, and with great coverts of vert for the succour of the said beasts there to abide; for the preservation and continuance of which, there are particular officers, laws, and privileges belonging to the same, requisite for that purpose, and proper only to a forest and no other place." *Manwood's Forest Laws*, p. 143. "Beasts of forest are properly hart, hind, buck, hare, boar, and wolf, but legally all wild beasts of venery." *Coke's Institutes*, vol. i. p. 233. "A purlieu is a portion of a forest which was disafforested by the Charta de Foresta." *Manwood*, 242.

"A *chase* is a privileged place for receipt of deer and beasts of the forest, and is of a middle nature, betwixt a forest and park. It is commonly less than a forest, and not endowed with so many liberties, as officers, laws, courts, and yet is of a larger compass than a park, having more officers and game than a park. Every forest is a chase, but every chase is not a forest. It differeth from a park in that it is not inclosed." *Manwood*, 49, 147. "Beasts of the chase are, the buck, doe, fox, martern, and roe." *Manwood*, 144.

"A *park* is a large parcel of ground privileged for wild beasts of chase by the king's grant, or by prescription. A park must be inclosed." *Read. Game.* "The beasts of park properly extend to the buck, doe, fox; but in common and legal sense to all the beasts of the forest." *Read. Game.*

"A *free warren* is a place privileged by prescription or grant of the king, for the preservation of the beasts and fowl of the warren, viz. hares, conies, partridges, and pheasants." *Manwood*, p. 44. "If a pheasant, or other bird of warren, flew into a free warren, the falconer could not follow it, but it became the property of the owner of the warren." *Manwood*.

A *decoy* for wild fowl is to this day privileged, in so far as the owner has the exclusive right to the birds frequenting it; and no person is allowed to fire a gun or otherwise make a disturbance within a reasonable distance of it, without permission from the owner.

Shooting. barrels, the patent breech and percussion-cap were invented, and the wire-cartridge has since been introduced. Not the least improvement has been that in the manufacture of gunpowder. The excellence of our guns and dogs has tended much to spread the love of shooting, which has become the most popular and universal of British field sports.

It has been remarked, that England (Great Britain) is peculiarly the land of sportsmen, the very name being unknown in all other countries. The observation is in a great measure true, for, if we look around the globe, we find that wherever wild animals are killed for the sake of sport, it is mostly by the Englishman. In Sweden the Englishman alone kills the bear for sport. The natives kill it for the sake of reward, or to rid themselves of a noxious neighbour. Their method is generally thus: The strength of the country is summoned *en masse*, and several hundreds of people armed, form a circle many miles in circumference, and march forward until they meet in the centre, by which means great numbers of bears, wolves, and lynxes are destroyed. But this is not done for sport; it is a compulsory matter, and the people engaged in it are paid by the government; it is a species of feudal duty, which the able-bodied are called upon to perform whenever public safety requires it. In Asia, the only sportsman that encounters the royal tiger is the Englishman; the native shekerrie shoots the tiger for profit. There also the buffalo and the boar are hunted by the Englishman alone. In Africa, it is the Englishman who hunts the lion, the hippopotamus, and the giraffe. And in America, it is the Englishman, or English settler, who hunts the panther, the bison, and the bear, for sport; the natives do so from necessity. Since, then, the Englishman is the universal sportsman, it behoves the officer, the emigrant, and the tourist, to make themselves acquainted not only with what may be called the first principles of sporting, but more especially with the sports peculiar to the countries to which they are proceeding, a theoretical knowledge of which may be gleaned from the volumes which annually proceed from the pens of our adventurous countrymen.

The Rifle. THE RIFLE. The only fire-arms used by the sportsman are the rifle, the musket, and the fowling-piece; the latter may be classified into the swivel-gun, which is fired from a rest, and the shoulder-gun. A short, wide-bored musket, charged with a round or oval iron ball, was formerly used for the destruction of such animals as the lion, tiger, or bear. In modern times, the musket has been superseded by the rifle, and the iron ball by a leaden one, hardened with tin and weighted with quicksilver. A short piece is said to be preferred to a long one for shooting tigers, bears, and the like, as it may be more readily loaded, and is more easily managed in cases of emergency; indeed we apprehend the shooter should seldom fire, except when the animal is so near to him that if he aim coolly, he can scarcely fail to lodge a ball. We subjoin the method of taking aim at wild beasts from practical sporting writers. Captain Williamson gives the following instructions for shooting tigers:[1] "If the motion of an animal through the grass be perceived, the nearest elephant should be halted; and its left shoulder being pointed towards the moving object, is the most favourable position for taking a good aim. The hunter should fire without hesitation, observing to proportion his level as far within the space between himself and the tops of the yielding grass as the height of the cover may dictate; by this precaution, equally necessary when shooting fish that are in any degree beneath the surface of the water, the iron ball will, in general, take effect." Mr. Lloyd says,[2] "If a man purposes attacking a bear at close quarters, a double gun is decidedly the best; if it be in the winter season, a detonator is very preferable. Owing to having flint locks, both my barrels, on one occasion, missed fire, which might have been attended with most serious consequences; a large ball is very desirable. The best points to hit a bear, or any other animal, are in the forehead, in the breast, under the ear, or at the back of the shoulder; bullets placed in other parts of the body of an old bear usually have little immediate effect. If the snow be deep, and the bear is crossing a man, he should always aim very low; he must often, indeed, fire into the snow, if he expects to hit the heart of the beast."

In 1826 it was found necessary to destroy an elephant in Exeter 'Change. A detachment of foot guards were called in, and directed by surgeons where to fire; and 152 bullets were fired before it was disabled. This proves how utterly ineffectual the leaden musket ball would be in the forest. Captain Harris, in his South African tour, in 1837, took with him a double-barrelled rifle, carrying balls two ounces weight, and thus armed, no beast could stand before him. Speaking of the forehead of the elephant, he says,[3] "A ball hardened with tin or quicksilver readily penetrates to the brain, and proves instantaneously fatal." He gives instances of his killing large elephants at a single shot, and seems to have had no difficulty with the "king of beasts," which he has slain "in every stage from whelphood to imbecility." According to Captain Harris, travelling through countries infested by wild beasts is not so dangerous as it is commonly thought to be. He says, indeed, that during part of his journey, "scarcely a day passed without our seeing two or three lions, but, like the rest of the animal creation, they uniformly retreated when disturbed by the approach of man. However troublesome we found the intrusions of the feline race during the night, they seldom, at any other time, shewed the least disposition to molest us, unless we commenced hostilities." He, however, does justice to the terrors of the maned monarch when he says, "those who have seen the monarch of the forest in crippling captivity only, immured in a cage barely double his own length, with his sinews relaxed by confinement, have seen but the shadow of that animal which 'clears the desert with his rolling eye.'"

Fallow-deer shooting. FALLOW-DEER SHOOTING. There are only three kinds of deer in Great Britain; the red, the fallow, and the roe. The fallow deer, which was the dun deer of the days of Robin Hood, is the common deer of the parks. The positions of a stag at rest when fired at may be reduced to three, for each of which a different aim should be adopted. First, when presenting his side to the shooter, the aim should be low behind the shoulder. Secondly, when standing obliquely from the shooter, the aim should be just under the ear, which is a vital part; there is too the chance, when this aim is selected, of reaching the brain through the upper or back part of the cheek, or of striking the animal in some other part of the neck, which will generally bring him down or so disable him that he will be readily recovered. It may be observed here, that the quickest mode of dispatching a dog, horse, or any other domestic animal is to shoot them through the neck, just under the ear. Thirdly, when standing or moving directly from the shooter, the aim should be at the back of the head; thus a chance is secured, should the part aimed at not be struck, of lodging a ball in the neck or spine. When a deer is approaching the shooter, or standing with its head towards him, he should wait until he can have a cross, an oblique, or a driving shot. When a deer is wounded, however slightly, one or more dogs should be instantly slipped. The dogs for this purpose should, as far as practicable, com-

[1] Oriental Field Sports, by Captain Thomas Williamson. London, 1805.
[2] Field Sports of the North of Europe, by L. Lloyd, Esq. London, 1828.
[3] Wild Sports of Southern Africa, by Captain William Cornwallis Harris. London, 1839.

Shooting. bine the nose of the bloodhound with the speed of the greyhound. A kind of wiry-haired greyhound is used for this purpose in the Highlands.

Deer stalking. Deer Stalking. The red deer, which is larger, and the roe-buck, which is smaller than the fallow deer, are found chiefly in the uncultivated mountainous districts of the North. To destroy the deer of an adversary was once a mode of annoyance. Chevy Chase, it would seem, from the three first stanzas of the famous ballad of that name, was an expedition of this description:

> " To drive the deer with hound and horn,
> Earl Piercy took his way;
> The child may rue that was unborn,
> The hunting of that day.
>
> " The stout Earl of Northumberland,
> A vow to God did make,
> *His pleasure in the Scottish woods,*
> *Three summer's days to take,*
>
> " With fifteen hundred bowmen bold,
> All chosen men of might,
> Who knew full well in time of need,
> To aim their shafts aright."

The pursuit of deer with the rifle is termed deer-stalking. To kill the semi-domesticated fallow deer requires little skill beyond that possessed by a good marksman. The skill of the deer-stalker, in pursuit of the red deer, is not only dependant on a good use of the rifle, but is shewn in his ability to find and approach deer; to do which successfully requires the most unwearied perseverance. Many of the Scottish forests wherein the stalking of deer in their wild state is practised, are of immense extent. It is on such tracts of land as the forests of Mar and Athole that the red deer is sought. The forest of Athole alone is said to be more than forty miles long, and in one part eighteen broad, of which about 30,000 imperial acres are devoted to grouse, 50,000 partly to grouse and partly to deer, and there are reserved solely for deer-stalking 52,000 imperial acres. In these vast solitudes, the Highlander stalks the antlered monarchs of the herd, harts which, a century ago, bore the scars of the weapons of his ancestors. An old Celtic rhyme which has been thus Englished, shews the great age to which the deer and the eagle are supposed to arrive.

> Thrice the age of a dog is that of a horse;
> Thrice the age of a horse is that of a man;
> Thrice the age of a man is that of a deer;
> Thrice the age of a deer is that of an eagle.

So far as regards the age of the eagle, these lines contain an assertion which can neither be proved nor negatived. It is different as regards deer. There has long existed a custom of marking fauns that have been caught, and as each forester has a distinct mark known as his own, the age of a marked deer can generally be nearly ascertained.

The deer-stalker has recourse to a thousand manœuvres to approach a herd or solitary stag. The animals are usually descried at a long distance, either by the naked eye, or by the aid of an achromatic telescope, and the mode of approaching them entirely depends upon the situation in which they are discovered. Should it seem impracticable to steal upon them while at rest, the stalkers, armed with rifles, wait in the defiles through which the deer are expected to pass, whilst the attendants make a circuitous movement to get beyond the deer and drive them in the direction required. The deer-stalker, besides being an excellent shot, should have good judgment of ground and a hardy frame, combined with the patience and power to undergo extreme fatigue and privation.

When the red deer is fired at, he is usually at a considerable distance, and perhaps bounding away at full speed. Behind the shoulder, therefore, is the favourite mark. " In killing deer,"[1] says Mr. Maxwell, " it is necessary to select the head, or aim directly behind the shoulder. A body-wound may eventually destroy the animal, but the chances are that he will carry off the ball." Mr. Scrope,[2] whose experience and success in deer-stalking render his remarks valuable, says, " the most perfect shots and celebrated sportsmen never succeed in killing deer without practice; indeed, at first, they are quite sure to miss the fairest running shots. This arises, I think, from their firing at distances to which they have been wholly unaccustomed, and is no reflection upon their skill. It is seldom that you fire at a less distance than a hundred yards, and this is as near as you would wish to get. The usual range will be between this and two hundred yards, beyond which, as a general rule, I never think it prudent to fire, lest I should hit the wrong animal, though deer may be killed at a much greater distance. Now the sportsman who has been accustomed to shot guns, is apt to fire with the same sort of aim that he takes at a grouse or any other common game; thus he invariably fires behind the quarry; for he does not consider that the ball, having three, four, or perhaps five times the distance to travel that his shot has, will not arrive at its destination nearly so soon; consequently, in a cross shot, he must keep his rifle more in advance. The exact degree, as he well knows, will depend upon the pace and remoteness of the object. Deer go much faster than they appear to do, and their pace is not uniform, like the flying of a bird; but they pitch in running, and this pitch must be calculated upon."

The interest and anxiety attending this sport must be as intense as the pursuit is laborious. After climbing for hours the mountain side, with the torrent thundering down the granite crags above him, and tremendous chasms yawning beneath him, the stalker, with his glass, at length descries in some remote valley, a herd too distant for the naked eye. He now descends into the tremendous glen beneath, fords the stream, wades the morass, and by a circuitous route threads the most intricate ravines to avoid giving the deer the wind. Having arrived near the brow of the hill, on the other side of which he believes them to be, he approaches on hands and knees, or rather vermicularly, and his attendant, with a spare rifle, does the same. A moment of breathless suspense ensues. He may be within shot of the herd, or they may be many miles distant, for he has not had a glimpse of them since he first discovered them an hour ago. A moment, and the antlers appear; another, and the herd is in sight. Resting his rifle on the heather, he takes a cool shot at the finest hart, which falls; the rest bound away; a shot from the spare rifle follows, the " smack" of the ball is heard, and the glass tells that another noble hart must die. The dogs, which had been kept far back, are slipped, and are out of sight in a moment. The sportsman follows; he again climbs a considerable way up the heights; he applies the telescope, but nothing of life can he behold, except his few followers on the knolls around him. With his ear to the ground he listens, and amidst the roar of innumerable torrents, faintly hears the dogs baying the quarry, but sees them not; he moves on from hill to hill towards the sound, and eventually another shot makes the hart his own. The deer is then gralloched, and partially covered with peat; the horns are left upright, and a handkerchief is tied to them to mark the spot, that the attendants may find it at the close of the day. Let the reader imagine how much the interest of all this is enhanced by the majestic scenery of an immense, trackless, treeless forest, to which domesticated life is a stranger, where mountain, corrie, cairn,

[1] Wild Sports in the West, by W. H. Maxwell, Esq. London, 1833.
[2] The Art of Deer-Stalking, by William Scrope, Esq., F.L.S. London, 1839.

Shooting. and glen, thrown promiscuously together, present the grandest of savage landscapes, which, as the field of wild adventure, cast into shade what Mr. Scrope calls "the tame and hedge-bound country of the south."

The Fowling-piece. THE FOWLING-PIECE. Before making choice of a gun, the shooter should determine what weight he can conveniently carry. The heaviest gun, as regards shooting, will be most effective, but he should recollect that unless he be a very robust person, a light gun will, on the whole, bring him more game, as a few additional pounds in the weight of a gun makes a deal of difference in the distance a person can travel in a day, and, moreover, he cannot shoot as well when fatigued.

The most approved guns under the system which prescribes a heavy charge of powder, and a light one of very small shot, are double barrels, weighing, according to the fancy of the shooter, from six to nine pounds, and bearing the following relative proportions of length to guage: fourteen guage, thirty-four inches long; seventeen guage, thirty-two inches long; twenty guage, thirty inches long. Taking the season throughout, we are convinced, that the most effective gun is a short, wide-bored one, each barrel being charged with rather less than $1\frac{1}{2}$ drams avoirdupois weight of powder, and full 2 oz. of No. 2 shot, containing 220 pellets. This is the general charge, but it may be varied according to circumstances. When game is wild, we would charge the reserve barrel, and, on some occasions, both barrels, with $2\frac{1}{2}$ drams of powder, and a No. 5 blue cartridge for partridges, and with a No. 4 or 5 red cartridge for grouse shooting. No. 7 shot is best for snipe shooting. Small shot may be used for partridge shooting in September, though we do not see any reason for not adhering to No. 2, except that birds very near the gun are liable to be more disfigured by it.

Barrels twenty-six or twenty-eight inches long, and fourteen or sixteen guage, are of convenient size. We think it will not be questioned that these barrels are as efficient as long narrow-bored ones for short distances, viz. under thirty-five yards, and nine-tenths of game brought to the bag is killed within that distance. And for making long shots, the wire-cartridge has obviated the necessity of using long guns. A most material advantage attending the use of a short gun is, the comparative ease with which it may be carried. A pound additional weight at the breech is not so fatiguing to the arm as half that weight added to the end of the barrel; it is the top-heavy gun that distresses the shooter.

Different proportions of powder and shot are required for different sizes of shot. The following may be the proper proportions for a gun not exceeding eight pounds:

Size of shot.	Weight of shot.	Weight of powder.
No.	oz.	drams.
2	2	$1\frac{4}{10}$
3	$1\frac{3}{4}$	$1\frac{1}{2}$
4	$1\frac{1}{2}$	$1\frac{3}{4}$
5	$1\frac{3}{8}$	2
6	$1\frac{1}{4}$	$2\frac{1}{4}$
7	$1\frac{1}{8}$	$2\frac{1}{2}$

These proportions cannot be materially deviated from without destroying the effect. If the powder is decreased, the discharge is weakened; if the powder is increased, the shot spreads; if the weight of shot is decreased, there will not be a sufficient number of pellets for effective shooting; if the weight of shot is increased, the discharge is weakened.

The usual objection to large shot is, that after it has travelled thirty yards it becomes dispersed; but let the powder be reduced to less than $1\frac{1}{2}$ dram, and that objection fails. If it is not overcharged with powder, a gun will shoot No. 2 shot close enough to kill at from thirty-five to fifty yards, with more certainty than if charged with small shot, and two or three drams of powder.

It is not so much the velocity as the momentum of a shot that renders it effective. The momentum of a shot increases in a direct ratio with its weight. The momentum of a No. 2 shot much more than compensates for the diminished weight of powder and additional weight of lead that we have recommended. Large shot droops more than small, and sooner comes to the ground, as it is not carried with the same velocity. It is the momentum, and not the velocity, that the shooter must look to.

We do not suppose that feathers or fur of game present any serious obstacle to either large or small shot; but if they did, the fact that large shot is most effective for shooting wild fowl armed with down, at once tells that it must be so for shooting game which is not so protected. Another advantage of large shot is, that when the aim taken is not quite correct, a single outside pellet will often bring down a bird, when it would require many small shots to do so.

The shooting of barrels depends mainly on three things, viz., the metal of which they are made, the boring, and the breeching. The quality of the metal is of much importance. All barrels expand when fired; and those made of inferior metal expand more than those made of stub-twist. Mr. Greener, in his excellent treatise on the "Gun,"[1] says, "that a barrel is a spring on an extended scale, and the more we can make it partake of the nature of a spring, the better. If we must have expansion, let us have it in its most beneficial form; an expansion that will aid the powder in expelling the lead. This cannot be entirely obtained, nor can the quantity of expansion be entirely destroyed, though you were to make your barrels of the weight of a twenty-four pounder. We must, therefore, decrease it, by making our iron as elastic and tenacious as possible. The qualities of elasticity and tenacity can only be obtained by hammer-hardening the iron. Barrels hammer-hardened will shoot as well without any artificial friction, as those whose friction is extreme, yet have not yet been benefited by the process."

The term friction implies a gradual contraction of the barrel towards the muzzle, which retards the progress of the shot, that more time may be allowed to the powder to burn. "The shooting of all barrels," says Mr. Greener, "depends on a certain degree of friction. The degree of friction necessary varies according to the nature and substance of the metal. Those metals that require least shoot best. The object of the friction is to create a greater force, by detaining the charge longer in the barrel. If, then, there should not be an extra quantity of powder to consume, the friction would be a decided evil." A greater degree of friction is generally allowed to a short barrel than to a long one. A gradual expansion of the barrel towards the muzzle is termed relief. Relief accelerates the progress of shot through the barrels. What is the proper degree of relief or friction for different descriptions of barrels, is a subject fruitful of much controversy; as is also the form of the breech. The best breech is that which will cause the greatest quantity of powder to consume in the barrel.

Mr. Greener would not prevent the barrel expanding when fired, by increasing its thickness, but by improving the quality of the metal. When the barrel expands much, or is held loosely when fired, a loss of strength is induced, as that power which, if possible, should be exerted on the shot, is uselessly expended in a contrary direction, whereas, when the barrel is firmly fixed, and made of metal that only

[1] The Gun, by William Greener. London, 1835.

expands in a trifling degree, or, as Mr. Greener observes, operates as a spring, that portion of the explosive force which strikes in any direction, except against the shot, is forced back, or rebounds upon the shot, and consequently becomes a portion of the available strength of the charge. Much of the force that is thrown on a solid fixed surface is returned, but not that which is expended on an yielding one.

Mr. Greener shews that much loss of strength is induced by barrels not being firmly held when fired; and argues that the mode of proving barrels by allowing them to fly back into sand is defective, as, by reason of the projectiles giving way in one direction and the barrels in the other at the same time, there is not a sufficient strain on the barrels to prove them effectively. On this subject he says, " Let any one take his gun and load it as usual; suspend it by two ropes so as it can fly back; place a quire of brown paper as directly in front of it as possible; fire it, by squeezing the trigger and the back side of the guard together, so as not to displace the gun; examine the impression the shot has made in the paper. If they have stuck in at the distance of forty yards, they have done well. Load again, and fire from the shoulder, and you will find the shots driven through a great number of the sheets. Load again, but first take the barrels from the stock, lest you should happen to break your stock, as I have seen done by a gentleman placing his gun on a stone wall; while he rested, the gun by accident went off and shivered the stock into many pieces, and severely cut his hand by the splintering. (So severe is the recoil from a gun on being fired, when resisted by a solid, unyielding substance. When fired from the shoulder it is different, as the body yields to the recoil, and thus prevents that which would inevitably be inflicted, if the shoulder were placed against a solid substance.) Secure the barrels on a piece of wood, and behind place anything firm; for instance, a piece of lead sufficiently heavy, and that will not injure the end of the breeches, technically called the buts, when they strike it. Having secured them perfectly, fire the barrel in any way you can, and then examine the force of the shots in the paper, and if you do not find that they have penetrated further than they did when fired from the shoulder, say my doctrine is false. It follows, as a matter of course, from these experiments, that in shooting, the more firmly a gun is held to the shoulder, the better it will shoot.

" It is upon these experiments that I found my objections to the practice of allowing best barrels, when proved, to fly back into sand. Such a mode of proof is of no use. Were they fixed like common barrels, the force of the proof would be increased one-half. I doubt whether the present method be any test at all. I am satisfied that the force exerted in this mode of proof on the barrel, is not equal to the pressure of a large sporting charge, when fired from the shoulder.

" The fact that the shooting powers of a gun are increased by its being fixed in an immoveable frame, is proved with the practice of mortars. Mortars on iron beds, and these firmly embedded in the earth, will throw a shell farther when on the ground, than when placed on a platform, or on board a ship. It is for the purpose of destroying the recoil, that mortars for sea-service, though of the same calibre as those intended for land-service, are made three times the weight. Dr. Hutton states, that he found no advantage by retarding the recoil in practice with artillery. He means, that no advantage is gained by stopping at three feet a gun accustomed to recoil to the distance of six. The statement is perfectly true. If he were to allow a gun to recoil only an inch, and then strike against a solid substance, he would gain nothing. For if it recoil ever so little, the shooting force is as much weakened as if it recoiled twice as far.

" To increase that force, a steady fixed resistance is required. The velocity of the projectile depends on the force of the immediate impulse. Before a gun, suffered to recoil, could rebound from striking some solid substance in its recoil, the charge would be gone, and could, therefore, receive no additional impetus from that rebound. The truth of this fact may be illustrated by throwing a hand-ball against any loose body with sufficient force to displace it. However hard or elastic that body might be, the ball would not rebound from it, but would fall perpendicularly down. Fix and secure that same body, and then the ball will rebound with little less force than that with which it was thrown against it. So it is with gunpowder. If it meet with a firm resistance, it will rebound and project the ball or shot with additional force."

On Charging the Fowling-piece. It may be premised that all powder, before being put into the barrel, is more or less damp; and most barrels, especially if they have been only imperfectly cleaned, or have been fired and laid by since being cleaned, are also more or less liable to damp. A portion, therefore, of powder should be flashed off in each barrel immediately before charging, for the triple purpose of expelling damp, proving whether the passage through the pivots on which the caps are to be placed, is open, and warming the barrels, so that any little moisture in the charge of powder may be absorbed. The barrels are then held perpendicularly and the powder poured in, in such manner that the whole charge may reach the bottom; and a wadding is then pressed down upon it. The shot is next poured in and another wadding pressed upon it. The shooter next removes the remains of the caps, and looks whether the powder has found its way to the orifice of the pivots, and if it has, he places fresh caps on. If the powder is not visible at the orifice of the pivots, he removes any obstacle with a pen-knife or pricker, and contrives to push down a few grains of powder.

Wire-cartridges.

Wire-Cartridges. The wire-cartridge (fig. 1.) was invented in 1828 by Mr. Jenour. It consists of a cylindrical case or net-work of wire, the meshes of which are somewhat more than an eighth of an inch square; at the lower end the wire partially closes; the wire case is then enveloped in fine paper, and at the upper end a cork wadding, cut so as to fit the guage of the gun, is affixed; the case is then filled with shot and bone dust. The first cartridges made, though ingenious in construction, were defective in operation. It was a matter of no ordinary difficulty to fabricate them in such a manner that the shot should leave the case at the precise distance required. This at first, could not be done so that they might be trusted in every instance. Every alternate cartridge might fire well; but the rest would fire irregularly, being liable to ball; that is, the shot would not leave the case until fifty or sixty yards from the gun, and such cartridges were, of course, not only useless but dangerous. They have been from time to time improved, and almost every difficulty has been overcome. The sporting cartridges now made never ball; they act with a considerable degree of precision and certainty; and that they may be safely trusted may be inferred from the fact that they are often preferred by persons engaged in pigeon matches. Various materials were used experimentally to fill up the interstices between the pellets, but nothing seems to answer so well as the material now used. Another difficulty in their construction presented itself. It was requisite to accommodate them to the various methods of boring pursued by different gunmakers, and the unequal length of barrels, the object in view being to produce a cartridge that would suit all barrels of the same guage; and this has been, in a great measure, if not wholly, accomplished. The liability to ball which, notwith-

Fig. 1.

Shooting. standing various improvements made in them, was not effectually obviated for many years, during which they were tried, and in many instances prematurely condemned, either from real defects, or from the parties not knowing how to use them. They were not brought to perfection until the year 1837.

The wire-cartridges possess two principal advantages over loose shot; they are propelled with greater velocity, and thrown more evenly. A loose charge is always thrown in patches; the shots of a cartridge, as seen on a target, are comparatively equi-distant from each other. There are four classes of wire-cartridges, which the patentees have named the *battue*, the *blue*, the *red*, and the *green;* each intended for a different range. There is some little difference in the construction of each of the three kinds; the meshes of the frame-work are larger in the battue and the blue than in the red, and in the red than in the green, and there are doubtless other differences not perceptible to the uninitiated. The battue and the blue cartridges are intended for general use; the battue for the shortest distance; the blues will kill several yards further than loose shot of the same size, and of the four kinds, are, in our opinion, decidedly to be preferred; each blue cartridge being thrown more nearly alike, they are more certain in their operation than the red and the green, which are intended for longer distances. The red may be serviceable in open places, when game is wild, and the shooter is provided with a gun of not less than fourteen guage, or with a very short barrel, which does not throw its shot very strongly. The green cartridges are intended chiefly for wild-fowl shooting; these should be used in barrels of not less than twelve guage. The red and green cartridges retain the shot in the case longer than the others, and are carried with an astonishing force to an incredible distance, and at the same time very closely. The red may generally be trusted for long distances, especially from barrels of large calibre; but at short distances the smallness of the circle they describe renders them objectionable. The green cartridges should never be used for shooting game. The blue and battue only should be used in barrels of small guage.

The wire-cartridges do not require either a greater or less charge of powder than loose shot, but there is this peculiarity attending them. A heavy charge of powder throws the shot from the cartridge more closely than a small charge, by reason of its allowing more time for the escape of shot from the net-work. This is exactly the reverse of the manner in which the loose charge acts. The greater the charge of powder when loose shot and wadding are used, the more is the shot dispersed, and *vice versâ*. Either loose shot or cartridge shot is projected with greater force and velocity when a heavy charge of powder is used. When birds lie well, we would recommend the shooter who adopts the cartridge to charge lightly with powder, to give the shots time to spread well; when moderately wild, we would charge lightly with powder in the first barrel, and heavily in the reserve barrel; but when birds are very wild, both barrels should be charged with as much powder as the shoulder can conveniently bear, so as to give the charge the greatest possible force, and at the same time the greatest practicable degree of closeness. It is at long distances that the superiority of the cartridge is conspicuous; when the loose charge is used, the increase of force that is obtained by loading heavily only tends to dispersing the shot, thereby rendering the increased momentum of little avail.

Amongst the advantages attending the adoption of wire-cartridges, it may be mentioned, that the recoil is not so severe, and consequently a lighter gun may be used, than with the loose charge, and this is a great relief to the shooter in a heavy country, and especially on the hills in August, when the heat of the sun is frequently overpowering. The cartridges act well when fired from short barrels, perhaps more satisfactorily than when fired from long ones. The increased facility and expedition of loading is another advantage which should not be overlooked. Shooting.

The main objection to wire-cartridges, and it is a material one to a person who is an indifferent marksman, is, that they do not describe a sufficient circle at short distances. When game is wild they are invaluable for the reserve barrel of a double gun.

The wire-cartridges usually kept on sale contain, for the different guages, the following weight of shot.

Calibre.	Weight of shot.	Calibre.	Weight of shot.
20	$\frac{7}{8}$ oz.	14	$1\frac{1}{4}$ oz.
19	1	13	$1\frac{3}{8}$
18	1	12	$1\frac{3}{8}$
17	1	11	$1\frac{1}{2}$
16	$1\frac{1}{8}$	10	$1\frac{3}{4}$
15	$1\frac{1}{4}$		

When ordering cartridges, it is necessary to give the *guage* of the barrel, the *weight* of the cartridge, the *size* of shot, and the *description*; that is, whether battue, blue, red, or green.

The green cartridges, fired from a common-sized fowling-piece, are not to be depended upon for any distance nearer than fifty yards; and, for that reason, they should only be used for wild-fowl shooting, for which sport they may answer very well when fired from a reserve barrel. We would not recommend their adoption, even for wild-fowl shooting, to a person using a common-sized single gun, since by so doing he would hazard missing when the most favourable opportunities of killing presented themselves. A No. 3 red cartridge would suit better.

The wire-cartridge has been proved to be much superior to the loose charge for the stanchion, and heavy shoulder guns used on the sea-coast and rivers. For the largest shoulder guns, B or B B loose shot, or a No. 1 cartridge is usually adopted. A A loose shot, or a B or No. 1 cartridge will better suit the stanchion gun.

Taking aim.

Taking Aim. As the manner of taking aim is a matter of primary importance to success in shooting, a few observations on that head may not be misplaced here. When the dog points, or when birds rise near to him, the shooter should immediately draw back both hammers with the right thumb;[1] but should the birds rise at a considerable distance, to save time he need only cock one barrel, as in this case, he has only to fire once. He should never be in haste. It is more prudent to let the bird escape than to fire hastily. If on open ground, he should not fire until the bird is at least twenty-five paces distant, by which means he avoids, on the one hand, the hazard of mangling it, and, on the other, a probability of missing; for at the distance of from twenty-five to thirty yards, whether the piece be charged with loose shot or the wire-cartridges, the range of the whole charge will be wide, yet the pellets will be so close together that nothing can escape, if the aim be true, and, what is of no less moment, the finger also obedient to the eye. He should be deliberate in bringing up the piece to his shoulder, and in making it to bear on the object, but the moment he has brought it to bear, the finger should act in co-operation with the eye, the eye being kept open the while, so that

[1] Many experienced sportsmen disapprove of the practice of cocking both barrels at the same time. They think that it ought to be a rule never to cock either barrel, until the game be upon the wing, then that the left barrel should be cocked and fired, and thereafter taken from the shoulder. The right barrel should then be cocked and fired if necessary; if not discharged, it should be put back to the half cock, and the left re-loaded.

Shooting. the shooter may see whether the bird falls, or feathers fly from it; for if he does not, he may rely that there is something defective in his system of managing the fowling-piece. A shooter only requires coolness, a very little mechanical knowledge, and a gun properly mounted. Possessing these requisites, he will not be deficient in any other which he will not be easily able to supply. The novice should learn to shoot high enough at winged, and low enough at footed game, and well forward at both. He should seldom shoot directly at the object; but at the wing, if the bird is moving obliquely from him, the head, if the bird is rising, the legs, if descending; but if crossing, or flying obliquely at a considerable angle, he should make an allowance of a few inches, according to the distance of the object from him. It is not usual, except in the cases of blackcock, to shoot at any object approaching the shooter. It should be allowed to pass, when he turns round and fires at it as it moves from him.

The Rook. *The Rook.* We commence our notice of the different kinds of shooting with the fowling-piece now chiefly practised, with a few observations on those birds, not coming under the denomination of game, which occasionally afford the first lessons to the younger brethren of the trigger, and which therefore may properly take precedence, in description, of the more difficult branches of the art.

Young rooks, in the month of May, are generally shot whilst sitting on the branches, near their nests, on the tops of the loftiest trees, so that it requires a steady aim, and hard-stricken shot to bring them down with certainty; for if only wounded, they will frequently cling to the bough with their claws, and die suspended in that manner. The rook should be fired at with a small charge of rather large shot, and a heavy charge of powder. Rooks are gregarious, and feed on grain, worms, and insects. It is only during the season of incubation, and until the young ones can fly, that they frequent the rookery, which is mostly a small plantation, or clump of old trees, and near to some habitation. When rooks choose any particular cluster of trees, or plantation to build in, the same trees will, if standing, be tenanted again the next year by the same rooks and their offspring. notwithstanding they may have been much fired at, or in some other way disturbed. This opinion is not universal. In some counties there exists a prejudice against the practice of firing at rooks with gunpowder, especially when the rooks are few, and the number of trees limited, lest the rooks should desert the rookery; and, therefore, that as little alarm as possible may be created, they are fired at with balls from the air-gun, and sometimes the young shooter will try his skill with the cross-bow. The old rook is distinguished from the young one by the thick end of either mandible being white; and the beak of the young rook is black to the insertion. They are distinguished from other birds of a somewhat similar appearance, by a slight variation of colour; the rook has a blue, the carrion-crow a brown tinge, the jackdaw is partially grey, the raven is jet black.

After young rooks have been fired at several times, some of the strongest and best-fledged will quit the rookery, and alight on hedges or trees at some distance, where the shooter flushes them, and they afford good sport to the tyro learning to shoot birds on the wing. A warm sunny day is best for rook-shooting. In cold weather, particularly on windy days, young rooks will not quit their nests.

The Wood-pigeon. *The Wood-pigeon.* The wood-pigeon is little regarded by the sportsman. A shot may be obtained by lying in ambush early in the morning, near to some wheat stubble, or field of newly-sown grain, where the birds feed; but the best sport the wood-pigeon affords is at the roosting places, where the shooter ought to take his station an hour before sunset. It is difficult to obtain a shot in any other manner, except when the birds are young, when they are sometimes killed in trees, in the same manner as young rooks. The shooter in pursuit of game often sees them, but rarely obtains a shot at them. Sometimes, but it is usually when he is not aware of them, they will suffer him to approach close to the tree in which they are perched. The tree is generally a large one, and perhaps in full foliage, and the shooter hears the rustling of the wings of the decamping birds, but seldom secures a shot. Whenever a wood-pigeon leaves a tree, the shooter should prepare for others, since, when there are several in the same tree, they will not leave it simultaneously, but move off in succession. They are large strong birds, and require heavy shot to bring them down.

Shooting tame pigeons is becoming a very common amusement; but it is oftener practised to decide a wager, than prove the skill of the parties. The Red House at Battersea, near London, is the scene of the principal matches. The birds are sprung from a trap, which is usually placed twenty-one yards from the gun; the birds of each person are provided by his opponent; blue rocks are the favourites; very heavy guns are used, but the weight of shot is usually limited. The birds must fall within a limited distance from the trap, or they are not counted amongst the successful shots.

The Lark, &c. *The lark, field-fare, lapwing, golden plover, and dottrel.* Larks and field-fares are often the object of the young shooter's pursuit. Field-fares, the blue-backs and red-wings, arrive in October, and remain during winter. They are easily approached during a frost, or when the ground is covered with snow. They will then be found in search of the berries of the mountain-ash, the holly, and the hawthorn, and are killed in great numbers. Like wood-pigeons, field-fares do not leave a tree, or rise from the ground simultaneously, so that when one bird flies off, if the shooter will hasten to the spot, he will, in all probability, meet with a lagger.

The lapwing or pewit is a bird much sought for by the juvenile shooter. Lapwings are commonly found on marshes, or wet land abounding in rushes. Except during the season of incubation, they collect in flocks, and are so very wary as to be difficult of approach. They are often killed for the sake of their toppings, which are useful to the angler. As they wing round the shooter, it is extremely difficult to decide whether they are within range or not; they should be within a moderate distance when fired at, or they will escape in the interstices of the charge, as the size of the body bears a small proportion to the apparent size of the bird when on the wing. It is not uncommon to see several feathers cut out of the wings, and the bird fly away as if unhurt.

All these birds afford amusement chiefly to schoolboys. The sportsman in pursuit of game does not think them worthy attention; but the golden or whistling plover, and the dottrel, which are birds often met with in hilly districts, are generally considered as worth firing at, if they accidentally come in the way, but are not worth the trouble of following.

The Land-rail. *The Land-rail.* The land-rail or corn-crake is a bird of passage. It may be found with pointers or spaniels early in spring, in hedges or long grass. The dogs for this sport should not be staunch; such as will foot the birds are best as it is with great difficulty they can be made to rise. It is only during the first fortnight after their arrival that they may be fairly killed in spring; after that time they begin to pair. In August and September, the sportsman sometimes casually meets with a land-rail, whilst beating for other birds.

Wild-fowl. Wild-fowl. Wild-fowl shooting is practised in various ways. The method of proceeding depends entirely on the situation in which the shooter expects to find the birds. In some of the inland counties, except during hard frosts, they are not met with anywhere but on large pools and ri-

Shooting. vers, and are only to be approached by having recourse to some stratagem, as waiting in a shed, or on an island, or on the banks of a pool, or stalking behind a horse trained to the purpose. The largest shoulder gun that is at hand may be used charged with the red or green wire-cartridges, the size of shot being regulated by the bore of the piece.

During a severe frost, wild-fowl are compelled to leave the pools, and are then found in small rivers, brooks, or in drains where there are springs of fresh water. The flights being broken, ducks are found singly or only few in number, and are consequently easy of access, and may be shot with a common fowling-piece. The size of shot should be No. 2, or 3. Wild-fowl are so fortified with down on some parts as to resist any but hard-stricken shot. Their back is the most vulnerable part, and all kinds of wild-fowl present it to the shooter as they rise. They are also easily brought down when they present a cross shot; but when approaching it is not advisable to fire at them. If a dog accompany the shooter, it should follow at heel. As the shooter pursues the course of a river or brook, he should keep out of sight as much as possible, and come suddenly on every turn or winding. When there is a mist during a frost, wild ducks will remain in the brooks and gutters all day. The earlier in the morning the better for this sport. Ducks may also be killed on the wing, on the verge of night, by the shooter lying hid near to fresh water springs. If it be a dark evening, he need only wait about a quarter of an hour, but if moonlight he may wait about an hour. They may also be walked up on a moonlight night, when, if they rise above the horizon, they may be killed almost as easily as in the day time. The objection to night shooting is, that birds knocked down are often lost. These are the principal methods by which ducks are killed by any but professed wild-fowl shooters.

The larger kinds of wild-fowl, such as hoopers *(wild swans)* and geese, can rarely be brought down by the common fowling-piece, unless struck on the head or back. Wild-fowl shooting, in creeks and harbours on the sea-coast, is conducted in a very different manner, and on a larger scale of operations. There are two kinds of guns used for the purpose, the shoulder-gun and the punt-gun; the latter being fired from a rest, or frame, or carriage, either in a boat or some other floating craft. Mr. Greener, to whose work we have already referred, says, "Never make duck guns (shoulder-guns) above seven-eighths in the bore, if you wish them to kill at a great distance, and not less than fifteen or sixteen pounds weight, and full four feet long." Colonel Hawker,[1] who has devoted nearly one hundred and fifty pages to the subject of wild-fowl shooting, says, "The barrel of a punt-gun, to be in good proportion, should, I conceive, (including the patent plug, of about six pounds weight, and from two to three inches in length), be about seventy or eighty pounds weight, from seven to nine feet long, and from an inch and a quarter to an inch and a half bore, according to the one length and weight, or the other. The smaller the bore is, in reason, the further you can kill at a small number of birds; but the larger size of these two shoots the best, and is the most regular pattern. Any thing beyond that size seldom answers." Both these writers seem to agree that the common punt-gun, though it weigh eighty or one hundred pounds, cannot be charged to the extent of its shooting powers, by reason of the tremendous recoil that would result; but each advises that the additional weight should be gained by using the barrels double. Thus more than a double advantage would be secured, for not only would there be two barrels at command, but the discharge from each barrel would be more effective. The charge of shot for a punt-gun averages from ten to twenty ounces; the shot is much larger than any used for shooting game. Shooting.

The Colonel, and we apprehend he is the only practical writer on this department of the subject, describes the various kinds of punts (which are flat-bottomed boats or canoes, so constructed as to be manageable either on sands, or in mud, or water,) used in several different counties, and gives the following directions for shooting wild-fowl, from a punt, with a large shoulder-gun. "Sit down on some straw or rushes, with your gun by your side, and take with you a small Newfoundland dog. Row about, till you can see or hear a flock of wild-fowl on the mud. To find them sitting, if by night, look at first very low, so as to bring the surface of the mud in contrast with the horizon, by which means you will overlook the black edges of the creeks and holes, instead of seeing, and perhaps mistaking them for birds.

"When you have rowed within two or three gun-shots of the fowl, take in your oars, and reconnoitre the creeks. Having ascertained which is likely to be the best, lie down, and push along with the *setting pole* or *gunning spread,* and while the mud banks stand above the little channels, you are so completely hid, that you will seldom fail to get a shot, provided there is a creek within reach of the birds, and you do not go directly to windward of them.

"On arriving sufficiently near, should the water be so low that you cannot present your gun at the birds without kneeling or standing up, you must get aground at the side of the creek, or steady your canoe by means of forcing each oar from between the *thowls* into the mud, otherwise the recoil of the gun will set her rocking, and thus you might probably be tipped out. Having made all fast, rise up and fire. Take care, however, to rise high enough to be well clear of the mud, or not a feather will you touch; and present as follows: By day, or moonlight, if the birds are close, directly at them; or if beyond forty yards, shoot at their heads; unless they are feeding in a concave place, where the tide has left a kind of plash, in which case you must level rather under them, or you will only graze their back feathers. In star-light, take your aim just at the top of the narrow black line, in which birds always appear to one who is low down; and when so dark that you cannot see your gun, present, as you think, about a foot over, or you will most likely shoot above a foot under them.

"Should you have been successful, you will, if at night, generally hear your cripples (wounded fowl) beating on the mud, before you can sufficiently recover your eyes, from being dazzled by the fire, to see them. Your man then puts on his mud-boards, (which are flat square pieces of wood fastened to the feet, to enable the party to walk or wade through mud), taking the setting pole to support him, and assist the dog in collecting the killed and wounded; taking care to secure first the outside birds, lest they should escape to a creek. During this time you are left in charge of the punt; and should, if possible, keep a look out, in order to see if any more birds fall dead or wounded from the company, before they have flown out of sight.

"The gunner generally calculates on bringing home the half only of what he shoots, from the difficulty of catching the whole of his winged birds, which he calls *cripples,* and those that (to use the pigeon phrase) fall out of bounds, which he calls *droppers.* If the birds fly up, he generally declines firing, knowing that the moment they are on the wing, they become so much more spread, that he could seldom get more than three or four, for which it would be hardly worth while to disturb the mud; particularly as

[1] Instructions to Young Sportsmen. Eighth edition. London, 1838.

widgeon, by night, if not fired at, will, in cold weather, probably settle again at no great distance.

"In following wild-fowl, it is easier to get within twenty yards of them by going to leeward, than a hundred and fifty if directly to windward, so very acute is their sense of smelling.

"The best time, therefore, to have sport with a canoe and a shoulder-gun, (provided it be low water, or half ebb, while you are hid in the creeks), is in clear, frosty, moonlight nights, when the wind happens to blow towards you as you face the moon. It is then impossible for the wild-fowl to smell you; and you may, by getting them directly under the light, have the most accurate outline of every bird, and even distinctly see them walking about, at a much greater distance than a gun would do execution. From thus being on the shining mud-banks, they appear quite black, except some of the old cock widgeons, on the wings of which the white is often plainly to be seen.

"It does not follow, however, that nothing can be done without a bright moon. So far from it, that some of the best shoulder-gunners in the kingdom prefer but very little moon, even for the mud. Here, by constant habit, they can easily distinguish the black phalanxes of widgeons from the shades on the places they frequent, and particularly if they are feeding among the puddles which have been left by the tide. In this pursuit, and when not favoured by the best of light, there are a few cautions to be given to an inexperienced shooter. First, to ascertain that the black patch to be seen *is* a flock of birds, which he will do, by observing the occasional change of feature in the outside of it. Secondly, on approaching them, to be careful that their enormous masses and tremendous noise do not deceive him in the distance, and tempt him to fire out of shot. And, thirdly, not to be too eager in getting his dead birds, as it sometimes happens, in hard weather, that the remainder of the flock will again pitch down among them, particularly if he has winged some of the younger birds, which have not the cunning to make off for a creek, like the old ones. In this case, a reserved gun would, probably, more than double the produce of his first shot. It should be understood, that this night shooting is chiefly at the widgeon, as the geese, of late years, (since there have been so many shooters), have seldom ventured much in harbour by night, except sometimes at high spring tides, with a full moon; and the greater part of the ducks, teal, dunbirds, and such like, repair inland to the ponds and fresh springs, unless driven to the salt feeding ground by severe frost.

"A company of widgeons, when first collecting, may be heard at an immense distance, by the whistling of the cocks and purring noise of the hens; but when they are quietly settled, and busy at feed, you sometimes can only hear the motion of their bills, which is similar to that of tame ducks."

Geese, ducks, widgeons, hoopers, curlews, and other wild-fowl, are killed in this manner; but the most destructive method of killing them is with the heavy stanchion or swivel punt-gun, used by the persons on the coast who make a trade of wild-fowl shooting. When a fair shot can be obtained by this method, from twenty to fifty birds may be killed at one discharge; but it is laborious, wearisome work, and, except for a single occasion, can scarcely be called sport. This kind of shooting is carried on in the night, usually in frosty weather, at which time sailing about on water, or working the canoe through mud, cannot be accompanied with very agreeable sensations.

The size of shot for punt-shooting should, in some measure, be regulated by the size of the birds expected to be met with, and their degree of tameness; yet it is well to be prepared with shot of sufficient size, as hoopers, geese, and other large birds, are sometimes found when least expected.

The Water-hen, &c.—There are various kinds of wild-fowl, which will dive rather than fly away when disturbed. They are, for the most part, clumsy birds on the wing, and are killed without difficulty when they can be made to rise. When shot at swimming, the shooter takes aim, and fires instantaneously, or they will be under water whilst he is drawing the trigger.

Dogs.

Sporting Dogs. Before noticing the different kinds of game which are the object of the shooter's pursuit, a few observations on sporting dogs may not be irrelevant. The shooter's dogs are of four kinds; the pointer, setter, spaniel, and retriever.

Pointers and setters.

Pointers and Setters. If dogs were unknown in Europe, and some traveller from a distant part of the southern hemisphere were to relate that he had seen a new species of quadruped with wonderfully fine olfactory nerves, by the aid of which it was enabled to hunt to death the hare, stag, fox, or jackal, the tale would readily be credited; for the instinct of the hound, as compared with that of other animals, is not such as to excite surprise. But were the traveller to relate that he had seen a quadruped which, untaught, would stand motionless, as if converted into a statue, on coming in contact with the slightest scent of game, he would not be believed; it would appear incredible, such is the extraordinary instinct of the pointer and setter. We use the term *extraordinary* advisedly. There are other animals, and indeed other dogs, which possess a degree of instinct more nearly approaching to reason, but none possessing so extraordinary an instinct, an instinct not analogous to that of any other living creature that we are aware of. The pointer seems to be endued with it for the artificial service of man; whereas the instincts of all other animals are conducive to the supply of their individual wants, and their usefulness to man is secondary thereto. It would be difficult to controvert the argument that this instinct was given to the pointer for the purpose of aiding men to capture or kill game, by means of such engines as nets or guns. This, we are aware, may be a doubtful position to maintain; but who can say for what other apparent purpose this peculiar faculty was given? It may, indeed, be urged, that the propensity to point, in the pointer, is a means ordained by providence for his subsistence in a wild state, by enabling him to approach within reach of his prey, and thus to accomplish, by another species of stealth, what the tiger and other animals of the cat tribe effect by ambuscade. Such an argument, however, is presumptively rebutted by the fact, that all existing races of wild dogs are gregarious, and resort to the chase for food; nor is there any record of the existence of dogs in a state of nature, except those calculated for the chase. It is therefore gratuitous to assert, that the instinct or faculty of pointing was bestowed upon the pointer as a means of subsistence, since he has ever been dependant on man for food.

It is strongly argued, that all dogs have descended from one common stock, and that by difference in food, climate, and training, they have become what they are at present; nor is it more improbable that such is the fact, than that the human race are descended from one common parent; for dogs are not more dissimilar than the various tribes of men, who differ not only in outward form, but morally and intellectually, as much as dogs vary in size, shape, temper, and sagacity. Those animals which can be domesticated improve by acquaintance with man, as the wild fruits by cultivation. All wild dogs have some qualities in common; but their instincts are somewhat limited, or not called forth. It is only in its domesticated state that we find the various qualities which render the dog so useful a servant to man. Wild dogs are, in comparison with domesticated dogs, what savages (for wherever they have been found, savages bear some resemblance to each other, and are engaged in similar pursuits) are to civilized society. It

is inconceivable that the mastiff, terrier, cur, and numberless other dogs besides the pointer, could ever have been in a wild state, as they do not seem to be possessed of any instincts or faculties that could enable them to subsist unattached to the human race.

The long received opinion that the lion, as the king of brutes, is possessed of the highest degree of physical courage, is exploded. The palm of courage is now awarded to the dog. Courage, however, in the common acceptation of the term, is not a characteristic trait of the pointer or setter, which are, perhaps, except the cur, the least courageous of the canine race. The dog is the only brute animal that prefers the society of man to that of its own species; and no dog is more affectionate or faithful to man than the pointer or the setter.

England is not less famous for its horses than for its sporting dogs. Our grey-hounds, fox-hounds, and harriers are unequalled, and that they are so results from the care that has been taken to keep each species distinct. All our pointers are, in some degree, of Spanish extraction; and such of them as have most Spanish blood in their veins are unquestionably the best. The Spanish pointer is about twenty-one inches in height. He has a large head, is heavily made, broad-chested, stout-limbed, with a large dew-lap; his eyes are full, and widely apart, and his nose is broad; his tail is straight, short, and thick, and his ears large, pendulous, and fine; he should have a round, and not a flat foot. When pointing, he stands on three legs, one of the fore legs being raised, and his face and tail are in a line with his back. This is his invariable position when he comes gradually upon the scent; but whenever, by running with the wind, or from any other circumstance, he comes suddenly upon game, he will stand in the most picturesque and sometimes indeed grotesque attitude, frequently with his body almost doubled. A pointer may be sometimes seen standing with all four feet collected together on the surface of a small stone on a wall when the birds are almost under him. A very old dog of this description, when fatigued with ranging and too enfeebled to maintain his point long in the natural position, will sit down on his haunches with his face towards the game, yet ever and anon turning his head wistfully to see whether the gun be approaching. Notwithstanding however the vaunted excellence of British pointers, the generality of them are not such as they ought to be. It is much to be lamented that the same care is not taken in the breeding of pointers and setters as of hounds. Scarcely two pointers are to be seen so much alike that a naturalist would pronounce them to belong to the same class of dogs, inasmuch as they are dissimilar in size, weight, and appearance. There are, properly speaking, but two classes, the Spaniard and the mongrel. Nearly all the pointers we see are, in fact, mongrels, although each may have more or less of the original Spanish blood. Such, however, is the force of nature that a dog having in him very little of the blood of the pointer may prove a very serviceable dog to the shooter. We frequently meet with very good dogs, dogs deemed by their owners first-rate, which bear little resemblance, in point of shape and appearance, to the true pointer. Some have the sharp nose of the fox, others the snubbed nose of the bull-dog; some are slenderly formed; some long-legged, others short-legged; some heavy-bodied, others light; in short, there is every possible diversity.

The attempt to lay down a written rule whereby to distinguish between a good and an indifferent pointer would be futile. How much of the blood of the pointer a dog has in him will be read in his countenance, rather than inferred from his general shape and appearance. There is an indescribable something in the countenance of a thorough-bred or nearly thorough-bred pointer, which a little habit of observation will enable the sportsman to detect with tolerable accuracy, so that he may judge of the capabilities of a dog, as a physiognomist will read at a glance a person's disposition and ability in his countenance. It is to the disciplined eye only that these all but infallible tokens are discernible.

The instinct of pointing, we apprehend, is an inextinguishable and indestructible principle in the blood of the pointer, which, however it may be mingled with inferior blood, will always, in some degree, manifest itself; and on this ground we build our theory that the further any dog is removed from the original Spanish pointer the worse the dog is; and, consequently, that all attempts to cross the pointer with any other blood must necessarily deteriorate the breed. The grey-hound is seldom or never crossed to give him additional fleetness, nor the hound to improve his nose; why then should the pointer be crossed with dogs which, in so far as the sports of the field are concerned, scarcely inherit one quality in common with him? Attempts, however, are constantly made to improve the pointer by a cross with the blood-hound, fox-hound, Newfoundland dog, or mastiff, sometimes with a view of improving his appearance, and bringing him to some fancied standard of perfection; but in reality inducing a deformity. One of these imaginary standards of perfection is, that to one part thorough Spanish blood, the pointer should have in him an eighth of the fox-hound, and a sixteenth of the blood-hound. A cross will sometimes produce dogs which are, to some eyes, the *beau idéal* of beauty; but however handsome such dogs may be, they will necessarily possess some quality not belonging to the pointer; for instance, a cross with the hound gives the propensity to trace hares, if not to give tongue. A thorough-bred pointer carries his head well up when ranging; he will not give tongue, nor has he much desire to chase footed game. The hound pointer may be sometimes detected by his coarse ears, by his tail being curled upwards, and being carried high, or by his rough coat. An occasional cross with the mastiff or Newfoundland dog is said to increase the fineness of nose, but it is converting the pointer into a mere retriever. The pointer, as we before observed, is naturally cowardly, as compared with other dogs; therefore, whenever a pointer is ferocious or courageous, it may be inferred that the blood of some of the larger or stronger dogs runs in his veins. Another and the main source of the unsightliness of sporting dogs is the allowing an indiscriminate intercourse between pointers and setters. Good dogs may be thus obtained sometimes, but they are invariably misshapen; they have generally the head and brush tail of the setter, with the body of the pointer, and their coats are not sleek, and instead of standing at their point, they will crouch. When the sire is nearly thorough-bred, dogs of a superior description, but certainly not the best dogs, are sometimes produced by the Newfoundland or some other bitch not strictly a pointer. We are not willing to allow that the pointer is improved in any quality that renders him valuable to the sportsman, by a cross with the hound or any other sort of dog; though we cannot deny that the setter is materially improved in appearance by a cross with the Newfoundland dog, but what it gains in appearance, it loses in other respects.

Breeding mongrels, especially crossing with hounds, has given the gamekeepers and dog-breakers an infinity of trouble which might have been avoided by keeping the blood pure. The best pointer is the offspring of a pointer-bitch by a pointer-dog; such a dog is nearly broken by nature. The Spanish pointer seldom requires the whip; the hound pointer has never enough of it. One of the main sources of the sportsman's pleasure is to see the dogs point well. A deal is said about this and that dog being remarkably fine-looking; the only time to appreciate the beauty of a dog is when he is ranging and pointing; then let the sportsman compare the real pointer with the spurious one.

Courage[1] is another attribute of the pointer; a high-couraged pointer will continue ranging till he has not, as the saying is, a leg to stand upon, even though he should not meet with game.

The usual price paid for breaking a dog is from two to five guineas. The breaker runs the dogs in spring, and again in August, but without the gun; this, followed by a week's shooting in September, renders their education complete, but unless they have sufficient practice afterwards, the initiatory lessons will soon be forgotten. Young dogs will learn more in six successive days, than in six weeks, if taken out only at the rate of one day per week. The dog-breaker should be a person of discriminating judgment, and possessed of a good temper; and the art of winning, not by brute force, but by judicious management, an ascendancy over the dogs entrusted to his care. Breaking dogs, when many young ones are taken out together, is a very difficult and tiresome task. One or more old staunch dogs are usually allowed to accompany the young ones, to induce them to back. A dog pointing is conscious of the presence of game. A dog which backs another is not aware of the proximity of game at the time, otherwise than by inference. Whenever the dog in advance points, it is the breaker's duty to make all the rest that acknowledge the scent to point, and all that do not acknowledge the scent should be shown the dog pointing, and be made to back, which is done by the breaker holding up his hand, and crying, in an undertone, "to-ho." The dogs are taught to fall the moment the game rises, or on the report of a gun. They should come in on hearing their names or the whistle, and should never be allowed to pass a fence before their master. The efficiency of the training which a dog has received may be conjectured from his manner of quartering his ground. He should range at a short distance in advance of the shooter, alternately to the right and left; and this should be taught rather by the motion of the hand, or by the person turning at the same time, than by the voice. An offence should never be overlooked if the dog seems conscious of it; but the breaker's knowledge of the disposition of the dog should be his guide in regulating the punishment. Some dogs will not bear the whip, or even rating, but require encouragement and good words on all occasions. When it is necessary to flog a headstrong dog, it should be done severely, the blows falling on the side, from the shoulder to the flank. The lash or switch with which the dog is punished, should not be made to lap round the body, nor should the dog be kicked. When the dog is in fault, and is very eager in pursuing the sport, no punishment that will be longer remembered can be administered than making him crouch five or ten minutes. In common with other sports, shooting has a vocabulary of its own. We have elsewhere given a list of some of the words made use of by the breakers and sportsmen to the dogs, which we transcribe, many of them being anything but euphonious to the unaccustomed ear. "*To-ho* spoken in an under-tone, when the dog catches the first notice of the scent of game, is a warning to him that he is close upon game, and is a direction to him to stand. There is no necessity for using it to a dog that knows his business. Spoken in a peremptory manner, it is used to make the dog crouch when he has flushed game, or been otherwise in fault. *Down-charge*, or *down-to-charge*, is used to make the dog, whether it be near or at a distance, to crouch when the shooter charges, that the dog may not flush game when the shooter is unprepared. When the dog will not crouch, but continues beating, the leg-strap may be put on. *Take-heed*, and *be-careful*, are used when the dog ranges over ground where it is customary to find birds. *Take-heed*, is a word of correction: *be-careful*, of encouragement. The former is used by way of caution or notice to prevent the dog flushing birds by running over the ground too fast; the latter is likewise a caution, but used when the dog beats slowly or carelessly. *'Ware fence* is used to prevent dogs passing a fence before the gun. The dog should never, on any account, leave an enclosure until its master has left it. *'Ware*, or *beware*, is used to rate a dog for giving chase to a hare, birds, or cattle. *Seek*, is a direction to the dog to look for a dead or wounded bird, hare, or rabbit. *Dead* is used to make a dog relinquish his hold of dead or wounded game. The retriever drops it. The dog should retain possession of wounded game until it is taken from him; for should he suffer a bird that is only slightly wounded to disengage itself from his grasp, another *seek* becomes necessary, and the bird is either lost, or despoiled of its plumage by the catching and recatching. Some dogs are taught to bring the game to their master. The breaker should teach the dog, in all cases, to retain game until it is taken from him, or until he hear the word *dead*, when he should instantly drop it. The dog should be punished if he break the skin with his teeth."[2]

The most useful dogs are those which are best broken. As much depends on the breaking as the breed of a dog. Dogs should be constantly shot over during the season by a successful shot, and exercised during the shooting recess by some person who understands well the management of them, otherwise they will fall off in value. The half-bred ones will become unmanageable, and even the thorough-bred ones will acquire disorderly habits.

We look upon the setter to be an inferior kind of pointer, perhaps originally a cross between the pointer and the spaniel, or some such dog as the Newfoundland, for it has some qualities in common with each. The pointer has the finer nose, and is more staunch than the setter. Pointers are averse to water; setters delight in it; hence the advantage of the latter on marshes to the snipe shooter. No pointer should be made to hunt alone; that is the duty of a retriever. The setter will face briars and gorse bushes better than the pointer, which is in this respect a tender dog; and for this reason the setter is preferred to the pointer for cover shooting. Besides, his being not so staunch as the pointer, is an additional advantage in heavy covers. The sportsman who shoots over well-broken pointers, frequently passes game in the woods, while the pointers, which are not seen by him, are at their point; the setter, being more impatient to run in, affords the shooter many shots in cover, which the over-staunch pointer would not. The pointer is always to be preferred on open grounds. In hot weather the pointer will endure more fatigue than the setter.

The Spaniel.

The Spaniel or Cock Dog. The spaniel is the best dog for beating covers, provided he can be kept near the gun. He is generally expected to give tongue when game is flushed; some spaniels will give notice of game before it springs, which may be very well where wood-cocks only are expected to be found. Wood-cock and pheasant shooting are usually combined; where covers are limited, pheasant shooting cannot be conducted too quietly. Wherever the underwood is so thick that the shooter cannot keep his eye on the dogs, spaniels are to be preferred to pointers or setters, whatever species of game the shooter may be in pursuit of. If spaniels cannot be kept near the shooter, they are the worst dogs he can employ.

Retrievers.

Retrievers. The business of the retriever is to find lost birds. Newfoundland dogs are the best for this purpose. They should have a remarkably fine sense of smelling, or they will be of little use in tracing a wounded pheasant, or other game, through a thick cover, where many birds

[1] Courage, as applied to the pointer, signifies a willingness and determination to range; it is an union of the qualities known by the terms mettle and bottom, as applied to horses.

[2] The Oakleigh Shooting Code. London, Ridgways. Third edition.

Shooting. have been running about. A good retriever will follow the bird on whose track he is first put, as a blood-hound will that of a human being or deer. They should be taught to hunt and retrieve, or in many instances their finding a wounded bird would be of no advantage to the shooter.

We proceed next to give some description of the art of shooting game, in the course of which we shall endeavour to confine our obseravtions to such of the habits and peculiarities of the birds and quadrupeds under notice, as it is essential the shooter should be made acquainted with, and at the same time to detail the means of proceeding most likely to ensure success in the pursuit of them.

The Partridge. *The Partridge.* We commence with the partridge, as shooting that bird is generally the young shooter's first lesson at game, although in the order of the season grouse shooting takes precedence. Partridge shooting commences on the first of September, and ends on the first of February.

The habits of the partridge at different seasons should be closely understood and studied by the shooter, that he may be able, with a tolerable degree of certainty, to find them at any given time. In the early part of the season, they will be found, just before sunrise, running to a brook, a spring, or marsh, to drink; from which place they almost immediately fly to some field where they can find abundance of insects, or else to the nearest corn-field or stubble-field, where they will remain, according to the state of the weather, or other circumstances, until nine or ten o'clock, when they go to bask. The basking place is commonly on a sandy bank-side facing the sun, where the whole covey sits huddled together for several hours. About four or five o'clock, they return to the stubbles to feed, and about six or seven they go to their jucking-place, a place of rest for the night, which is mostly in aftermath, or in a rough pasture field, where they remain huddled together until morning. Such are their habits during the early part of the season; but their times of feeding and basking varies much with the length of the days. While the corn is standing, unless the weather be very fine or very wet, partridges will often remain in it all day; when fine, they bask on the outskirts; when wet, they run to some bare place in a sheltered situation, where they will be found crowded together as if basking, for they seldom remain long in corn or grass when it is wet. Birds lie best on a hot day. They are wildest on a damp or boisterous day.

The usual way of proceeding in search of partridges in September is, to try the stubbles first, and next the potato and turnip field. Birds frequently bask amongst potatoes or turnips, especially when those fields are contiguous to a stubble-field. The best partridge shooting is obtained in potato and turnip fields. It not unfrequently happens that potatoes or turnips are grown on a headland in a corn field; in that case the headland will be a favourite resort of birds.

After the middle of October it is ever uncertain where birds will be found; the stubbles having been pretty well gleaned, birds do not remain in them so long as in the early part of the season. When disturbed at this time they will sometimes take shelter in woods, when they are flushed one by one. The best shots that can be obtained at partridges in winter, are when the birds are driven into woods.

When a covey separates, the shooter will generally be able to kill many birds, but late in the season it is seldom that the covey can be broken. In November and December the shooter must not expect to have his birds pointed, but must remain content with firing at long distances. We transcribe the following observations on dispersing coveys: "In the early part of the season, when the shooter *breaks* a covey, he should proceed without loss of time in search of the dispersed birds, for the parent birds begin to call almost immediately on their alighting, the young ones answer, and in less than half an hour, if not prevented by the presence of the shooter and his dogs, the whole covey will be re-assembled, probably in security in some snug corner, where the shooter least thinks of looking for them. As the season advances birds are longer in re-assembling after being dispersed. It is necessary to beat very closely for dispersed birds, as they do not stir for some time after alighting, on which account dogs cannot wind them until nearly upon them, especially as they resort to the roughest places when dispersed. Birds dispersed afford the primest sport. The pointing is often beautiful, the bird being generally in a patch of rushes, or tuft of grass or fern, and close to the dog. When a bird has been running about some time, dogs easily come upon the scent of it; but when it has not stirred since alighting, and has perhaps crept into a drain, or run into a hedge-bottom, or the sedgy side of a ditch, no dog can wind it until close upon it, and the very best dogs will sometimes flush a single bird. In the month of October, and afterwards, the shooter will find it difficult to approach within gun-shot of a covey, nor can he disperse them, except by firing at them when he chances to come close upon them. Should he then be so fortunate as to disperse a covey, he may follow them leisurly, for they will then lie several hours in their lurking place, which is chosen with much tact, as a patch of rushes, a gorse bush, a holly bush, the bottom of a double bank fence, or a coppice or wood. The length of time that will transpire before a dispersed covey will re-assemble, depends, too, on the time of the day, and state of the weather. In hot weather, they will lie still for several hours. A covey dispersed early in the morning, or late at night, will soon re-assemble. A covey dispersed between the hours of ten and two, will be some time in re-assembling. A covey found in the morning in a stubble field, and dispersed, will next assemble near the basking place. A covey dispersed after two o'clock, will next assemble in the stubble field at feeding time. A covey disturbed and dispersed late in the afternoon, or evening, will next re-assemble near the jucking-place. A covey being disturbed on or near to their jucking-place, will seek a fresh one, perhaps about two fields distant; and if often disturbed at night on their jucking-place, they will seek another stubble field to feed in, and change their quarters altogether. The most certain method of driving partridges from a farm, is to disturb them night after night at their jucking-place, which is usually in a meadow, adjoining to a corn field, where the aftermath is suffered to grow, or in a field rough with rushes, fern, thistles, or heather. When a covey is dispersed on a dry hot day, it is necessary to search much longer, and beat closer, for the dispersed birds, than when the day is cool, and the ground moist. A dog should be only slightly rated for flushing a bird on a hot day."[1]

The number of birds in a covey varies much, perhaps the average may be from ten to fifteen. In some years, when the coveys are large after a fine hatching season, it is not uncommon to see upwards of twenty birds in a covey; and sometimes after a wet season, ten birds may be deemed a fair covey. Birds are always most numerous after a dry summer. When there are thunder-storms about midsummer, great numbers of young birds are drowned. The young birds have many enemies besides the elements, such as cats, young dogs, hawks, foxes, and vermin of different descriptions. When the eggs are taken, or the young birds destroyed soon after leaving the shell, there will be a second hatch. Sportsmen often meet with second hatches in September, when the old birds rise screaming, and generally alight within fifty yards, as if to decoy the dog or sportsman from the brood. In that case the fair sportsman will not fire at the old birds, but will call in his dogs and leave

[1] The Oakleigh Shooting Code.

Shooting. the ground. At such times he should look well after the young dogs, as, when they see the birds running, they are apt to snap up such of them as cannot get out of the way. The very young birds are called cheepers, from their uttering a scream as they rise. Full grown birds never scream as they rise, except when the young ones are helpless, nor do young birds after they are large enough for the table.

The cock partridge is distinguished from the hen by the brown feathers which form a crescent, or horse-shoe, as it is sometimes called, on the breast.

The pointer is decidedly the best dog for partridge shooting. Markers and retrievers will be of much service to the shooter whose object is to kill a great quantity of birds, rather than to enjoy the sport.

The Pheasant.

The Pheasant. The pheasant is the most splendidly arrayed of undomesticated British birds. It is deservedly in high request amongst sportsmen, and it claims the first attention of the game-preserver. The numberless plantations and coppices which are everywhere springing up, afford yearly additional shelter. The pheasant prefers woods of oak and beech, that it may feed on the acorns and mast. The fine old woods consisting of these trees may perhaps be diminishing, but they are more than replaced by plantations of larch or other quick-growing trees. Pheasants generally choose the larch or spruce-fir to roost in, and plantations of this description, if near corn, turnip, or potato fields, afford sufficient cover for them. They are, in many counties, allowed to become so numerous, as to do serious mischief to the labours of husbandry.

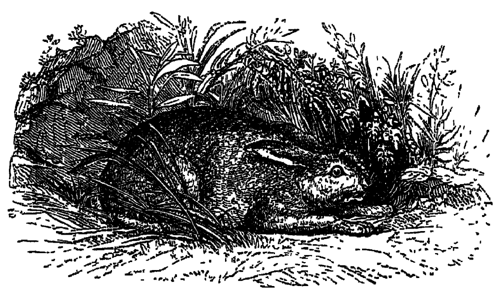
During August and the early part of September, pheasants will remain nearly all day in potato and corn fields. Pheasant shooting commences on the first of October, and ends on the first of February. In October, the shooter usually meets with them in potato and turnip fields, deep stubbles and rushy fields near covers, but especially under hedges, holly trees, or in coppices near to covers. In such situations they will suffer the shooter to approach very near to them; they are generally pointed by the dogs, and, a large majority of them being young birds, are easily killed; but in that month the trees are so full of foliage, and the briars and brushwood are so annoying, that it is seldom possible to beat the woods with any degree of pleasure, for not only are they almost impervious, but the pheasants are seldom seen when they rise, or if seen and shot, are very frequently lost, or not found without considerable loss of time. It is in November, when the birds have moulted, and when the leaves have fallen, and the brambles are decaying, and the paths in the woods are beginning to be worn, that pheasant shooting is in perfection. The birds are then full grown, and also better fed than later in the season.

It is not usual to kill the hens wherever pheasants are strictly preserved; but it is necessary to kill the cocks where they are too numerous. Pheasants do not pair, and as it is better that there should be but few cocks, the shooter's being able to single them out and kill them, tends ultimately to the increase, and not to the diminution of the number of birds in cover. At the commencement of the season the shooter will frequently flush a nide of pheasants, but in the after part of the season he will oftener find solitary birds. Pheasants will occasionally wander a considerable distance from the wood to which they belong, especially during winter, in search of food, and in wet and foggy weather. The pheasant basks at the root of a tree, or under a hedge, in the same manner as the partridge, but each bird nestles itself separately. Pheasants approach nearer to domesticated poultry than any other kind of game. Pheasant shooting is most destructive where the plantations are not more than forty yards wide; when the shooters remain on the outside, while the beaters and dogs rouse the game within. The pheasant shooter does not expect set shots; his object is to cause the birds to rise as near to him as he can. Having no notice of them, he should ever be on the alert for snap shots. Shooting.

A short double-barrelled fowling-piece, of wide bore, is preferable to a long one. The shot should be large, and it is well to use plenty of it. A close-shooting gun is not to be recommended to the pheasant shooter. The birds should rarely be fired at in cover when more than thirty yards from the gun, or they will escape wounded in the underwood. They are generally brought down within twenty yards from the gun. Pheasants are most plentiful in Norfolk, Suffolk, and some of the adjoining counties. There are some in every county in England, and in most of the counties in Scotland. A perfect bird has a white annular space on the neck, but this mark is often wanting.

The pheasant makes a considerable noise when rising, sufficiently so to unnerve the young and over-anxious shooter. The bird should be allowed to rise clear of the bushes, and to its full height, before the shooter fires at it, or it is probable he will fire too low; and again, the short fan-like feathers on either side of the tail appear, as the bird is rising, to be part of the bird, making the body seem longer and larger than it really is; and this circumstance, together with the rapidity of the movement of the bird when rising, is the cause of the shooter firing too low. The aim should always be at the head, unless the bird is crossing, and then well forward. Firing too soon, lest the bird should be out of reach, is a very common error, particularly with young sportsmen.

For reasons which we have before adverted to, the setter, or cock-dog, is to be preferred to the pointer for pheasant shooting. Pheasants will sometimes lie very close, so that it is with great difficulty they can be made to rise; therefore dogs that will dash into the thicket are most useful. Beaters and retrievers are indispensable to the pheasant shooter.



The Hare. The shooter seldom beats purposely for hares. Birds are mainly the object of his pursuit. He chooses his ground, and regulates the charge of his fowling-piece with reference to the birds he expects to meet with. Hares are started casually, as it were, while he is in quest of birds. Leveret shooting often commences with grouse shooting, on the 12th of August, though it is not uncommon, nor is it considered unfair, to kill leverets during the summer months. Hares are not in season until September. The shooter should desist from killing them in February, but he is not prevented from killing them at any season, by any legislative enactment, if he have taken out a game certificate. It is the prescriptive law of the chase, held sacred by sportsmen, that prevents him. The Hare.

In September, hares lie close, in hedges, in woods, or in growing corn, and are somewhat difficult to be found. They are always exceedingly restless in wild windy weather, and they are then found, particularly after a storm, in pasture and stubble fields. Dogs will frequently point them. In November and December, they are often seen on their seats, or forms, as they are sometimes called, by the shooter keeping his eyes on the ground about eight or ten

yards from him. It is usual, however, to allow the hare a chance of escape, by starting her before firing at her; it is accounted unsportsmanlike to kill puss on her seat. In January, hares are found on fallows, marshes, or in pastures, or in or near to gardens.

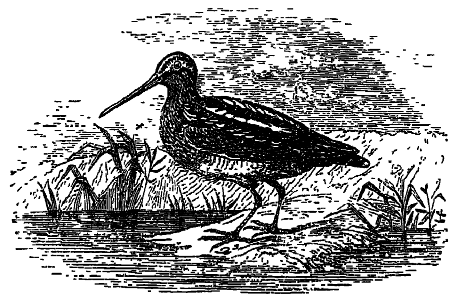
The shooter should fire well forward at a hare, and not too high. He should not fire at a long distance, as the probability of his wounding her would be greater than that of killing her. If running direct from him, a hare should not be fired at, unless within twenty-five paces from the gun, or she will often run off, though severely wounded in the hind-quarters. A beater will render essential service to the shooter in quest of hares, in the early part of the season; the beater walks on the contrary side of the hedge to the shooter, and a few yards in advance, so that the hare, to avoid the former, jumps out on the side of the latter. When beating hedges in the vicinity of covers, the shooter should take care to place himself on that side nearest the covers. When shooting at the edge of a cover, if the hare fired at is not quite deprived of the use of her legs, it would be advisable to fire again immediately, for should she crawl through the hedge, the chances would be against her being retrieved.

The Rabbit.

The Rabbit. Rabbits are alternately deemed game and vermin. They are sometimes shot for sport, sometimes for profit, and sometimes on account of the mischief they do to trees and other vegetation. They sometimes seat themselves all day long, after the manner of hares, but more frequently they remain the greater portion of the day in their burrows. As they are shy of approach, and run under ground on the least alarm, the shooter frequently finds it expedient to hide himself at a little distance from the warren, and wait until they come out. Where rabbits are numerous, as in most warrens they are, some will be continually playing within a few yards of the entrance of the burrows, and when found in such situations (for they are very tenacious of life), they should be struck very hard, or they will contrive to crawl, or rather roll into their earths, before the shooter can pick them up. It is astonishing what efforts they will make to escape, though three legs be broken, when near to the entrance of a burrow. It is of little use firing at them when they are more than twenty paces distant from the gun. Rabbits afford more what are termed snap-shots than any other game, as they are mostly found in or near to plantations, or amongst brambles, hollies, gorse or deep fern, in places of extreme difficulty. It requires a quick eye and steady hand to stop a rabbit running across furrows, or over uneven ground. Rabbits for sale, or when destroyed as vermin, are oftener taken by means of ferrets and nets, than killed by the gun. A short gun, having a large bore, and charged heavily with powder, and a small quantity of No. 4 shot, is best for rabbit shooting. It would be well that a companion or servant should lead a dog in a slip—a terrier is as good as any—to be loosed the moment the gun is fired; thus many a rabbit will be secured, that would else have run into its hole. When earthed, it frequently happens that a rabbit is not able to crawl more than three or four feet deep from the surface, where it dies, when it may be recovered by thrusting a bramble down the hole, and twisting it so as to entangle the rabbit; but a more certain method, if the rabbit is not too far down, is to screw the worm of the ramrod into its body, and so drag it out, as a cartridge is drawn from the barrel of a gun The best time for rabbit shooting is in the evening, or during sunshine just after a shower, when great numbers of the rabbits venture from their burrows.

The Bustard.

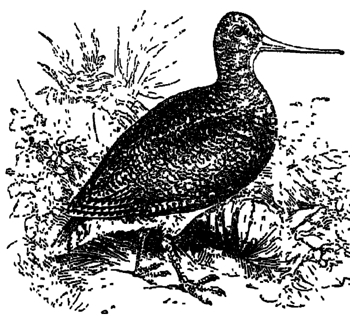
The Bustard. The bustard is a rare but valuable acquisition to the game-bag. As it cannot be approached unless the shooter takes advantage of some adventitious circumstances, it is seldom an object of pursuit to the sportsman. Bustard shooting commences on the first of September, and ends on the first of March.



The Snipe

The Snipe. There are three kinds of snipes, viz. the solitary or double snipe, the full or whole snipe, and the jack or half snipe. The last is considered to be scarcely worth powder and shot; it is the full snipe which principally engages the shooter's attention. We have before given directions for shooting this bird. "The common or full snipe is a shy bird when in company, but when alone will allow the shooter to approach within a dozen paces of it before it springs. When it does spring, however, it moves with a velocity that defies the epithet *slow!* It is best to shoot as soon as possible. The shooter will bring down a snipe with much less difficulty at from fifteen to twenty paces than at any other distance. The aim is thus taken before the bird begins to make its cross flights, and before it has attained its full speed. The irregularity of its flight is of little consequence during the first and second twirling, before the bird is safely on the wing, since its flight is then comparatively tardy. But let the snipe fly ten yards from whence it sprang,—let it be, for instance, twenty-five paces distant from the gun, it is then at the top of its speed, and in the very midst of its sidelong, elliptical gyrations, and more than a match for the majority of shooters, especially if the day be windy. A snipe killed at fifteen or twenty paces distance, with No. 7 shot, the aim being true, will be struck by twenty or thirty pellets, but the chances are more than twenty to one against the aim being true. The snipe, when struck, is generally three or four inches from the centre of the cone which the shot forms as it flies, which is very different from being in the exact centre. A section of the body of a snipe does not present a surface as large as that of a penny-piece. If any person will fire at a target at fifteen yards distance, he will find that a snipe would not be cut to pieces even at that distance, unless it chanced to be precisely in the centre of the charge as thrown. When speaking of a snipe presenting no larger a surface as a mark than a penny-piece, we of course mean a snipe flying directly from the shooter. It would be imprudent to shoot at a snipe flying across at less than twenty-five paces distance, as it then presents more than double the surface of one going straight from the shooter. Thirty paces is the distance we should prefer for a cross or oblique shot. At thirty, or even at twenty-five yards, unless the barrel throws shot remarkably close, there are interstices in the charge as thrown, in which a snipe would escape untouched. Provided the flight of a snipe were equally steady at all distances, and that in every instance the shooter could choose

Shooting. his own distance, a snipe would have the least chance for its life at twenty yards. But there are two points to be attended to in determining the proper distance—the flight of the bird, and the manner in which the shot is thrown. In snipe-shooting the latter is subservient to the former. The few full snipes occasionally found on heathery and rush-clad hills, as well as in the enclosed grounds, lie much more dispersed than the gregarious birds of the marsh. Hence those found on the uplands are easy, and those on the fens difficult of approach. It is, however, the same description of bird that is found in both situations." When the shooter uses wire cartridges, which, by the bye, are not precisely calculated for snipe-shooting, it would be prudent to allow the bird to move to a considerable distance before firing. It is scarcely necessary to add, that the shot used for snipe-shooting should be very small. When several snipes rise together, they are styled a wisp.



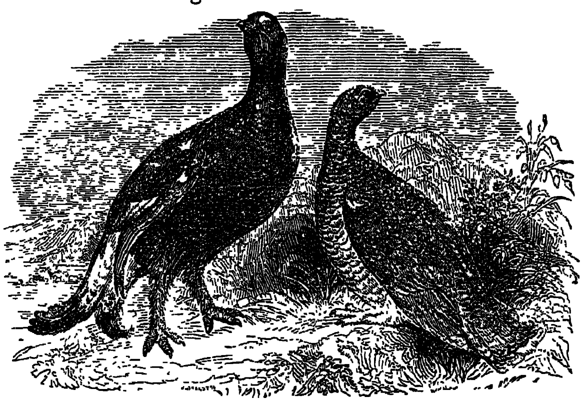
The Woodcock. *The Woodcock.* There is a proverb current among sportsmen, that to kill a woodcock is to perform a day's work, which doubtlessly originated in the circumstance of a woodcock being seldom found until a very large extent of wood has been closely beaten by both men and dogs. In the month of November, however, when woodcocks are most abundant, it would not be a difficult task, according to that standard of labour, to do the work of a week in a day, in any noted cover, for every cover frequented by woodcocks, (or cocks as they are called in the sportsman's nomenclature), acquires a notoriety which it seldom loses, since any wood well frequented with cocks one year, has generally a fair supply the next. But whether the same cocks that frequent a wood this year, return the next, with their offspring, or whether an entirely new set of occupants take possession, we leave the ornithologist to decide. A certain description of woods are seldom known to fail of woodcocks during the winter months; these woods or plantations are such as are swampy, or have a stream of water running through them, or woods abounding in springs, or where, from the nature of the ground, or want of draining, the top water encourages the growth of moss. The woodcock is rarely found where moss is not abundant. During a frost, cocks are found near fresh water springs; at other times, they are most commonly flushed in the open glades of the densest woods, or rather in those parts of the woods not choked up at the bottom with fern, rushes, or brambles, but where they can freely run about, and in those parts where willows, osiers, hazel-trees, or crate-wood is plentiful. In such places it will readily be ascertained whether there are cocks or not, by the borings in the moss or dead leaves, and by the droppings. Should the cock not be brought down, it will not fly far after being fired at; it should, when practicable, be marked down, as by this means several successive shots may be obtained at it when the gun is unsuccessful. It is seldom that the skilful shooter springs a cock which he does not eventually kill. The difficulty of woodcock shooting arises, for the most part, from the birds springing in the thickest part of woods, and contriving to wing their flight through the trees, in such a manner as to baffle the sportsman's aim. After being fired at in a wood, cocks will frequently alight amongst hedge-rows on the outskirts, especially under a hedge running close to and parallel with a water-course, when they are easily killed, as they will not rise until the shooter is close upon them; and their flight is not difficult to master when there are no trees to obstruct the aim. Woodcocks are found in October on moors, and in covers near the sea. About the last week in October they find their way to the inland covers, where they remain during the early part of the winter, and they are sometimes found there again in March. A sharp frost, or a dense fog, at the end of October or beginning of November, is usually the shooter's first intimation of the arrival of cocks; and if he is ambitious of the fame of killing them, he must fag hard during the month of November, or it is probable that his return for the season of the numbers bagged will not be satisfactory. November is unquestionably the best month for cock shooting. Shooting.

The Red Grouse. *The Red Grouse.* Grouse shooting commences on the 12th of August. We have already alluded to the vast extent of the northern moors. The number of birds killed on the opening day, on some parts, is very great. It is not uncommon for an experienced and skilful shooter, on the best moors, to bag fifty brace on the 12th of August. What may be termed a good day's sport, differs much on different moors. On well-preserved moors, the average may be from ten to twenty brace. On subscription moors, the shooter should not be dissatisfied if he has the opportunity of killing from three to five brace per day, during the first week of the season, though this would be deemed a low average for the Scottish moors. After the first week, few sportsmen, except those residing in the immediate neighbourhood of the hills, ever trouble the moor game.

Many causes contribute to the popularity of grouse shooting, amongst which may be enumerated the following. It commences during the parliamentary recess, and long vacation—the legislator's, lawyer's, and collegian's holiday; and it is no wonder that after being cooped up all summer, these, or any other classes of society, should seek relaxation in the sports of the field. August is the season when every one, from the peer to the shopkeeper, who can afford the indulgence, either rusticates or travels. In that month the casual tourist, the laker, and the angler, are often in the North, when the temptation to draw a trigger is irresistible. Grouse shooting fascinates the young shooter more than any other kind of sport, inasmuch as the season commences with it. The opening day is looked forward to with pleasing anticipation all summer. To the more practised sportsman, grouse shooting recommends itself by reason of the superiority of the sport over every other kind of shooting. Partridge shooting is a comparatively tame and uninteresting amusement. Partridge shooting, as compared with grouse shooting, may be termed domestic sporting. To the majority of sportsmen, a grouse shooting excursion only occurs once a year, and then lasts only a few days. The sport therefore seldom palls; but during the long interval of time that elapses between each, the coming season is ever looked forward to with additional interest. Grouse shooting is, in many respects, a source of greater expenditure to the sportsman: it requires more preparation, and is attended with more difficulties than any other kind of shooting; but these circumstances, whatever some people may imagine to the contrary, so far from detracting from, serve to enhance the enjoyment of the sport; for we are apt to estimate whatever is obtained with difficulty and expense at a higher rate than what is gratuitously afforded us. To the lover of the romantic and the picturesque, grouse shooting has attractions of the highest order. It is the sport of all others peculiarly British: the partridge, the pheasant, the black-cock, are widely dispersed over other countries; but the red grouse is only found in the British Islands.

Shooting.

There are seldom more than a dozen grouse in a brood; rarely indeed so many. Towards the end of autumn, the broods congregate together, and are seldom seen afterwards until pairing time in January or February, except in great numbers. Broods thus associated are termed packs. When it happens that the birds are well grown at the opening of the season, and much fired at in August, they will pack before September. When there is fine weather in August, grouse, until the broods are packed, will suffer the shooter to approach very near to them before they rise. In wet or windy weather they are wild. Very few grouse are killed by the sportsman after August; they are then scarcely approachable. Grouse delight in tall young heather, when there are plenty of bare places or pads or tracks. Hares also, and cocks, and we may perhaps add, pheasants, in their respective covers, delight in those parts where they can run about freely. The brow of a hill is more likely ground than either extreme heights or valleys, or flats. Solitary birds lie better than broods. When birds are wild, the shooter should follow an individual rather than a brood. It is well understood by sportsmen, that the fewer birds there are in a brood, nide, or covey, the better will they lie. Grouse bask on the sunny hill-side, oftentimes under a rock, or in a stone pit, during the middle of the day, at which time the task of ranging for them is toilsome in the extreme. Grouse shooters should be accompanied by a guide and markkers. The former is indispensable to a person not intimately acquainted with every turn and knoll, during the mist that nine mornings out of ten envelopes the hills in August. It is inconceivable how completely bewildered a person who fancies he is acquainted with every inch of ground may be when surrounded by the haze. Neither sun, moon, nor stars are visible; nor is there a fence, road, or building to direct him. A stone pit, or mountain rill, are often the only objects that present themselves, except the interminable heather. The distant hills that would else be his guides, are shut out from his view, which does not extend beyond the range of his fowling-piece. At such times it requires no ordinary precaution to prevent losing young dogs, which can scarcely be prevented running off when a gun is fired in the distance. During the continuance of the mist, which generally disappears about eight o'clock, markers can be of but little use, except that they may be employed in carrying a basket, extra guns and shot, or leading dogs, of which it is well to have a change. No dog can range two days successively for grouse. Pointers, for reasons we have before given, are preferable to setters, or any other kind of dogs, for grouse shooting. Grouse shooters should separate and range singly; they should have no noisy attendants; nor any dogs that require rating. The sport cannot be carried on too quietly. If the shooter throws off before eight o'clock, which it is not prudent to do unless there are many guns on the moors or foul weather is expected in the afternoon, he should run only one dog as long as the heather is wet, afterwards two, and in the afternoon three dogs. In wet weather one dog is quite sufficient. If hot weather, we advise rest from eleven to two. If the shooter have not exhausted himself during the middle of the day he will best fill his bag in the afternoon; he may not, indeed, then find so many, but those he does find will be dispersed birds that will almost lie to be trodden on. An old shooter thus on a dry afternoon following a wet morning will sometimes load himself or his attendant, after the less experienced have left the moor disgusted, with scarcely a bird in their possession. Shooters are generally recommended to carry as heavy a gun as they can conveniently manage on the moors. It should be borne in mind that the heaviest gun will do most execution; but none except those accustomed to such exercise, can carry a heavy gun with comfort all day long, exposed to an autumnal sun. We would therefore not recommend barrels more than thirty inches long, nor of a larger guage than sixteen, on account of the excessive heat of the weather at this season. As the sportsman, in grouse shooting, has ever an opportunity of choosing his own distance when birds rise near to him, he will be more certain of killing if he let the birds fly twenty-five yards from him before he fires the first barrel, when, if he have both barrels cocked, he will have ample time to throw in the reserve barrel while the birds are within reasonable distance. In nothing is the superiority of the detonating over the flint lock more apparent than in its allowing the shooter to fire the second so soon after the first barrel. We suspect that the habit of taking the gun from the shoulder after the first barrel was fired, originated in the necessity of waiting until the smoke from the pan was blown away, which nuisance no longer exists. A person who is a decidedly bad shot should not use the cartridge in the first barrel, as the loose charge gives a larger circle at a short distance, and consequently increases the chance of killing.



The Blackcock.

The Blackcock. Black game shooting commences on the 20th of August, and ends, with red grouse shooting, on the 10th of December. Black game frequent moors covered with heather, but they are as often found in rushy fields, or even in stubbles adjoining to moors. They are not met with at any great altitude, but confine themselves chiefly to the lower hills, or the base of the loftier mountains. They are seldom found, except where there are plantations or forests of fir trees. Black game do not frequent the central parts of large wastes so much as those parts bordering on inclosed lands. Red grouse recede where civilization progresses; and they are consequently in a fair way, at no very distant period, of being banished from England. As a vast extent of heath-land is not requisite for black game, there is no room to fear their extinction for some centuries to come. Although not so numerous as red grouse, they are more widely scattered over England. Even in the south of England there is cover congenial to them. Should both black and red game become extinct in England, the hills of Scotland will long afford shelter to each. With the exception of the pheasant, black game is the only species of game not yearly diminishing in number in Britain. A full-grown blackcock weighs the same as a fine pheasant cock, about three pounds and a half. The female, which is called the grey-hen, and ought never to be fired at, is much smaller. Black game shooting on moors resembles red grouse shooting, and in the woods, pheasant shooting. The black cock is a magnificent bird, and an old one is ever deemed a valuable addition to the contents of the game bag. Black game have increased very considerably in England during the last few years, still they are much more abundant in Scotland. Sweden is perhaps the country best suited to them.

The Capercailzie.

The Capercailzie. Similar to the blackcock, in many respects, is the capercailzie, or cock of the wood, once the native, and now the denizen of the Highland forests. The

Shooting. capercailzie cock weighs sixteen pounds. Speaking of this bird, as it exists in Sweden, Mr. Lloyd says,[1] "The favourite haunts of the capercali are extensive fir woods; in coppices or small cover he is seldom or never found. The principal food of the capercali, when in a state of nature, consists of the leaves of the Scotch fir; he very rarely, however, feeds upon those of the spruces; he also eats juniper berries, cranberries, blaeberries, and other berries common to the northern forests; and occasionally also, in the winter time, the buds of the birch, &c. The young capercali feed principally at first on ants, worms, insects, &c." It was the felling of the timber, aided, perhaps, by the cross-bow, which is not ill-adapted to the purpose, that exterminated this primeval habitant of the old Caledonian forests. Some years since an attempt was made to re-introduce this bird to its ancient haunts in Scotland, but without success. "It is a pity," continues Mr. Lloyd, "that attempts are not made once more to introduce the capercali into the United Kingdom, for, if the experiment was undertaken with judgment, it would most probably be attended with success; the climate, soil, &c. in Scotland, at least, not being very disimilar, in many respects, to the south of Sweden. In Scotland, besides, independently of the natural forests, there are now considerable tracks of land planted with pines, from which trees, when the ground is covered with snow, those birds obtain nearly the whole of their sustenance." Since this was written, several brace of these birds have been sent over from Sweden; and on the estates of the Marquis of Breadalbane the experiment of localising them is in course of trial. We believe they were procured by Mr. Lloyd himself, and under his auspices, from his knowledge of the habits of the bird, we doubt not that the cock of the wood will become permanently established in the Highlands. It may be inferred that the same description of country (the heaths and forests being on a more extended scale,) which suits the blackcock, would likewise suit the capercailzie, since, as Mr. Lloyd observers, "the capercali occasionally breed with the black game; the produce of which partake of the leading characteristics of both species. Their size and colour, however, greatly depend upon whether the connexion was between the capercali cock and the grey hen, or *vice versâ*." In winter, the male birds congregate in packs after the manner of black game. In Sweden the capercailzie is usually shot with the rifle.

The Ptarmigan. *The Ptarmigan.* We have now for some time traversed, with the reader, the highest hills that are covered with heather, but there are heights beyond. The poet says,

> For Liberty! go seek
> Earth's highest rocks and ocean's deepest caves!
> Go where the eagle and the sea-snake dwell![2]

It may be admissible in poetry to give the highest cliffs to the king of birds, but zoology assigns a lower elevation to "the eagle's birth-place;" yes, you may ascend above the ăerie of the eagle, where the croak of the raven is never heard, where the fox and the weazel but seldom disturb the lonely habitants. You may ascend until, in the glowing language of Mr. Mudie,[3] "you begin at last to feel alone, severed entirely from the world of society, of life, and of growth, and committed to the solitude of the ancient hills and immeasurable sky. The snow lies thick on the side of the summit, and even peers over the top, defying the utmost efforts of solstitial heat. There is no plant under your feet, save lichen on the rock, apparently as hard and as strong as that to which it adheres—it can hardly be said to grow—and moss in some crevice, undistinguishable from the dull and cold mud into which the storms of many winters have abraded the granite. You are above the reach of all sound from the inhabited parts of the country." And what do we find in this region of snow? "A few mottled pebbles, or at least what appear to be such, each about twice the size of your hand, lie at some distance, where the decomposed rock, and the rudiments of what may be called the most elevated mountain vegetation, just begin to ruffle the surface. By and by a cloud shadows the sun, the air blows chill as November, and a few drops fall, freezing or melting in their descent, you cannot well tell which. The mottled pebbles begin to move; you throw a stone at them to shew that you can move pebbles as well as the mountain. The stone hits beyond them; they run toward your feet, as if claiming your protection; they are birds, ptarmigan, the uppermost tenants of the island, whom not even winds, which could uproot forests, and frosts, which could all but congeal mercury, can drive from these their mountain haunts. It has often been observed, that of all the human inhabitants of the earth, the mountaineer, be his mountain ever so barren, is the last to quit; and the same holds true of the mountain bird." The same writer traces the different elevations at which various species of game is found, beginning with the pheasant, as the tenant of the lowermost woods; the partridge, of the plain; the blackcock, of the confines of cultivation; the grouse, of the lesser hills and mountain-side; and the ptarmigan, of the snow-crowned summits. He also adds, "in these birds we trace a sort of resemblance to the general colour of the places which they inhabit, though we know not well the cause of the colour in either case. The ptarmigan is mossy rock in summer, hoar frost in autumn, and snow in winter. Grouse are brown heather, black game are peat-bank and shingle, and partridges are clods and withered stalks all the year round." And we will add, the capercailzie is the black branch of the pine. A similar scale is applicable to the seasons at which these birds are hatched. Although, taking each species individually, we find the earliest birds in the warmest country and on the richest land: collectively, the order is reversed; the higher their location, the earlier do they arrive at their full growth. The ptarmigan is ready for the table before the period at which it may be legally shot, the twelfth of August. Descending the hill, we find the red grouse not three parts grown at that period. A little lower, and the scarcely-fledged black-cock rises almost helpless, on the twentieth of August. Lower still, on the fertile plain, the young partridge does not assume his grey mantle and purple crescent until long after the first of September. And in the warm woods the pheasant does not don his panoply of gold until the fall of the leaf.

Few are the sportsmen who climb the granite cliffs, and wade the winter snows in which ptarmigan delight to bury themselves. A ramble there, is a journey of curiosity or observation, rather than a sporting excursion. It is a pilgrimage to the loftiest Highland altitudes. The fowling-piece becomes converted into the palmer's staff; and the sportsman merges in the adventurer, the enthusiast, the worshipper of Nature! (O. S. C.)

[1] Field Sports of the North of Europe.
[2] Rienzi, a Tragedy. (1st edition.) London.
[3] The Feathered Tribes of the British Islands. By Robert Mudie. 2d edition. 1835. London, Whittaker.

SHORE, JANE. See ENGLAND, § *Edward IV.*

SHOREHAM, NEW, a parliamentary borough, market-town and seaport of England, in the county of Sussex, at the mouth of the Adur, 6 miles W. of Brighton, and 56 S. by W. of London. It consists for the most part of irregular streets and quaint old houses, but has recently been much improved. Near its centre stands the market-house, supported on Doric pillars. The parish church is a fine specimen of Norman architecture, being the remains of a large cruciform edifice: the nave is in ruins, but the east front and tower are very fine. The town contains also places of worship for Independents and Wesleyan Methodists. Here, too, is a grammar school, called the College of St Nicholas; as well as various other schools, a museum, conservatory, and theatre. The custom-house is an elegant building in the Grecian style. The harbour is formed by the Adur, which has a bar at its mouth, having from 14 to 17 feet of water at high tides. An artificial channel has been cut for the river, with piers on each side. The chief business carried on in the town is ship-building. Many people are also employed in fishing, and there are extensive manufactures of cement. The Adur was formerly crossed by a ford, but a handsome suspension bridge was erected at Shoreham in 1833. The number of sailing vessels registered at the port, December 31, 1857, was 129, tonnage 16,131; of steamers, 2, tonnage 31. In the year ending at that date, there entered 812 sailing vessels, tonnage 80,449; and 52 steamers, tonnage 8440—in all, 864 vessels, tonnage 88,889: and there cleared 374 sailing vessels, tonnage 17,901; and 52 steamers, tonnage 8154—in all, 426 vessels, tonnage 26,055. The borough of Shoreham returns two members to Parliament. It includes nearly all the rape of Bamber; and had, in 1851, a population of 30,553. That of the parish was only 2590.

SHORT, JAMES, an optician of note, was born in Edinburgh on the 22d of June, in the year 1710. After spending two years at Heriot's Hospital, he, at the age of twelve, was removed to the High School, where he showed a considerable taste for classical literature. In 1726 he entered the university, and took his master's degree with distinction. He had been fortunate enough to have the celebrated Maclaurin for his preceptor, who having soon discovered the bent of his genius, and made a proper estimate of the extent of his capacity, encouraged him to prosecute those studies in which nature had qualified him to make the greatest figure. Under the eye of that eminent master, he began in 1732 to construct Gregorian telescopes, in which he attained to great perfection. In the year 1736 Short was called to London, at the desire of Queen Caroline, to give instructions in mathematics to the Duke of Cumberland; and immediately on his appointment to that honourable office he was elected a fellow of the Royal Society, and patronised by the Earls of Morton and Macclesfield. He made numerous telescopes, during his residence in London, of great magnifying power. He died on the 15th of June 1768, at Newington Butts, near London, in his fifty-eighth year.

SHORT-HAND. See STENOGRAPHY.

SHOVEL, SIR CLOUDESLY, a distinguished British admiral, was born of poor parents in 1650. He was first put apprentice to a shoemaker, but disliking this profession, he a few years afterwards abandoned it and went to sea. He was at first a cabin boy with Sir Christopher Mynns; but having applied to the study of navigation with indefatigable industry, his skill as a seaman soon raised him above that station. The corsairs of Tripoli having committed great outrages on the English in the Mediterranean, Sir John Narborough was sent in 1674 to reduce them to order. As he had received orders to try the effects of negotiation before he proceeded to hostilities, he sent Shovel, at that time a lieutenant in his fleet, to demand satisfaction. The Dey treated him with a great deal of disrespect, and sent him back without an answer. Sir John despatched him a second time, with orders to remark particularly the situation of things on shore. The behaviour of the Dey was worse than ever, and upon Shovel's return he informed Sir John that it would perhaps be possible, notwithstanding their fortifications, to burn all the ships in the harbour. The boats were accordingly manned, and the command of them given to Lieutenant Shovel, who seized the guard-ship, and burned four others, without losing a man. This action so terrified the Tripolins that they sued for peace. Sir John Narborough gave so favourable an account of this exploit, that Shovel was soon afterwards made captain of the Sapphire, a fifth-rate ship. In the battle of Bantry Bay, after the Revolution, he commanded the Edgar, and, for his gallant behaviour in that action, was soon afterwards knighted by King William. Next year he was employed in transporting an army into Ireland, a service which he performed with so much diligence and dexterity, that the king raised him to the rank of rear-admiral of the blue, and delivered his commission with his own hands. Soon afterwards he was made rear-admiral of the red, and shared the glory of the victory at La Hogue. In 1694 he bombarded Dunkirk. In 1703 he commanded the grand fleet in the Mediterranean, and did everything in his power to assist the Protestants who were in arms in the Cevennes. Soon after the battle of Malaga, he was presented by Prince George to Queen Anne, who received him graciously, and next year employed him as commander-in-chief. In 1705 he commanded the fleet, together with the Earl of Peterborough and Monmouth, which was sent into the Mediterranean; and it was owing to him chiefly that Barcelona was taken. After an unsuccessful attempt upon Toulon he sailed for Gibraltar, and from thence homewards with a part of the fleet. On the 22d of October, at night, his ship, with three others, was cast away on the rocks of Scilly, and all on board perished. His body was found on the island of Scilly by some fishermen, who stripped it of a valuable ring, and afterwards buried it. Some say he was murdered by the wreckers, but this statement cannot be verified. Paxton, the purser of the Arundel, hearing of his death, found out the fellows, and obliged them to discover where they had buried the body. He carried it on board his own ship to Portsmouth, whence it was conveyed to London, and there this eminent seaman was interred with great solemnity in Westminster Abbey. A monument was afterwards erected to his memory by the direction of the queen. Sir Cloudesly married the widow of his patron, Sir John Narborough, by whom he left two daughters.

SHREWSBURY, a market-town, parliamentary and municipal borough of England, capital of Shropshire, pleasantly situated on the Severn, 50 miles S. by E. of Liverpool, and 153 N.W. by W. of London. It occupies a commanding eminence which gradually rises from the banks of the river, whose stream gracefully bends in course round three sides of the town, thus forming a peninsula having its narrow isthmus towards the N.E. The general character of the town is antique; its streets are irregular, and many of its houses are picturesque old edifices, built, at least partially, of wood. The town, however, contains not a few very superior stone buildings. The river is crossed by two handsome bridges, the English and the Welsh, the former of which has seven arches, and the latter five. The English bridge leads to the suburb of Abbey-Foregate on the E., and the Welsh to that of Frankwell on the W. Portions of the ancient walls still remain, and also the keep of the castle, but the latter has been modernised. It is a square, solid tower of the age of Edward I. There is also a fine Norman gateway, and some remains of a very ancient British fortress. Many of the public buildings of Shrewsbury are remark-

able. Among them are the market-house, which was built in the reign of Elizabeth, and is one of the most richly decorated buildings of the kind in England; the town and county hall, a large commodious edifice; and a fine Grecian structure, containing the post-office, music hall, and newsroom. There are also numerous churches, some of which are possessed of much interest. The abbey church is so called because it formerly belonged to a Benedictine abbey, founded in 1083. It was originally cruciform, but was partially pulled down at the time of the dissolution of the abbey. The north porch, nave, and western tower are the portions that still remain. St Chad's is a handsome modern building of a circular form, in the Grecian style; St Alkmund's is also modern, with the exception of the tower and spire of the more ancient edifice, 184 feet high; and St Mary's is a spacious cruciform church in the Norman and early English styles. The last has very rich old stained windows, and an elegant tower and spire, rising to the height of 220 feet. Besides these, there are other places of worship, mostly modern, belonging to the Established Church, and to the Wesleyan, Primitive, and Calvinistic Methodists, Independents, Baptists, Quakers, Roman Catholics, and Unitarians. There are in all 13 churches and 26 dissenting chapels. The royal free grammar school occupies a lofty freestone structure, forming three sides of a court. This institution was founded by Edward VI., and greatly enlarged by Elizabeth. It has an endowment of about L.2600 a year, and many scholarships and exhibitions at the universities. In the present century this school rose to great celebrity under its master, Dr Butler, afterwards Bishop of Lichfield; and among its distinguished scholars in former times were Sir Philip Sidney and Fulke Greville. Shrewsbury has also a British school, and several national and charity schools. There are a public library, theatre, assembly rooms, circus, and public baths; a military depôt, town and county jail and house of correction, and a lunatic asylum. Near the entrance of the town, from London, stands a Doric column in honour of Lord Hill; and in the corn exchange, under the market-house, is a statue of the Duke of York, father of Edward IV., brought from the old Welsh bridge. To the S.W. of the town, along the river's side, is a place called the Quarry, supposed to occupy the site of a Roman theatre, and now used for a public walk. It has an area of 20 acres, and is planted with lime-trees. Various manufactures are carried on, especially those of thread, canvas, and malt; and the brawn and cakes of Shrewsbury have long been famous. There are also in the vicinity important iron-works. Salmon-fishing is pursued with much success in the Severn, and that river is navigable for vessels of thirty or forty tons. A large trade is carried on with the agriculturists in the neighbourhood, and railways to all parts of England radiate from the town. There are several private and joint-stock banks, and a savings' bank. Weekly and monthly markets are held. The borough is governed by a mayor, ten aldermen, and thirty councillors, and sends two members to the House of Commons. It is believed that a fortress was erected here by the Britons after they found the Roman Uriconium (Wroxeter) no longer tenable against the Saxons. This must have taken place in the fifth century. The fortress was called by the Britons *Pengwern*, or Alder Hill. But even this at length fell before the victorious arms of the Saxons, who changed the name to *Scrobbesbyrig*, or Shrubstown, whence the present name. In the time of Alfred, Shrewsbury was one of the chief cities in England; and his daughter Ethelfleda founded here the church of St Alkmund. After the Norman Conquest it formed part of the earldom of Shrewsbury, given by William to Roger de Montgomery, who built the castle here; but it was subsequently forfeited to the crown. Standing as it does on the confines of Wales, Shrewsbury was the scene of many conflicts between the rival nations. In 1215 it was taken by the Welsh under Llewellyn the Great, but not long retained; and, in 1264, it was again for a short time in the hands of the Welsh. Edward I., in 1277, strengthened Shrewsbury, and made it his head-quarters; and in 1283 assembled a Parliament here for the trial of David, the last prince of Wales, who was executed as a traitor. The name of Shrewsbury is likewise conspicuous in the Wars of the Roses, and in the historical dramas of Shakspeare. Here, in 1403, the forces of Henry IV. defeated the insurgents under the Percys and Owen Glendower. In the civil war of the seventeenth century, Shrewsbury was held by a royalist garrison until 1645, when it was surprised and taken by the parliamentary forces. After the Restoration, the castle and property attached to it were conferred by Charles II. on the Earl of Bradford, from whom they have been transferred to the Duke of Cleveland, the present proprietor. Pop. of the borough (1851) 19,681.

SHROPSHIRE, or SALOP, an inland county of England. It is bounded on the N. by Cheshire and the Welsh counties of Flint and Denbigh; on the W. by the Welsh counties of Denbigh, Montgomery, and Radnor; on the S. by Herefordshire and Worcestershire; and on the E. by Staffordshire. It is of an oblong figure, extending from N. to S., and contains a variety of projections and indentations. Its greatest length is about 48, and its greatest breadth 40 miles. Its superficial contents are 1343 square miles, or 859,520 statute acres.

The face of the county is very much diversified. On the western side it has the wild appearance of the adjoining principality of Wales. Several of the Welsh mountain-chains extend across the frontier of that country into Shropshire. Such are the Berwyn Hills in the north, which rise to the height of 1300 feet; the picturesque Breiddin Hills, on the right bank of the Severn; and a long range of smooth, rounded hills, extending from Radnorshire into Shropshire, and known under the name of Clun Forest. Throughout the rest of the county the land is rather undulating, tolerably wooded, and with many beautiful rivulets meandering along the different valleys. The whole tract of country in the east and north, from Wellington to the termination of the county between Oswestry and Chirk, exhibits the mild beauties of a fertile and cultivated district, enclosed by well-formed hedges into fields, of dimensions well calculated for advantageous husbandry, and ornamented with several seats of noblemen and gentlemen, which present a most pleasing succession of pictures to the traveller. In the portion south and west of the Severn, there are three principal chains of hills, extending from S.W. to N.E. These are on the west the Longmynd, in the centre the Caradoc Hills, and on the east Wenlock Edge. The last of these rises abruptly out of the valley on the west, but has a very gradual slope towards the east. The Caradoc Hills extend across the Severn, and terminate in the well-known hill called the Wrekin.

That singular insulated mountain, rising from a plain to the height of 1320 feet, exhibits its sugar-loaf form over the tops of the smaller elevations in its vicinity, and increases the interest of the scenery. In the southern division of the county, the Brown Clee Hill and the Titterson Clee Hill rise to greater elevations than the Wrekin, and produce much picturesque variety. These two are the highest summits in the county; the former reaching the height of 1805, and the latter that of 1750 feet.

The chief river is the Severn, which runs through the whole extent of the county from N.W. to S.E. It is navigable at all seasons to the Bristol Channel downwards, and in wet seasons upwards to Welshpool, in Montgomeryshire. Its whole course through Shropshire is 90 miles, flowing at first towards the east, and then turning to the

south. The fish found in the Severn, in its course through Shropshire, are salmon, pike, flounders, grayling, and eels. There are also some lampreys, but they are less abundant than in the lower parts of the river. The principal tributary rivers are the Camlet, the Vyrnwey, the Tern, the Clun, the Ony, the Teme, the Perry, the Rea, and the Corve. There are, besides, innumerable rivulets and streams, which adorn and fertilize the country. The lakes of Shropshire, though neither numerous nor extensive, form a variety in its landscapes rarely to be seen in the midland counties of England. Adjoining the town of Ellesmere is a beautiful lake of 116 acres, with some others smaller near it. On the western side of the county is Mereton Pool, of 45 acres. On the north of the Severn are Fennymere, Llynclyspool, and Ancot; and at Shrawardine is a fine lake of 40 acres. That side of the county which most abounds in running streams has few or no lakes. The canals of this county, if not equal in extent to those in some others, yield to none in the skill of their construction, in the obstacles they have surmounted, or in the beneficial consequences by which they have been followed. The first canal was a private undertaking by a Mr Reynolds, completed in the year 1788, for the conveyance of his ironstone and coals. It was of no great length, but a descent of 73 feet was conducted by a well-contrived inclined plane and double railroad, by means of which the loaded boat passing down drew up another with a load nearly equal to one third of its own weight. This contrivance was found to be applicable to similar purposes upon a larger scale, and was speedily adopted by a company who, under the power of an act of Parliament, constructed the Shropshire Canal, which passes through the most considerable iron and coal works, till it reaches the Severn. The Ellesmere Canal is a most important undertaking, as by it a communication is opened between the Severn and all the great canals and rivers in the north of England. Bristol and Liverpool are thus become connected by inland navigation; and the rivers Severn, Dee, Mersey, Trent, and Humber, are united for the purposes of conveyance. In other means of communication Shropshire is not deficient. It is traversed by many good roads; that from London to Holyhead, formerly the great route to Dublin, passing through this county. Several railways also afford more rapid means of transit. The Birmingham, Shrewsbury, and Chester line enters Shropshire from the east, and leaves it on the N.W. A branch of this line diverges to Stafford, and another shorter one to Oswestry. A great part of the Shrewsbury and Hereford line also lies in the county, running southwards from Shrewsbury to Ludlow. Besides these main lines, there are many short railways and tram-roads used in connection with the various mines for conveying their produce to the furnace or to the canals. The river Severn nearly forms a line of demarcation between two distinct geological formations which occupy the county; the northern portion, consisting for the most part of red sandstone, and the southern of older formations. The new red sandstone forms a basin round a central deposit of lias, between Whitchurch and Market-Drayton. Around and beneath this, occupying the whole north of Shropshire, and portions also of Staffordshire and Cheshire, lie the deposits of new red sandstone, with the lowest strata nearest the outside. The southern limit of this formation extends south of the Severn in the west of the county, and again at a point near the Caradoc Hills; but further east it does not reach so far as that river, and terminates near Newport on the border of Staffordshire. It is succeeded by various different formations. At some places Silurian rocks extend to the north of the Severn, and the Wrekin is composed of trap; but the most important deposits in this the central part of Shropshire are those of coal. Of these the most valuable is that of Coalbrookdale; but there are also extensive fields about Westbury and Pontesbury in the west; and others completely isolated near Oswestry in the north, and in several places in the south. A large extent of old red sandstone occupies the S.E. portion of Shropshire; and a separate deposit of the same rock forms Clun Forest in the S.W. The remainder of the county, a portion equal to one-fourth of its area, lying in the S.W., consists of the Silurian and Cambrian systems of rocks. Among these are limestone, sandstone, and several varieties of trap-rock.

In a county of such extent the soil must be very varied. On the eastern side, the valleys are flat and warm, and the soil generally of a sandy nature. In the middle part, the soil is most tenacious, and the bottoms of the wider valleys have frequently a stiff but rich clay. On the most western parts, the soil is very shallow, resting upon rocks of varied description; and is better calculated for sheep-pasture than for producing grain. There are some moorlands, but enclosures and drainage have considerably diminished their extent. A very great portion of the soil rests on a limestone subsoil; and almost the whole of the plains are easy to work with light ploughs and two or three horses. The easterly wind generally prevails in the spring, and the westerly in autumn; but the former is more remarkable for regularity than the latter. The whole of the county enjoys a salubrious air; but on the hills, on the western side, the cold of winter is most intensely felt.

The agriculture of the county has made considerable progress of late, though in some parts it is still in a very backward condition. In the west of the county progress is much retarded by the small size of the farms, and the short leases by which they are held. In this portion they frequently do not exceed 20 acres in extent, while in the east their size varies from 100 to 500 acres. Most of the farms are arable, but some depend chiefly on hay, dairy produce, and the rearing of cattle and sheep. The Herefordshire breed of cattle is common in the south, along with various mixed breeds. The most prevailing breed of sheep is one resembling the Southdown, but many of the New Leicesters are to be seen, and in the hilly parts of the county are many of the fine woolled Welsh sheep. The meadows on the banks of the Severn, and on the flat lands contiguous to the smallest streams, afford pasturage for numerous cows, whose milk affords a kind of cheese, commonly sold under the denomination of Cheshire, though much inferior to the genuine article. The corn generally cultivated is either wheat, barley, oats, or pease, and the crops on an average equal in productiveness those of the best districts of the kingdom. Hops are grown in small quantities upon that part of the county which adjoins to Herefordshire. Some small portions of land are appropriated to the growth of hemp and flax. The cultivation of potatoes has been very much extended of late years, and now furnishes a large proportion of the aliment of the labouring part of the population. The growth of hay, and the cultivation of artificial grasses, are more neglected than any other branch of rural economy. On the flat lands the deposits from the overflowing of the streams sufficiently enrich them without any artificial manure; but the hay produced on such situations is liable to be much injured by the floods that frequently occur in summer. This, however, is guarded against by embankments in the upper part of the river.

A great portion of the wealth of this county consists in the mineral productions, which are most profusely found beneath its surface. The chief of these are lead, iron, limestone, freestone, pipe-clay, and coals. The lead is procured in considerable quantities, chiefly from the mines of Stiperstone and Snailbeach. The matrix of the ore is crystallized quartz, sulphate and carbonate of barytes, and carbonate of lime. The quantity of lead ore obtained in the county in 1858 was 3994 tons, yielding 2993 tons of lead,

being considerably above the average of the previous ten years. The total amount of ore raised in that period was 35,602 tons, yielding 25,916 tons of lead, or 72·796 tons of metal for every 100 tons of ore. The iron ore is found contiguous to the coal, and frequently close to it. This is especially the case about Coalbrookdale, a division peculiarly rich in those minerals. This district is about 8 miles long and 2 broad, on the banks of the Severn, on the western side of the Wrekin, and running parallel with it, from N.E. to S.W. The whole, but especially the southern part, of the coal district, is considerably above the plain of Shropshire, so that at one part the height is 500 feet above the Severn. The works of the dale supply both iron and coal, as well as limestone, in great quantities; and every part of the process, from digging the ore to the completion of the manufacture, including the conversion of the coal into coke, is performed on the spot. Arthur Young, describing this part of the county, says—" Coalbrookdale is a winding glen, between two immense hills, which break into various forms, being all thickly covered, and forming most beautiful sheets of hanging woods. The noise of the forges, mills, furnaces, &c., with all their vast machinery, the flames bursting from the furnaces, with the burning coal, and the smoke of the limekilns, are altogether horribly sublime." A bridge of cast-iron, the first, we believe, constructed in this kingdom, thrown over the Severn, gives to the whole scenery a most romantic appearance. Soon after it was ascertained that iron might be made with coals reduced to the state of coke, as well as from wood, the operation of coking was begun here by Lord Dundonald, with a view to obtain the fossil tar in the course of the process. This operation led to the discovery of that gas, extracted from coal, whose brilliant light now serves to illuminate so many of our streets and public buildings. In this dale was discovered, in opening a coal-mine, a copious spring of fossil tar. It yielded, at first, very plenteously, but the quantity diminished in a few years, and although it still runs, its produce is but of small amount. Though the iron-works were first begun on a large scale in this dale, they are by no means confined to it; for in many other parts of the county they are carried on to an extent that is unequalled in any other country but Great Britain. The quantity of iron ore raised in Shropshire in 1858 was 150,500 tons, valued at L.38,135. There are in all 32 furnaces in the county, of which 25 are in blast; and these produced in the year above mentioned 101,016 tons of pig-iron. In the same year there were produced from 57 collieries, 749,360 tons of coal. The number of persons employed in the various mining operations in Shropshire, and in manufactures connected with them, amounts to several thousands. The manufacture of iron is here carried on with great care and skill, and with the aid of powerful machinery.

Besides the process of separating the iron from its ore, and bringing it into the state of bar-iron and pig-iron, the other steps in the application of that mineral to general purposes are made within this county. The larger kind of iron goods, whether cast or wrought, are prepared, and many of the iron bridges erected in different parts of the kingdom have been made here. Some of the largest establishments for making porcelain have been formed here, especially that for iron-stone china in Coalbrookdale. Glass, earthenware, bricks and tiles, are also made in the county, as well as coarse linen cloth, carpets, and gloves.

Shropshire contains two divisions, a north and a south; and is subdivided into 14 hundreds. It returns in all 12 members to Parliament; two each for the northern and southern divisions; and two each for the boroughs of Bridgnorth, Ludlow, Shrewsbury, and Wenlock. Its ecclesiastical division is into 225 parishes, with parts of 19 others; belonging to the dioceses of St Asaph, Hereford, and Lichfield. According to the census of 1851, the county contained in all 679 places of worship, with 145,186 sittings. Of the former, 291 belonged to the Established Church, 262 to Wesleyan Methodists of various subordinate sects, 59 to Independents, 31 to Baptists, 11 each to Calvinistic Methodists and Roman Catholics, 3 to Quakers, &c. At the same period the total number of public day-schools was 247, attended by 18,859 scholars; the number of private day-schools 312, attended by 6395 scholars. There were also 298 Sunday-schools, attended by 22,705 scholars, and 14 evening schools for adults, attended by 175 scholars.

Before the Roman conquest of Britain, the present county of Shropshire was divided by the Severn between the Cornavii on the east, and the Ordovices on the west. Under the Romans the same river formed the boundary between Flavia Cæsariensis and Britannia Secunda, the latter comprehending the modern Wales, and the former the centre of England. Numerous remains of old British camps still exist in various parts of the county, especially one called Caer Caradoc, near Church Stretton, and the Gaer ditches near Clun. The latter is believed by some to be the place where Caractacus was defeated by Ostorius Scapula. The chief Roman station was Uriconium, now Wroxeter, where there are extensive remains. There is also a camp near Bridgnorth, and a Roman road known by the name of Watling Street, traverses the county. After the departure of the Romans and the invasion of Britain by the Saxons, this county was the scene of frequent encounters between the natives and the invaders; and many of the half mythical exploits of the celebrated King Arthur are said to have taken place here. Ultimately the Saxons extended their dominion as far as the foot of the Welsh hills, and established in Shropshire and the adjacent county a kingdom called *Myrenaland*, or *Mercia*, the land of the marchmen or borderers. In order to defend this country from the attacks of the Welsh, Offa, one of its kings, erected a dyke extending from the Dee to the Bristol Channel. Several portions of this fortification may still be traced in the extreme west of Shropshire, and are still known under the name of Offa's dyke. At a later period the Danes also penetrated as far as this part of the country, and built a fortress on the Severn below Bridgnorth. When they were expelled, and the Heptarchy united under Alfred, Shropshire was made a county, deriving its original name of *Scrobbescyre* from *Scrobbesburg*, or Shrewsbury, its chief town. After the Norman conquest, almost the whole county was granted to Roger de Montgomery. Our limits do not admit of lengthened descriptions of the numerous remains of ancient architecture which are still existing in this county. The most remarkable are Haughmond Abbey, about 4 miles from Shrewsbury; the walls of Wroxeter, of British and Roman construction; the Abbey of Buildwas, founded in 1135 by Roger bishop of Chester, for monks of the Cistercian order; the Monastery of Wenlock, founded in 680, destroyed by the Danes, and afterwards re-established; the Roman camp, called the Walls, at Quatford; the castle of Ludlow, celebrated for its splendour in the reigns of Henry VIII. and of Elizabeth, during the latter period the residence of the Sidneys, and in the reign of Charles I. immortalized as the place where Milton composed some of his works; Wannington Castle, near Oswestry, a house of strength before the Norman conquest; Lilleshall Abbey, near Newport, with one of the most highly adorned Norman arches in the kingdom; and Boscobel House, with the oak in the grounds near it which served as a shelter to Charles II., when, after the battle of Worcester, he was closely pursued by the victorious party. The principal seats of noblemen and gentlemen are Walcot, belonging to Earl Powis; Lilleshall to the Duke of Sutherland; Hawkstone to Viscount Hill; Weston Hall

to the Earl of Bradford; Attingham House to Lord Berwick; Burwarton Hall to Viscount Boyne; Shavington Hall to the Earl of Kilmorey; Willey Park to Lord Forester; Acton Burnell to Sir Edward Smythe; Aldenham to Sir John Acton, &c. The population of Shropshire at each of the decennial periods of census was as follows:—in 1801, 182,695; 1811, 199,263; 1821, 215,058; 1831, 230,990; 1841, 241,685; 1851, 244,898.

SHROVE-TUESDAY is the Tuesday after Quinquagesima Sunday, or the day immediately preceding the first of Lent, being so called from the Saxon word to *shrive*, which signifies to confess. The reader may consult Brand's *Popular Antiquities* for an account of the ancient Shrovetide amusements of the people of England.

SHROUDS, a range of large ropes extending from the mast-heads to the right and left side of the ship, to support the masts, and enable them to carry sail. They receive their names according to the masts or portions of the ship to which they belong.

SHUMLA, or SHUMNA, a fortified town of European Turkey, Bulgaria, in the pashalic and 58 miles S.S.W. of Silistria, 225 miles N.N.W. of Constantinople. It is a place of great importance in a military view, insomuch that it has obtained the name of the key of the Balkan; for to this point there converge roads and tracks from all the chief fortresses on the Danube to the north, and from the passes of the Balkan to the south. The fortifications of the town are not themselves the sources of its strength, but the entrenched camps that have been formed on the heights to the south and west, commanding the town and preventing an enemy from approaching by this route to the passes of the mountains. The town has more the appearance of a vast village than of a fortified place; it is spread over a wide extent of ground, each house standing with its own stables and cow-houses in the middle of a separate yard. A rivulet divides it into an upper and a lower town. The former is inhabited by Turks, and contains numerous handsome mosques and baths; while the latter, occupied by Jews and Christians, is very unhealthy, chiefly on account of its extreme dirt. Shumla contains a Greek and an Armenian church, several Bulgarian schools, infantry and cavalry barracks, and a new hospital, all of stone. There are three forts in the plain and one on the hills; but the fortifications were in an unfinished state until the Russian war in 1854, when they were completed. Some remains of antiquity still exist here in the shape of decaying arches and fountains. The mausoleum of Djezzar Hassan Pasha is one of the finest objects in the town. The copper and lead foundries of Shumla are considered the best in Turkey; weaving and silk-spinning are also carried on, and the trade of the town is very considerable. Wine, hardware, and manufactured goods are the principal articles of commerce. Shumla was first conquered by the Turks in 1387. In subsequent times it has been three times attacked by Russian armies, but always without success. The dates of these attempts were 1774, 1810, and 1828. On the last occasion, however, in the following year, Marshal Diebitch, leaving the town on his right, succeeded in crossing the Balkan by a pass further to the east. The population of Shumla is estimated at 30,000.

SHUMSHABAD, a town of British India, in the district and 12 miles N.W. of Furruckabad, 88 miles N.E. of Agra. It stands in a marshy track 8 miles from the west bank of the Ganges, and formerly was a much more important town than it is at present, yielding an annual revenue of L.20,000. Pop. 6920.

SHUSHA, or SHUSHI, a town of Asiatic Russia, capital of a circle in the government of Shamaka, Transcaucasia, 70 miles S.E. of Ganjeh. It is fortified, and occupies a strong position on a mountain accessible only from one side. Silk and woollen cloth are manufactured here. Shusha was founded by Nadir Shah, and was at one time the capital of the khanat of Karabagh. Pop. 13,469.

SHUSTER, a town of Persia, in the province of Khuzistan, at the foot of a low range of hills on the Karun, which is here crossed by an ancient bridge about 300 yards long, 170 miles W. by S. of Ispahan. Immediately above the town the river divides into two branches, thus enclosing it on two sides; while a wet ditch or small canal connecting the two completes the circuit of the town. A steep rock rises abruptly from the river's edge, and on this is built a castle, a place of no great strength, as its walls are dilapidated, and it is commanded by higher ground in the vicinity. In the castle is the large substantial residence of the governor. The town occupies the slope of the hill towards the S.W. It is mostly built of stone, and has many handsome edifices; the streets, however, are generally very narrow. It is divided into twelve quarters, each governed by its separate chief, according to a sort of feudal system. Having been almost depopulated by the plague in 1832, Shuster does not contain more than 13,000 inhabitants, though the number of houses exceeds 10,000.

SHUTTLE. See WEAVING.

SIAK, a native state in the Island of Sumatra, on the coast of the Strait of Malacca, extending from the equator to about 3. N. Lat., and from the central mountains down to the sea. It is nearly square, about 160 miles each way, and is bounded by the river Kampar in the south, and the Assahan in the north. It derives its name from the river Siak, which traverses its central portion, and overflows the low flat regions which lie along the coast. The chief productions of the country are rice, cotton, various vegetables and fruits, honey, ivory, and bamboos. There are large numbers of cattle and game. There are numerous trading places along the coast, and several islands afford behind them shelter for ships. The whole coast, however, is very much infested with pirates. The state is governed by a sultan, who resides at Siak, the capital. At this place an active trade is carried on in the produce of the country with Singapore, Penang, &c.

SIAM, an independent kingdom of Eastern India, extending from about the 5th to the 21st degree of north latitude, and from the 98th to the 105th degree of east longitude. Its area is probably not less than 250,000 square miles. It is bounded on the N. by Laos; E. by Laos, Camboja, and the Gulf of Siam; S. by the Gulf of Siam and the Malay peninsula; and W. by the Bay of Bengal, the Tenasserim provinces, and the Birman empire.

Within these boundaries are included not only Siam Proper, but likewise the tributary Malayan states on the south, the conquered territory of Camboja and Korat on the east, and the tributary Laos states on the north and north-east. The Malayan tributary states are Patani, Tringanu, Kalantan, and Quedah. The dependence of these states, however, especially the last three, is little else than nominal; with regard to Patani it is more complete, on account of its population being to a large extent Siamese. Camboja is now nearly divided between Siam and Cochin-China. Of this once powerful kingdom only a small remnant, of about two degrees of longitude, and three or four of latitude, with the single seaport of Kampot, and perhaps half a million of subjects, remain to the present monarch. Korat is only a small territory; but it has a walled town of great strength, which can only be approached through a dense and dangerous jungle. The Laos states are divided into two very distinct sections; those who *tattoo* their bodies, and those who do not. The tattooed, or black-bellies, occupy the districts of Xieng-Mai, Laphun, Lakhon, Muang-Phrë, and Muang-Nan; the non-tattooed, or white-bellies, live in the districts of Muang-Lom and Muang-Luang-Phra-Bang. The western region of the country is inhabited by the white-bellies, the eastern by the black-

bellies. They are divided into a number of petty kingdoms; but few of them are strictly independent, most of them being tributary to the king of Siam. (See *Royal Geo. Soc. Jour.*, vol. xxvi.)

The country of Siam is traversed, from north to south, by several mountain-chains, which descend from the mountainous province of Yun-nan, in China. Two of these ranges enclose between them the fertile valley of the Menam, which may be said to comprise the whole of Siam Proper. The western chain separates the waters of the Menam from the Saluen, and extends southwards to the mouth of the Tenasserim river. On the eastern bank of that stream rises the chain of the "Three Hundred Peaks," a name derived from its sharp and conical summits. It terminates about 11. N. Lat.; but is succeeded by other ranges, which traverse the Malay peninsula. The mountain-chain which divides the Menam from the Mei-kong, or Camboja river, is little known; but where seen and visited it seems to be of moderate elevation, and is richly covered with vegetation. Of the western mountains of Siam, some of the summits are estimated to rise to the height of 5000 or 6000 feet; but as yet our information of the nature of the country is very vague and meagre. The mountains seem to be mostly covered with a thick jungle of trees.

Siam possesses a great extent of sea-coast. The Gulf of Siam is almost entirely bordered by its territory, and it has also about 500 miles of coast on the Bay of Bengal. Altogether, it may be said to have a coast-line of about 2000 miles. The Gulf of Siam is about 500 miles in length, from south-east to north-west, and has an average breadth of about 250. It is little exposed to the typhoons and tempests which do so much damage in the Chinese seas. There is a gulf-current, which, from October to March, flows from north to south, at the rate of nearly three miles an hour; after April its ordinary course is from south to north. "The Admiralty charts," says Sir John Bowring, "are full of extraordinary blunders. Some were pointed out by Mr Crawfurd more than a third of a century ago, but have remained uncorrected to the present hour." Recently, however, this gulf has been surveyed by Mr John Richards, R.N., and it is hoped that these errors will now be corrected. (See *Royal Geog. Society's Proceedings* for 1859.) The gulf contains numerous islands all along its coasts. They are of small size, but many of them are valuable as furnishing the edible birds' nests which form so large an article of commerce with China. In the Bay of Bengal, too, off the Siamese coast, there are numerous islands, usually of small size, rocky, and elevated. The largest are St Matthews and Salanga, or Junk Ceylon, each being about 16 miles in length by 6 in breadth. The channels between them are generally of great depth, and seldom less than 4 or 5 fathoms.

The practicability of establishing communication between the Bay of Bengal and the Gulf of Siam, by means of a ship-canal cut across the Isthmus of Krah, has been advocated by more than one writer. The direct distance across the isthmus, in about 11. N. Lat., is about 50 miles; and it is said that only a few miles of cutting would be required. There is on the one side the Pakchan river, which falls into the Bay of Bengal, and on the other the Choomphon river, which enters the Gulf of Siam, both navigable for boats; while the space between them is so low, that, according to the natives, the two rivers frequently commingle their waters during the spring-tides. A canal here would be of immense importance to vessels trading between India and Eastern Asia, and would effect a saving in time often to be estimated, not by days, but by weeks. "A ship-canal here," says Sir John Bowring "if practicable, would be next in importance to those which have been proposed to cross the Isthmus of Darien in America, and that of Suez in Egypt."

The most important river of Siam is the Menam, or Meinam, a name signifying, in Siamese, "Mother of Waters." It takes its rise in the mountains of Yun-nan, in China, by two branches, which unite about N. Lat. 22. The western, called Nan-ting-ho, rises about N. Lat. 24., and is the longer of these branches; but the Meiprein is considered by the Siamese the main stream. The united river still retains the name of Meiprein, and flows through Lower Laos, or Yan-shan, becoming navigable for boats at Xang-Mai, the capital of that territory. Farther down, however, its navigation is impeded by rapids and cataracts. After being joined by the Phitsalok, it takes the name of Menam. In the flat country of Siam Proper it more than once divides itself into several streams, and falls into the Gulf of Siam by three mouths, after a course of about 800 miles. The Menam, like the Nile, annually overflows its banks, and fertilises a large district of country. Its waters begin to rise in the month of June, and in August they overflow the banks to a height sometimes exceeding six feet above their ordinary level. They generally remain in this state till the month of November, when they begin to subside; and by the end of December the river has returned to its natural bed. When the waters are supposed to have reached their height, the king deputes a hundred priests to command the inundation to proceed no farther. This, however, does not always succeed; and sometimes the country suffers fearfully from an extraordinary rise of the waters. During the prevalence of the inundation the country has the appearance of one vast lake, and boats traverse it in all directions. The valley of Menam is estimated to be about 450 miles in length, with an average breadth of about 50 miles, "constituting," says Sir John Bowring, "according to the usually received estimates, an area of above 22,000 square miles of territory, whose fertility is not exceeded by that of any portion of the globe." The principal mouth of the Menam is the eastern, on which the town of Bang-kok stands, and is the only one navigable for large vessels. The most western mouth is the Me-klong, so called from the river of that name which falls into it, and which is said to be navigable for boats for about 200 miles. The central mouth also receives a river, the Tachin, which is navigable for a considerable distance. East of the eastern mouth of the Menam is another large river, the Bang-pa-kong, which rises in the mountains of Camboja, between 15. and 16. N. Lat., and is said to carry down a volume of water not much less than the Menam itself. The plain of Siam Proper is intersected by numerous canals. In the east of Siam is Meikong, or Camboja river, one of the largest of Southern Asia. It rises in the mountains of Yun-nan, about N. Lat. 27. 20., and, flowing in a south by east direction, through Laos and Camboja, falls into the sea by three mouths, about N. Lat. 9. 35. It has a length of about 1500 miles; but its navigation is much impeded by sand-banks at its mouths. In the west the principal river of Siam is the Saluen, which for several hundred miles forms the boundary between it and Burmah. It rises in the eastern portion of Tibet, flows south through the Chinese province of Yun-nan, forms the boundary between the Burmese empire on the west, and the territories of Laos and Siam on the east, and then flows through the northern portion of the Tenasserim provinces, to its mouth in the Bay of Bengal. It has a length of probably about 800 miles, but seems to be little suited for navigation. The climate of Siam is, for a tropical region, salubrious. The Siamese suffer from those diseases common to tropical countries—fevers, diarrhœas, and dysenteries being the most fatal. Travellers who pass into the interior are very liable to the jungle fever. The year, as in other tropical countries, is divided into a wet and a dry season. At Bang-kok the dry season lasts from October to April, and during this period the weather is temperate; but in April and the beginning of May, before the rains set in,

the heat becomes very oppressive, the thermometer being as high as 95° or 96° in the shade. The rains commence early in May, and continue to September. The prevailing winds are regular, blowing at different seasons of the year from all points of the compass. About the end of September the north-east monsoon begins to prevail, whence the wind veers gradually round towards the east, south, and west.

This interesting country is particularly rich in natural productions. "In its great outlines," says Sir John Bowring, "the animal, mineral, and vegetable world resembles that of other tropical regions, though in every part of the field there are varieties in detail which belong to the domain of the naturalist. They will become in time the objects of particular attention; and no portion of the East is probably so inviting as the Siamese regions, from their extent, their richness, and their novelty. There is, indeed, almost everything to explore; and the inquirer may now 'expatiate boldly,' with a certainty of having a full recompense for his exertions and investigations." Of the geology or mineralogy of Siam little is yet known. Tin abounds, and forms an important article of export. Copper and lead are also obtained in large quantities. Antimony and zinc exist, but the ores are not worked. Silver is found in combination with copper, lead, and arsenic; and gold is obtained in many parts. Iron mines are wrought at Tha Sung by the Chinese, and the ore is said to be very rich. Precious stones abound in various parts of the country. Agriculture is in a very backward state, and their implements of husbandry are of the very rudest description. In many places the land is prepared by turning in herds of buffaloes during the rainy season, to trample down the weeds and move the soil, which is then harrowed by a coarse rake, or a bush of thorny shrubs, after which the seed is broadcast upon the surface. The most important crop is rice, of which large quantities are now exported. The annual produce of rice at present is estimated at 25,000 tons; but by improved and extended cultivation, this might be raised to 100,000 tons. "The extent of cultivable rice land," says Sir John Bowring, "is capable of being doubled or trebled; there is now only one rice harvest in a year, and there might well be two." The sugar-cane is largely cultivated, but principally under the direction of the Chinese settlers. According to the authority already quoted, sugar will probably become the most important of all the exports of Siam, the soil being particularly adapted to its cultivation. Maize is extensively cultivated, particularly in the mountainous districts. The bamboo is to the natives one of the most valuable of products, being made to serve an almost infinite variety of purposes. Siam is noted for the great variety and abundance of its fruit-trees. The whole neighbourhood of Bang-kok is one forest of fruit-trees, and the products are both various and excellent. The chief fruits are the cocoanut, banana, pine-apple, tamarind, mango, guava, orange, lemon, citron, pomegranate, mangosteen, and *durian*, a fruit of an exquisite flavour, but with a very disagreeable odour. Among the other vegetable products of the country are cotton, tobacco, sago, black pepper, cardamums, sapanwood, gamboge, and gutta-percha. The Aquila, or eagle wood (*lignum aloes*) is of great consumption as a perfume among the nations of Eastern Asia.

The elephant is very common in Siam, and here that animal is said to attain its greatest perfection, being sometimes twelve or thirteen feet in height. They are extensively used throughout the country for riding and carrying burdens, except in the capital, where their use is restricted to a few persons of high rank. The destruction of even the wild elephant is prohibited, yet many are killed surreptitiously for the sake of their tusks. Tigers abound, especially in the Laos country; and the leopard and tiger-cat are common. Of ruminating animals there are several species of deer, the goat, the ox, and the buffalo. Animals of the monkey tribe are numerous. Dogs and cats are seen in large numbers in the streets and houses of the Siamese. Bears, wild pigs, and porcupines, are common in the jungles and forests. The feathered tribes are very numerous, and range from the humming-bird to the *karien*, a species of stork as tall as a man. The reptiles of Siam are multitudinous, and include crocodiles, tortoises, lizards, serpents, &c. Of insects, the *caccus lacca* produces the gum called lac in commerce.

The population of Siam is variously given, but may be estimated at from 5,000,000 to 6,000,000. It is made up of different races, the principal of which are Siamese, Chinese, Laos, Malays, and Cambojans. The Siamese are supposed to amount to about 1,800,000, and are principally located on the banks of the Menam and tributary streams south of N. Lat. 20., and down the peninsula to about N. Lat. 7. The Laos population is estimated at about 1,000,000, and principally occupy the great valley through which the Camboja flows, between N. Lat. 13. and 21. The Cambojans, who are only about half as numerous as the Laos, occupy the southern districts of the Camboja, down to the frontiers of Cochin-China. The Malayans, of whom there are probably nearly 1,000,000, occupy the peninsula south of N. Lat. 7. The Chinese settlers in Siam are estimated at about 1,500,000. (See Bowring's *Siam.*)

The government of Siam is a pure despotism, uncontrolled by laws, ancient usages, or any form of assembly. There is, indeed, a body of laws occupying, it is said, about seventy volumes, but the king has the power of at any time superseding the ordinary course of justice. He has, indeed, absolute power over the property, liberty, and lives of his subjects. There are practically three principal tribunals for the administration of justice, those of the king, the princes, and the provincial governors; but bribery prevails in every department, and from the judge down to the lowest clerk every one has his price. The king sits in public during a certain part of one day in the week for the purpose of receiving complaints. There is a second or inferior king of Siam, who exercises a kind of secondary or reflected authority, the exact nature or extent of which does not seem to be clearly defined. He is generally a brother or near relative of the king. A characteristic feature of Siamese society is the abject submission of every inferior to all who are superior to him in the social scale. "No man of inferior rank dares to raise his head to the level of that of his superior; no person can cross a bridge if an individual of higher grade chances to be passing below; no mean person may walk upon a floor above that occupied by his betters. . . . Honours almost divine, language quite devotional, humiliations the most degrading, mark the difference between sovereign and subject; and to some extent the same reverence is paid to age which is exhibited towards authority." (Bowring's *Siam.*) A large part of the population is in a state of slavery; and every man above the age of twenty is bound to devote four months of the year to the service of the king. Public officers are often made responsible for the faults of those committed to their care; and parents are frequently made to bear a part of the punishment inflicted on their children because they ought to have taught them better. The parent has absolute power over his children, and may even sell them for slaves; but he cannot take away their life. Polygamy is legal, but there is always one wife in chief who has the pre-eminence and control over the rest. Marriage is a purely civil rite, and divorces are frequent and obtained with little difficulty.

The bonzes or priests are charged with the public education, and schools are attached to most of the religious establishments. Elementary education seems to be pretty

generally diffused among the male population, and a considerable portion of them are able to read and write; but the females are almost entirely neglected. Instruction is chiefly confined to the creeds and rites of Buddhism, and there are few means of acquiring any of the higher branches of knowledge.

The religion of Siam is Buddhism. The priests or bonzes (Siamese *Phra*) are very numerous, exceeding, it is said, a hundred thousand. They generally live in convents attached to the temples, and are relieved of all taxes or services to the king or state. Every male must at some period of his life become a candidate for the priestly office, and remain for at least three months in a monastery, after which he may return to his secular condition. At the head of the priesthood is the *Sangkharat*, or high priest, who is appointed by the king, and who always resides in the palace. His authority is supreme over all the pagodas and bonzes of the kingdom; but beyond this he has no temporal or spiritual authority. The priesthood is supported by the spontaneous offerings of the people; and their duty is to atone for the transgressions of those who bestow alms upon them. They are held in the highest veneration, and are relieved from all bodily labour. The manufactures of the Siamese are few and unimportant. In the useful arts they are much behind several of the other eastern nations. In the manufacture of gold and silver vessels they display considerable skill; and the copper and iron founders are said to be ingenious workmen. The cotton stuffs which form the ordinary dresses of the people are chiefly imported from other countries; but there is a silk stuff worn only by persons in high rank and manufactured in Siam, which the Siamese boast has never been successfully imitated elsewhere. Earthenware of a coarse quality is produced by native manufacturers, and paper is made from the bark of a tree or plant called *khri*. The preparation of leather is extensively carried on.

Bangkok, the capital of Siam, was at one time the third in point of importance among the commercial cities east of the Cape of Good Hope, being inferior only to Calcutta and Canton. A long period of bad legislation, however, totally stripped it of its importance, and when visited by Sir John Bowring in 1855, "all that remained to represent foreign trade was one English (half-caste) merchant, one Armenian, and a few Anglo-Indians from Bombay and Surat." Since the treaties with England and the United States the trade has rapidly increased, and a writer in Hunt's *Merchant's Magazine*, who was there in May 1858, states that at that time there were "sixty-five large American and European ships at the city and in the roads." An increased demand for the productions of the country has given a stimulus to exertion, and already an increase in the produce of various articles has taken place. Rice and sugar are at present the staple articles of export; but gums, sapan wood, teak wood, gamboge, pepper, cocoa-nut oil, ivory, silk, cotton, and skins are also exported. A considerable trade is carried on with China.

The Siamese average about 5 feet 3 inches in height. The face is broad and flat, with large and prominent cheek-bones; the nose small but round not flattened as in the negro, and the nostrils distended; the mouth wide, with thick but not projecting lips; and the eyes small, with outer angles slightly turned up. Their skin is fairer than that of other Asiatics beyond the Ganges; and among the higher classes a bright yellow colour, almost like gold, is imparted to it by the use of a cosmetic. Their hair is black, thick, coarse, and long; and they dye their teeth black. In character the Siamese are idle, timid, and almost passionless; servile, fond of amusements, and mercenary. Lying and deceit is common to them with other oriental nations. The Siamese annals begin about five centuries before the Christian era, with the usual amount of fable; but from the founding of the city of Ayuthia, the ancient capital of the kingdom, about the middle of the fourteenth century, they seem to be tolerably reliable. (See Bowring's *Siam*.) The first European nation that established communication with Siam was the Portuguese, when engaged in the siege of Malacca in 1511. Soon after this a considerable number of Portuguese seem to have been located in the country, and we find them rendering valuable assistance to the Siamese in their wars with the neighbouring nations. About the beginning of the seventeenth century the Dutch obtained a footing in the country, and from that time Portuguese influence gradually declined. Towards the end of the seventeenth century, a Greek sailor named Phaulcon arrived in the country, and so ingratiated himself with the king as to be appointed prime minister. He persuaded the king to cultivate friendship with European countries, and induced him to send ambassadors to the Court of Louis XIV. These arrived in France in 1684, and also visited London, when a commercial treaty was concluded with the government of Charles II. The French king, in 1685, despatched an embassy to Siam, with a view to convert the King of Siam to the Catholic faith. This not succeeding, two years later a second embassy was sent out with 500 soldiers, which also failed in its object; and soon after a revolution happening in the country, the royal family were driven from the throne, Phaulcon was murdered, and the French were expelled from the country. About 1766 the country was overrun by the Burmese, who took by assault the capital, Yuthia, and committed great slaughter.

The English seem to have had little intercourse with the Siamese till very recently. In 1822 Mr John Crawfurd was commissioned by the Marquis of Hastings, then governor-general of India, to visit Siam and endeavour to establish commercial relations between that country and India, but met with comparatively little success. In 1826 a commercial treaty was concluded with England, and a similar treaty was concluded with the United States in 1833. In 1855 Sir John Bowring visited Siam, was very favourably received, and succeeded in concluding a treaty of friendship and commerce between her British Majesty and the King of Siam. A British consul is now allowed to reside at Bangkok, and British subjects may reside permanently there or within a certain distance from that town. British vessels may trade freely at any of the seaports of Siam, and in place of the previous heavy restrictions, merchandise is now subject to slight import or export duties. A similar treaty has since been concluded with the United States. For farther information regarding Siam and the Siamese see especially Sir John Bowring's ***Kingdom and People of Siam***, London, 1857.

SIBERIA. See Russia, *Asiatic*.

SIBYLS (Σίβυλλα, *Sibylla*, said to be derived from Διὸς and βουλή, signifying ***the counsel of Zeus***), in pagan antiquity, certain women said to have been endowed with a prophetical spirit, and who delivered oracles, showing the fates and revolutions of kingdoms. Their number is unknown. Plato speaks of one, others of two, Pliny of three, Ælian of four, and Varro of ten; an opinion which is universally adopted by the learned. These ten Sibyls generally resided in the following places: Persia, Lybia, Delphi, Cumæ in Italy, Erythræa, Samos, Cumæ in Æolia, Marpessa on the Hellespont, Ancyra in Phrygia, and Tyburtis. The most celebrated of the Sibyls is that of Cumæ in Italy, whom some have called by the different names of Amalthæa, Demophile, Herophile, Daphine, Manto, Phemonoë, and Deiphobe. It is said that Apollo became enamoured of her, and that to make her sensible of his passion he offered to give her whatever she asked. The Sibyl demanded to live as many years as she had grains of sand in her hand, but unfortunately forgot to ask for the enjoyment

of the health, vigour, and bloom of which she was then in possession. She had already lived about 700 years when Æneas came to Italy, and, as some have imagined, she had three centuries more to live before her years were as numerous as the grains of sand which she had had in her hand. She gave Æneas instructions how to find his father in the infernal regions, and even conducted him to the entrance of hell. According to the most authentic historians of the Roman republic, one of the Sibyls came to the palace of Tarquin II. with nine volumes, which she offered to sell for a very high price (Pliny *N. H.*, xiii. 28). The monarch disregarded her, and she immediately disappeared, but soon afterwards returned, when she had burned three of the volumes. She asked the same price for the remaining six books; and, when Tarquin refused to buy them, she burned three more, and still persisted in demanding the same sum of money for the three that were left. This extraordinary behaviour astonished Tarquin; he bought the books, and the Sibyl instantly vanished, and never afterwards appeared to the world. These books were preserved with great care by the monarch, and called the Sibylline verses. A college of priests was appointed to take care of them; and such reverence did the Romans entertain for these prophetical books, that they were consulted with the greatest solemnity when the state seemed to be in danger. When the capitol was burned in the troubles of Sylla, the Sibylline verses, which were deposited there, perished in the conflagration; and to repair the loss which the republic seemed to have sustained, commissioners were immediately sent to different parts of Greece to collect whatever verses could be found of the inspired writings of the Sibyls. The fate of these Sibylline verses, which were collected after the conflagration of the capitol, is unknown. There are now many Sibylline verses extant, but they are universally reckoned spurious; and it is evident that they were composed in the second century by some of the followers of Christianity, who wished to convince the heathens of their error, by assisting the cause of truth with the arms of pious artifice.

SICARD, Abbé. See Deaf and Dumb.

SICILIES, KINGDOM OF THE TWO.

The whole of this kingdom, denominated in Italian the *Regno delle Due Sicilie*, has an area of 32,530 geographical square miles, and a population, in January 1855, of 9,088,377 inhabitants. It extends in N. Lat. from 36. 38. to 42. 55., and in E. Long. from 12. 25. to 18. 30. Some of the smaller islands, however, extend far beyond these limits. It is bounded on every side by the sea, except on the N.W., where it comes into contact with the Papal States. Being situated on both sides of the Straits of Messina, it is naturally divided into two portions, which are distinguished by the official appellation, Naples, or the continental part, of *Dominî al di quà del Faro;* and Sicily, or the island part, of *Dominî al di là del Faro.*

The continental part, or *Dominî al di quà del Faro*, called also *Regno di Napoli*, comprises the southern and most beautiful half of the Italian Peninsula. It forms the ankle, spur, heel, and foot of the boot (*lo Stivale*) to which the configuration of Italy is often compared. It extends in N. Lat. from 37. 55. to 42. 55, and in East Long. from 13.15 to 18.30., and has an area of 24,971 geographical square miles, and a population (in January 1855) of 6,857,357 inhabitants. It is bounded on the N.W. by the States of the Pope, on the W., as far down as the Straits of Messina, by the Tyrrhenian, on the S.E. from the Straits to the Cape of Leuca, by the Ionian, and on the N.E. by the Adriatic Sea. The frontier line on the N.W., nearly the same as it was at the foundation of the monarchy in 1130, is, with its windings, about 185 miles, and in a direct line 105 miles long. It extends from the north bank of the river Tronto, on the Adriatic, across the chain of the Apennines, to the small stream of San Magno near Portella, on the Tyrrhenian Sea, 2 miles east of Terracina.

The length of the kingdom from the Tronto to the Capo dell' Armi, following the curved line of the Apennines, is 350 miles; and its greatest breadth from the Punta della Campanella, opposite the Island of Capri, to Brindisi, on the Adriatic, from W. to E., is about 200 miles. South of that line it becomes very narrow; from the mouth of the Crati, on the Ionian, to Cirella, on the Tyrrhenian Sea, it is not more than 29 miles; and only 16 miles between the gulfs of Sta. Eufemia and Squillace, farther south.

The physical geography of the country is chiefly determined by the chain of the Apennines, which, by their numerous ranges, offshoots, and valleys, cover most of its surface, and greatly contribute to its variety and picturesque beauty. These mountains, which have already been described in this work under head Italy, on entering the kingdom on the N.W. from the papal territory, branch into two lofty ranges, one of which, keeping so near the Adriatic as to leave only a narrow strip of lowland along the shore, attains the greatest elevation of the whole chain in Monte Corno, called also the Gran Sasso d'Italia, 10,154 English feet, and Monte Amaro, the highest peak of the Maiella group, 8956 feet above the level of the sea. The western range, sweeping round the sources of the Aterno, forms the high peaks of Monte Velino, 7780 feet, and Monte Greco, 7875 feet, and unites again with the other in the high tableland of the Piano di Cinquemiglia, whence the main chain keeps more in the centre of the Peninsula, and at La Meta swells to an elevation of 7480 feet. From this point the main chain, in its progress southwards, keeps constantly in the centre of the Peninsula, but scatters in a confused and irregular mass over a great tract of country, and sends important offshoots east and west, till it forms the lofty central group of the Terminio, in Lat. 41 and Long. 15. 25. The Terminio is at once the boundary of the provinces of Principato Ultra, Principato Citra and Capitanata, and the watershed whence four of the most important rivers in the kingdom—the Sele, the Calore, the Sabato, and the Ofanto—begin their course. The highest peaks of this part of the chain are Monte Mileto, in the Matese group, 6745 feet, and the Terminio itself, 5680 feet.

From the Terminio the Apennines take an eastern direction, and form the lofty group between Rionero and Potenza, which divides the basin of the Ofanto from those of the Bradano and the Basento, and from near Lagopesole send south-east an offshoot, which encloses the Apulian plain, and gradually diminishing in height, ends at the Cape of Sta. Maria di Leuca. From Potenza they take a southern course, and approaching the Tyrrhenian Sea at the head of the Gulf of Policastro, swell into the high table-land of Campotanese, and the lofty group of the Pollino, which in Dolcedorme, its highest peak, attains an elevation of 6875 feet. From that group the chain, scarcely receding from the sea-shore, rises at Monte Cocuzzo to 5620 feet, forms the high table-land of La Sila, and sinks abruptly south of Tiriolo to such an insignificant elevation between the Gulfs of Squillace and Sta. Eufemia, as to have often suggested the idea of a canal across the low neck of land that separates them. Immediately to the south of that neck the mountains rise again, and form the lofty group of the Aspro-

monte, which in Montalto, its highest peak at the toe of Italy, attains an elevation of 4380 feet.

Totally detached from the chain of the Apennines, from whose nearest slopes it is separated by an extensive plain, called the Tavoliere di Puglia, rises the isolated group of Monte Gargano (*Garganus*), a lofty promontory, boldly projecting east for the length of 35 miles into the Adriatic, between the mouth of the Fortore on the north-west and the Gulf of Manfredonia on the south-east. Its highest peak attains an elevation of 5120 feet above the level of the sea.

The Apennines, as well as the Gargano, which belongs to the same geological formation, consist chiefly of limestone; primary rocks crop out, but to no great extent, in the Maiella group, among the mountains of Montecorvino, in the Pollino, &c. The group of the Aspromonte, however, is chiefly a granite mass, and in its geological character is more like the Madonia Mountains on the opposite coast of Sicily than like the Apennines.

Enclosed or in part surrounded by the Apennines, but totally distinct from them both in their geological formation and physical character, are the volcanic districts of Campania and Apulia. The former consists of the three groups of Roccamonfina, the Flegraean Fields, and Vesuvius; the latter of Mount Vulture.

The volcanic hills of Roccamonfina rise 4 miles north-east of the towns of Sessa and Teano, nearly midway between the Volturno and the Garigliano. The outer edge or circular ridge of their great crater encloses a space of 9 miles in circumference, within which are two smaller cones, the highest of which, called Montagna di Sta. Croce, is 3200 feet above the level of the sea. The lavas of Roccamonfina are easily distinguished by their colour, and their large crystals of leucite. The volcanic tufa, which is found in large deposits along the banks of the Garigliano and the Volturno, and in some of the lower valleys of the Apennines on the frontier of Terra di Lavoro, is supposed to have been emitted by this volcano. Roccamonfina has shown no signs of activity in historical times.

The Flegraean Fields comprise the country between the banks of the Lagno and the Sebeto, as well as the adjoining islands of Nisida, Procida, and Ischia. They contain numerous large and small craters, and several cones, the highest of which are—Monte San Nicola (*Epomeus*) in Ischia, 2610 feet; Monte Barbaro (*Gaurus*), 1860 feet; and Camaldoli, 1488 feet. Monte Barbaro, composed of beds of loose scoriæ and pumiceous tufa, has a deep crater of 3½ miles in circumference, enclosing a plain of great fertility, which is entered by a break on the east wall of the crater. A larger crater is that of the Astroni, which is 4½ miles in circumference, and quite unbroken. Its interior is covered with large ilexes and oaks. The Flegraean Fields, in which are the Fusaro, Lucrino, Averno, and Agnano lakes, have been active in historical times. From the south-east wall of the Solfatara crater, midway between Pozzuoli and the Lake of Agnano, a stream of lava poured forth in 1198, which crossed the ancient Via Puteolana, and reached the sea. Even at present, from the crevices within the Solfatara, steam and noxious gases constantly exhale, and flames are occasionally seen at night. From the flanks of Mount Epomeo, in Ischia, a stream of lava containing a large quantity of felspar, issued in 1302, and descended to the shore, 2 miles off. And in 1538, after a succession of violent earthquakes, on the 28th, 29th, and 30th of September, the country round Pozzuoli was convulsed by eruptions of steam, pumiceous ashes, lapilli, scoriæ, and black mud, which elevated the whole coast from Miseno to Cape Coroglio, and raised, 1½ mile west of Pozzuoli, a conical hill called Monte Nuovo, 440 feet high and 1½ mile in circumference, on the spot where the village of Tripergola and part of Lake Lucrino stood. The tufa hills, on the slopes of which the city of Naples is built, belong to the Flegraean group.

Mount Vesuvius, one of the most active volcanoes in the world, an account of which will be found in this work under head VESUVIUS, rises to the east of Naples, between the shore of the bay, on the south, and the Apennines, on the north and east. It is 30 miles in circumference, and at a certain height divides into two points; the Somma, whose highest peak, the Punta del Nasone, is 3747 feet above the level of the sea, and Vesuvius proper, which, at the Punta del Palo, on the north brim of the crater, attains an elevation of 3949 feet. The height of the eruptive cone is subject to great variations; in March 1850 it was 4235; and in June 1858 it had been lowered to 4075 feet. At the commencement of the Christian era Vesuvius was considered as an extinct volcano, and no records existed of its having burned in historical times. But under the reign of Titus, in A.D. 79, on the 24th of August, after a succession of earthquakes, which had begun some years before, a tremendous explosion took place, which is memorable as the eruption that destroyed Herculaneum, Pompeii, Stabiae, and several smaller villages on the slopes of the mountain, and caused the death of Pliny the naturalist, whose nephew, Pliny the younger, has left us an interesting account of the event. Since that time Vesuvius has not ceased to be more or less active, and till 1858 more than fifty-six great eruptions, not to count smaller ones, had taken place, of which there are historical records.

Mount Vulture rises at the west end of the Apulian plain, on the frontier of Basilicata, out of the cretaceous macigno formation of the Apennines, which surround it almost on every side. It has shown no activity in historical times; and the absence of streams of lava, coupled with the beds of travertino resting in several places on the volcanic formation, prove its very great antiquity. Its inner regions are clothed with forests, and within its widest crater there are two small lakes. It has several cones, but the central and highest peak, called Il Pizzuto di Melfi, attains an elevation of 4357 feet above the level of the sea.

The surface and physical character of the provinces vary very much. The three provinces of the Abruzzi and the adjoining province of Molise, are almost entirely covered by mountains, and high table-lands and valleys, which give them a pastoral more than an agricultural character. Some of the valleys are of great fertility, especially the beautiful valley of Sulmona, watered by the Gizio and the Sagittario; but in general they have a cold climate, and southern plants do not thrive well. Between the valley of Sulmona to the north, and the valley of the Sangro to the south is the Piano di Cinquemiglia, a high table-land about 4300 feet above the level of the sea, and surrounded by higher mountains, which enjoys the privilege of being the most wintry spot in Italy. The high road from Naples to the Abruzzi is carried through it; but the sudden snowstorms and strong winds to which the table-land is exposed make it dangerous, and often impassable in winter, and sometimes even late in the spring. On its southern end is Roccarasa, the most elevated village in Italy, being 4370 feet above the level of the sea. To the east, along the shore of the Adriatic, there is a plain extending from the slopes of the Apennines to the sea, varying from 1 to 13 miles in breadth. This strip of lowland has a mild temperature, favourable to the growth of the olive-tree, and, in some more sheltered situations, even of the orange.

The province of Terra di Lavoro is covered to the east by the lofty groups of the Mainardi, the Matese, and the Taburno, part of the main chain of the Apennines; to the north-west by an offshoot, which descends to the sea between Terracina and Gaeta; and that of Naples to the

south-east has a lofty offshoot, which forms the mountains of La Cava Castellammare and Sorrento, and enclosing the Bay of Naples to the east, ends opposite the island of Capri. Within those boundaries is the great Campanian plain, celebrated in ancient as well as in modern times for its inexhaustible fertility. Strabo calls it the richest plain in the world. Its uniformity is broken by the two volcanic groups of the Flegraean Fields and Mount Vesuvius. It has a volcanic soil, but near the foot of the mountains it is covered by a detritus of gravel, washed down by the heavy rains. The small state of Pontecorvo, belonging to the Pope, is inclosed in the Terra di Lavoro.

Principato Ultra is traversed by the range of the Apennines, which, with their offshoots, cover most of its surface. The large valley, in the midst of which the city of Avellino, the capital, is situated, is of considerable fertility; but as a whole it is a poor district. In the heart of this province is Benevento, the capital of a territory of 45 square miles belonging to the Pope. Napoleon conferred it on Talleyrand, but the Congress of Vienna restored it to the Holy See.

In Principato Citra, on the south-west, bordering the Gulf of Salerno, is a vast plain, 28 miles long, and from 2 to 12 miles broad. It is surrounded by the Apennines on all sides, except on the west, where it is bounded by the sea. To the east is the great mass of the classic Alburno (*Alburnus*), the lower buttresses of which are washed by the Sele. Four miles from the left bank of this river towards the south end of the plain, are the ruins of PAESTUM, already described in this work. The plain is at present little cultivated, and visited by malaria. The surface of the rest of the province is of a mountainous character.

Basilicata is in great part covered by the main range and numerous offshoots of the Apennines, except on the south-east, where a large and rich tract of flat country extends from the foot of the mountains to the Gulf of Taranto. This plain is watered by the Bradano and the Basento, and though at present in great part a waste, in ancient times it was the source of the wealth and prosperity of Metapontum. To the south-west there is a smaller plain, on the Gulf of Policastro, near the site of ancient *Velia*. The centre of Basilicata is the wildest, least civilized, and poorest district in the kingdom.

Nearly two-thirds of the area of the three provinces into which Calabria is divided are also of a mountainous character, especially on the western side. On the eastern shore there is a large extent of low country, a continuation of the great plain of Basilicata, watered by numerous streams, and possessing great fertility and a very mild temperature. Sybaris, Thurium, Croto, and other cities of Magna Græcia, flourished on this plain, which now is in great part deserted. In the heart of Calabria there is a vast mountain table-land called La Sila (*Sila*), about 40 miles long and from 16 to 20 miles broad, which extends through the greatest part of Calabria Citra and enters Calabria Ultra II. Its highest peaks are clothed with magnificent firs (*Pinus silvestris*), and the lower ones with oak, beeches, and elms. It is intersected by numerous ravines, and well watered by several streams, which give it excellent pasturages in summer. The forests of La Sila were well known to the ancients, and to this day supply the greatest amount of timber to the royal navy of Naples. The Piana di Monteleone, and the plain of Gioia, on the west shore of Calabria Ultra I., offer extensive tracts of rich lowland, covered chiefly with olives, oranges, and other trees of southern climates.

Capitanata, Terra di Bari, and Terra d'Otranto, which are known by the general denomination of Puglia (*Apulia*), are almost an unbroken level country, stretching from the slopes of the Apennines to the shores of the Adriatic and the Ionian Sea. The northern part of Puglia, called *Puglia Piana*, forming the province of Capitanata, and extending from the Tiferno to the Ofanto River, consists of a great plain called the *Tavoliere di Puglia* which slopes gently from the mountains to the sea, where it is bounded by the isolated group of Mount Gargano. The Tavoliere, which is about 80 miles long and 30 miles broad, belongs almost entirely to the crown, and is chiefly laid out in pasture. Its surface is covered with wild capers, and the only trees to be seen are, here and there, some wild pears. From October to May it is enlivened by about 2,500,000 sheep, which descend from the mountains of the Abruzzi and Molise, where they pass the summer months.

The south part of Puglia, called *Puglia Pietrosa*, and including Terra di Bari and Terra d'Otranto, has, on the south-west, a chain of low rocky hills, called *Le Murgie* (an offshoot of the Apennines, from which they branch off near Venosa), which divide it from Basilicata, and gradually sink into insignificance as they descend south-east to the Cape of Sta. Maria di Leuca. The flat country continues between the Murgie and the sea for more than 56 miles from the Ofanto to Monopoli, where the Murgie come so near the Adriatic as to leave only a narrow strip of lowland till near San Vito, whence to the Cape of Leuca it is but an undulating plain, with some rising ground in the centre. On the Gulf of Taranto the surface of Terra d'Otranto is also generally flat, and joins the plain of Basilicata near the banks of the Bradano.

The Neapolitan rivers, owing to the absence of tides, have no harbours of any use at their mouths, except for small boats; but they greatly contribute to the fertility of the country, and would do more so if, instead of letting them, by their overflowing, flood the country and produce marshy plains and malaria, the natural advantages they offer for a vast system of embanking and irrigation were properly turned to account. The most important of them are—

On the western coast, the Liri or Garigliano (*Liris*), which drains the valleys west of Lake Fucino, and an extensive district of the Papal States. It rises in several distinct springs from the side of a conical hill, below the village of Cappadocia, in the midst of a most wild and picturesque scenery, in the Abruzzo Ultra II. It flows at first in a south-east direction through the alpine valleys of Nerfa and Roveto, receiving several small mountain-streams, till it emerges into the open country, at Sora, where it takes a turn to the south-west, and forms a series of small cascades (*le Cascatelle*), below the *Insula Fibreni* of Cicero. On being joined by the Fibreno (*Fibrenus*), a small clear stream which issues from the Lake of Posta, it forms, 4 miles below Sora, the Falls of Isola, about 100 feet high, one of the most remarkable waterfalls in Italy. Below Isola the Liri again bends its course to the south-east, and soon after passing Ceprano receives the Sacco or Tolero (*Trerus*), its most considerable tributary, the sources of which are 40 miles higher up, in the elevated district between the Palestrina and the Lepini mountains. After this junction it takes the name of Garigliano, and on receiving, 5 miles lower down, the waters of the Melfa (*Melfis*), which rises in the flanks of the Meta, it resumes abruptly a south-west direction, and after a course of 60 geographical miles, enters the sea near the site of ancient *Minturnæ*, in the Bay of Gaeta. In the lower part of its course it is navigable for boats; and near its mouth it has a suspension-bridge, over which the high road from Rome to Naples is carried.

The Volturno (*Vulturnus*), which drains great part of ancient *Campania* and *Samnium*, rises among the Samnitic Apennines 5 miles south of Alfidena, and emerging into the Campanian plain below Venafro, follows a south-east course till it is joined by the Calore. Turning thence to the west-south-west, it flows round the walls of Capua (the ancient *Casilinum*), and after a course of 100 miles,

falls into the sea 20 miles below that city, near the village of Castel Volturno, midway between the mouth of the Garigliano and the site of ancient *Cumæ*. It is a deep, rapid, and turbid stream, and subject to sudden and great overflowings of its banks.

The Calore (*Calor*) rises in the group of the Terminio, and flowing first north and then west, after a course of 60 miles, unites with the Volturno near Caiazzo. Its two principal tributaries are the Tamaro (*Tamarus*), which rises near Boiano, in the province of Molise, and joins the Calore 5 miles above Benevento; and the Sabato (*Sabatus*), which also rises in the group of the Terminio, and taking a different course, unites eventually with the Calore, just below Benevento.

The Sarno (*Sarnus*), which drains the plain east of Vesuvius, springs as a clear and abundant stream from a perpendicular rock behind the town of the same name, and after a course of about 20 miles, falls into the Bay of Naples, 3 miles north of Castellammare. In ancient times it flowed under the walls of Pompeii, and entered the sea close to its gates. The great eruption of Vesuvius of A.D. 79, by filling up an arm of the sea, changed the course of the Sarno, whose mouth at present is two miles from Pompeii.

The Sele (*Silarus*) drains the province of Principato Citra, and has a course of 64 miles. It rises near the town of Caposele, in the group of the Terminio, not far from the sources of the Ofanto, and flows south till it receives the Tanagro (*Tanager*), a considerable stream which rises in the mountains of Lagonegro, drains the broad valley of Diano, and after a course of 30 miles, unites with the Sele, north of Mount Alburno. The Sele takes thence a south-west direction, skirts the north-west basis of the latter mountain, traverses the plain of Pæstum, where it receives the Calore, which rises among the mountains of the Cilento, and falls into the Bay of Salerno, 5 miles north of the site of Pæstum.

From the mouth of the Sele to the Straits of Messina, the range of the Apennines coming too near the Tyrrhenian shore, there are no rivers, but numerous mountain-torrents, each draining its own valley, and often dry in summer. The most important of these streams are, proceeding from north to south, the Alento, the Molpa (*Melpes*), the Mingardo, the Basento, the Lao (*Laus*), which fall into the Gulf of Policastro, the Savuto (*Ocinarus*), and the Lamato into the Gulf of Sta. Eufemia; and the Mesima and Marro (*Metaurus*), which drain the plain of Gioia and the Piana di Monteleone, and fall into the Gulf of Gioia.

The principal rivers that flow into the Adriatic are—the Tronto (*Truentus*), which divides Naples from the States of the Pope, and drains both frontiers. It rises among the mountains of Amatrice, and is navigable for boats only a few miles above its mouth. The Tordino, the sources of which are near those of the Tronto, and the Vomano (*Vomanus*), which rises in the lofty group of the Gran Sasso, empty themselves at a short distance from each other. The Pescara, which in the upper part of its course preserves its ancient name of *Aternus*, drains the whole valleys of Aquila and Sulmona, and the south-west slopes of the Gran Sasso. It rises near S. Vittorino, in the Abruzzo Ultra II., and flows south-east through a broad elevated valley more than 2000 feet high, from which it escapes into the lower valley of Sulmona, by a narrow gorge in the mountains, through which the ancient *Via Valeria* was carried. At Popoli the Aterno unites with the Gizio and the Sagittario, which descend from the Maiella group and drain the valley of Sulmona, and taking the name of Pescara and a north-east course, falls into the sea at the fortress of that name.

The Sangro (*Sagrus*) rises in the group of mountains that enclose the basin of Lake Fucinus on the south-west, and follows a south-east direction through an upland valley shut in on the north by the lofty Monte Greco. From this upper basin it emerges through a narrow gorge into a lower valley, passes under Castel di Sangro, and turning abruptly to the north-east, after a course of more than 70 miles, falls into the sea midway between Ortona and Vasto. The Trigno (*Trinius*), which has a course of nearly 60 miles from west-south-west to east-north-east, rises among the mountains of Agnone, and falls into the sea 7 miles south of Vasto. The Biferno (*Tifernus*) rises near Boiano, on the north slope of the lofty group of the Matese, and after a course of more than 60 miles from south-south-west to east-north-east, falls into the sea 4 miles south of Termoli. The Fortore (*Frento*), about 50 miles long, has its sources in the mountains of La Riccia and Baselice, and its mouth north of the Lake of Lesina, in Capitanata, opposite the group of the Tremiti Islands. The Cervaro (*Cerbalus*) and the Carapella have their sources at a short distance in the mountains of Ariano and Trivico, traverse parallel to each other the Apulian plain, and fall, the former into the Pantano Salso, and the latter into the sea, south of Manfredonia. The Ofanto (*Aufidus*), the largest of the rivers of this part of Italy, rises in the lofty group of the Terminio, about 24 miles from the Tyrrhenian Sea, and after a course of more than 80 miles, discharges itself into the Adriatic, 6 miles north of the city of Barletta. At first it flows south-east, but, checked in its course by the volcanic group of Mount Vulture, by a sudden turn north-west, sweeps round the foot of that mountain, and emerging into the Apulian plain, traverses it from south-south-west to east-north-east, as far as the sea, passing a mile below Canosa, and by the site of ancient *Cannæ*.

From the mouth of the Ofanto to that of the Bradano, a coast line of nearly 300 geographical miles, there are no rivers, and scarcely any torrents which are not dried up in summer.

The Bradano (*Bradanus*), which separates the provinces of Basilicata and Terra d'Otranto, issues out of the small Lake of Pesole, 5 miles south-east of Atella, and draining an extensive hilly tract of Basilicata, falls into the Ionian Sea north of the site of ancient Metapontum. The Basento (*Casuentus*), the sources of which are near those of the Bradano, the Salandrella (*Acalandrus?*) the Agri (*Aciris*), and the Sinno (*Siris*), all rise on the east flank of the Apennines in their progress from Potenza towards the Gulf of Policastro, and flowing nearly parallel to each other from north-west to south-east, especially in the latter part of their course, discharge themselves at a short distance of each other into the Gulf of Taranto.

The Crati (*Crathis*), the largest river of Calabria, rises in the table-land of La Sila, a few miles south of Cosenza, under the walls of which it flows, and after a course of 64 miles, discharges itself into the Gulf of Taranto, midway between Capo Spulico and Capo del Trionto, to the south of some ruins which mark the site of *Thurii*. At first it flows due north, but after its junction with the Mucrone, which drains the western Sila, it turns abruptly to the north-east, and finally due east till it falls into the sea. Three miles above its mouth it receives the waters of its principal tributary, the Coscile (*Sybaris*), a considerable stream that rises in a wooded dell below the west flanks of the Pollino, and drains the north frontier of Calabria. In ancient times the Sybaris had a separate outlet into the sea. South of the Crati, the Neto (*Neæthus*), remarkable for the rich pastures of its banks, is the only other stream of any consequence as far as the Straits of Messina. It rises in the east flank of the Sila, and falls into the Ionian Sea 9 miles north of Cotrone.

The Lake Fucino (*Fucinus*), called also Lake of Celano, from the city of that name on its north-east shore, is the

largest lake of the kingdom. It is embosomed in the high Apennines of the Abruzzo Ultra II., at an elevation of 2230 feet above the level of the sea, and has a circumference of 35 miles, and an area of 36,315 acres. Its deepest part in 1853 was 53 feet, but it is subject to great rises and falls. Its shores are often frozen in winter, but the lake itself is known to have been frozen only five times since the twelfth century. Numerous small streams flow into it, but there is no visible outlet. The Romans made several attempts to relieve the towns on the shores from its destructive inundations, till at length the Emperor Claudius caused an emissary to be constructed at his own expense, on condition of getting from the *Marsi* the land reclaimed by the drainage. To this effect a tunnel 3 miles and 788 yards long was cut under Mount Salviano and the Campi Palentini, partly through a solid calcareous rock, and partly through a loose slaty marl, by means of which the waters of the lake were conveyed into the Liris, at the head of the valley of Roveto, below the modern village of Capistrello. This tunnel was aired by numerous perpendicular shafts along its course. Having been choked up during the middle ages, the Neapolitan government in 1826 undertook to repair it; but the works had little advanced in 1852, when the government granted all the lands that can be reclaimed by drainage to a company, who are now carrying out the works, the estimate of which is set at L.217,000.

The Lake of Scanno, situated among the mountains that enclose the valley of Sulmona on the west, in the Abruzzo Ultra II., is about 5 miles in circumference, and one of the most sequestered and finest lakes in Italy; it discharges its surplus water by means of the Sagittario, a tributary of the Pescara. The Lake of Fondi (*Lacus Fundanus*), between the town of that name and the sea, in the Terra di Lavoro, near the Papal frontier, is about 7 miles in circumference, but very shallow and marshy. The small lakes of Matese and Telese are in the same province; the former, on the summit of the Matese mountains, is 3 miles in circuit, and well stocked with trout; the other, at the south-west foot of the same group, is a pool, which renders the neighbourhood unhealthy by the exhalation of sulphuretted hydrogen.

In the district of Pozzuoli, near Naples, are several small lakes which, with the exception of Patria and Licola, are evidently of volcanic origin. The Lake of Patria (*Literna Palus*), a lagoon near the shore, 7 miles south of the mouth of the Volturno, is formed by the Lagno (*Clanius*), a sluggish stream which rises near Avella, and drains part of the Campanian plain. On its shore was *Liternum*, where Scipio Africanus had a villa in which he died in voluntary exile 184 B.C., ordering that on his tomb should be inscribed, *Ingrata Patria, ne ossa quidem mea habes.* The name of Patria was derived from a fragment of this inscription built into the walls of a martello tower, hence called *Torre di Patria.* On the same shore, a few miles south, is Licola, a small marshy lake, supposed to have originated with a canal begun by Nero to connect Lake Avernus and the Tiber.

The Lake Fusaro (*Acherusia Palus*) between Cape Miseno and the site of *Cumæ,* of which it was once the port, is supposed to be the crater of an extinct volcano. A sandy bar separates it from the sea, with which it communicates by a canal. It has brackish water, and is now famous for its oysters. Two miles from the Fusaro, at the bottom of the Bay of Baiæ, is the Lucrino (*Lucrinus*), now a narrow marsh filled with reeds, and protected from the encroachments of the sea by a dyke of remote antiquity. Formerly it was larger and deeper, and supplied the Roman epicures with oysters and mussels—

> "Murice Baiano melior Lucrina peloris,
> Ostrea Circeis."—Hor. *Sat.* ii. iv. 32.

But the volcanic eruption of September 1538 filled up one half of it by the formation of Monte Nuovo. About half a mile from the Lucrino, and west of Monte Nuovo, is Lake Averno (*Avernus*), 1½ miles in circumference, 4 feet above the level of the sea, and about 250 deep. It is clearly the crater of an extinct volcano, and is embosomed among steep hills of volcanic tufa on all sides except the south, where it communicated formerly with the Lucrino by a canal cut by Agrippa, who converted the two lakes into a port (*Portus Julius*) for a portion of the Roman fleet, which gave in it a representation of the naval battle of *Actium,* in the presence of Augustus. This canal was also filled up by the eruption of Monte Nuovo, but since 1857 the government has begun to re-open it with a view of converting Lake Averno into a great wet-dock, in which part of the royal navy might be safe from an attack. The poisonous qualities ascribed to Lake Avernus no longer exist.

> "Quam super haud ullæ poterant impune volantes
> Tendere iter pennis. Talis sese halitus atris
> Faucibus effundens, supera ad convexa ferebat:
> Unde locum Graii dixerunt nomine Avornum."
> —Virg. *Æn.* vi. 239.

Water-fowl are seen upon it in winter, and its fresh waters, in which men bathe with impunity, are well stocked with tench and other fish. On its shores there are several remains, the most interesting of which are—on the east side, a large ruin, octangular externally and circular within, more than 100 feet in diameter, and called the Temple of Apollo, but supposed to have been a Hall of Baths; on the south side, a tunnel called the Cave of the Sibyl (*Grotta della Sibilla*), cut through the tufa cliffs, probably by Cocceius under Agrippa's orders, to open a shorter and covered communication between the Lucrino and the Averno.

The Lake of Agnano, 2 miles north-east of Pozzuoli, is 3½ miles in circumference, and enclosed by volcanic hills. It is a source of malaria to the surrounding district, especially in summer, when large quantities of hemp are steeped in its waters. As neither the lake, nor the crater in which it is placed are mentioned by any of the Roman authors, it is thence inferred that they must have been formed by some volcanic changes during the dark ages. On the south-east bank of the lake is the celebrated *Grotta del Cane,* so well described by Addison, who visited it in the beginning of the last century. It is a small aperture at the foot of the hill, resembling a cellar, from the floor and sides of which there is constantly exhaling carbonic acid gas, which from its greater specific gravity rises only to a certain height, leaving the upper part of the cave free from its effluvia. Addison found that a pistol could not go off at the bottom of the cave, and that animal life of any kind was extinct in a few minutes. The grotto has received its name from experiments being generally practised upon dogs.

The lake, or rather pool, of Ansanto (*Amsanctus*) is worth noticing merely for its celebrity,—

> "Est locus, Italiæ in medio sub montibus altis,
> Nobilis, et fama multis numeratus in oris,
> Amsancti valles." Virg. *Æn.* vii., 563.

It is placed in a deep crater-like valley, among limestone hills, 2 miles S.E. of Frigento, in the province of Principata Ultra, and consists of two ponds, the largest of which is only 160 feet in circuit, and 7 feet deep. The water is dark and muddy, and from the carbonic acid gas and sulphuretted hydrogen that is constantly escaping, it appears to be in violent ebullition, though its temperature little exceeds that of the surrounding atmosphere. Near it are seen bones of birds, arrested on their wings in crossing the valley by the noxious exhalations.

The Lake of Lesina, at the N.W. foot of Mount Gargano, close to the right bank of the Fortore; the Lake of

Varano, at the N. foot of the same mountain; the Pantano Salso, close to the sea-shore, 3 miles S. of Manfredonia; and Lake Salpi, 5 miles further S.E. along the coast, all in the province of Capitanata, are the other lakes of any size. The Lake Salpi (*Palus Salapina*), 11 miles long and 2 broad, is of salt water, and has an artificial outlet by a canal through the low sandy bank that separates it from the sea. On its western shore stood *Salapia*, an important city of *Apulia*, of which the lake is supposed to have been the port. The lakes of Posta, 4 miles E. of Sora, in the Terra di Lavoro; Dragone, near Volturara, in Principato Ultra; and Pesole, and Serino (*Lacus Niger*), in Basilicata, are so small as to require no particular notice.

The Two Sicilies possess a larger extent of sea-coast than, with the exception of Great Britain, any other country in Europe. The most productive parts of the kingdom, as well as the most densely inhabited, are near the coast; and in surveying it the most interesting recollections of classical history are revived. In the continental part there are 1134 miles of coast, of which 392 are washed by the Tyrrhenian, 374 by the Ionian, and 368 by the Adriatic Sea.

The whole Tyrrhenian coast is for the most part bold and rocky, and though ill furnished with good harbours for large vessels, has several projecting headlands, deep indentations, and capacious bays affording a good anchorage. Of these bays the most northern is that of Gaeta (*Sinus Caietanus*), shut in on the north by the projecting headland on which the city and fortress of Gaeta are situated. It is capacious, with good anchorage ground at a depth of from 12 to 14 fathoms at the north-west end of the citadel. Gaeta is the strongest fortress in the kingdom; in 1798 it was disgracefully surrendered by the Swiss General Tschudy to the French, who, in their turn, surrendered it to the Bourbons in 1799. In 1806 it sustained a memorable siege, well known from the operations of our navy in support of the besieged against the French. Since 1848 its fortifications have been so much extended and strengthened as to render it one of the strongest places in Italy.

South and south-west of Gaeta, at a distance from 28 to 36 miles, are the small islands of Palmarola (*Palmaria*), Ponza (*Pontia*), Zannone (*Sinonia*), Ventotene (*Pandataria*), and San Stefano. They are all of volcanic origin, except Zannone, which is of limestone, covered by trachyte. Ponza, the largest, is 12 miles in circumference. At San Stefano, the smallest, there is the Ergastolo, or prison for life, for state as well as common criminals.

The next bay to the south is that of Naples, generally considered as one of the most beautiful and interesting in the world. The Greeks called it *Crater*, on account of its form, a name still given to it by the local hydrographers. At its entrance are the islands of ISCHIA and PROCIDA to the north-west, and the island of CAPRI to the south-east, which are all described under their respective heads. Its width from Ischia to Capri is 14 miles, and its depth from W. to E. 16 miles; its circuit from the Capo della Campanella on the S.E., to the Capo di Miseno, on the N.W., is more than 30 miles, and nearly 48 if the islands are included. The head of the bay washes the foot of Vesuvius. On its west side, the low range of volcanic hills which end in the promontory of Posilipo, form the two inner bays—of Naples on the east, and of Pozzuoli on the west. The latter includes the smaller sheltered Bay of Baiæ, and is bounded to the south-west by the Cape of Miseno. The Bay of Baiæ has a hilly and sterile coast of volcanic tufa, and being subject to malaria, is nearly deserted. Yet in ancient times all its shores were thickly inhabited, and covered with towns and magnificent villas belonging to the wealthy Romans, who preferred Baiæ to any other residence in the world.

"Nullus in orbe sinus Baiis prælucet amœnis."—*Hor. Ep.* i., i, 83.

The whole shore is covered with ruins, in several places advancing into the sea, upon which the Patrician villas had encroached.

> "Marisque Baiis obstrepentis urges,
> Summovere littora,
> Parum locuples continente ripa."—*Hor.* Od. ii., 17, 17.

In the tufa of the promontory of Miseno are excavated vast caverns, supposed to have been magazines for the Roman fleet stationed in a port sheltered by the Cape, three piers of which are still to be seen under water on the opening into the inner basin called Mare Morto. On the Cape itself are vast remains of a theatre and other buildings. The Bay of Baiæ offers very safe and sheltered anchorage.

In rounding the small island of Nisida and the Cape of Posilipo, the inner Bay of Naples opens to the eyes with its shores thickly dotted with buildings and gardens. The city of Naples presents itself rising in the form of an amphitheatre from the sea-shore to the slopes of the surrounding hills, and, beyond the city, a vast plain, richly cultivated and watered by the winding little stream Sebeto. On the eastern side of the bay, Vesuvius, with its double summit, rises in majestic solitude from the plain, clothed with rich vegetation to about one-half of its height, and the other half barren and furrowed by streams of basaltic lava. Along its base and on its sides are scattered numerous villages and villas built on streams of lava, which successive eruptions of ashes and pumiceous fragments have covered with the most fertile of soils. On the sea-shore, at the south-west foot of Vesuvius, 4 miles from Naples, are the large villages of Portici and Resina, built over ancient HERCULANEUM; 6 miles further east was POMPEII. Both cities being described in this work under their respective heads, we abstain here from any further notice of them. The harbour of Naples is three or four fathoms in its deepest part; it is protected by a mole that makes it safe for ships once within it, but after a S.W. gale it is not easy to enter it. The anchorage of men-of-war is outside the mole, about 1 mile S.S.E. of the light-house, where there is a depth of from 25 to 38 fathoms. Ships can be conveniently supplied with water at the mole.

At the furthermost eastern recess of the bay, where the coast suddenly bends west, is the town of Castellammare, built on the lower slopes of Monte Santangelo, and along the sheltered beach of a small bay, bounded on the N.W. by Capo Bruno, and on the S.W. by Capo Orlando. It arose from the ruins of Stabiæ, which was destroyed by the eruption of Vesuvius of A.D. 79. The port, with four fathoms of water, and protected by a mole, is secure, and contains the dockyards in which the largest ships of the royal navy are built. The S.E. boundary of the Bay of Naples is formed by the mountains that from Castellammare extend to the Capo della Campanella, which is divided from the island of Capri by a canal 4 miles broad, and from 60 to 80 fathoms deep, but exactly in the midst of which there is a sunken rock. The highest peak of this range is Monte Santangelo, south of Castellammare, 4722 feet. The town of Vico, Sorrento with its orange and citron groves, and numerous other villages, are on the north slopes of this range.

After passing to the south the island of CAPRI, we find the Gulf or Bay of Salerno (*Sinus Pæstanus*), which extends from the Punta della Campanella to the Punta di Licosa (*Promontorium Posidium*), about 46 miles across, and has a depth of 30 miles. From Campanella to Salerno, a distance of about 20 miles, the coast is bold and rocky, and dotted by numerous villages, of which the largest are Positano and Amalfi. The latter place was once celebrated for the trade of the Levant, which made it populous and wealthy. It was the birth-place of Flavio Gioia, who, in the beginning of the thirteenth century, either invented or perfected the mariner's compass. It is now a poor town of about

 5000 inhabitants; but nothing can surpass the romantic beauty of its situation on the sea-shore, at the entrance of a narrow gorge between high mountains, crowned by the ruins of its former castles. Salerno, which gives the name to the bay, stretches along the beach, with a ruined castle on a hill behind it. The road is much exposed to south-westerly winds; but there is a mole, behind which small vessels may find shelter. From Salerno the coast continues with a smooth sandy beach, and almost in a straight line south, bordering the plain of Pæstum to Agropoli, where the hills of the Cilento approach the sea and form the headland of Licosa, the southern boundary of the bay, opposite to which, separated by a narrow channel, is a small island of the same name (*Leucosia*).

From Licosa the coast trends towards the south-east, with no good port till it reaches the safe anchorage formed by the headland which, by the name of Palinuro, reminds us of the pilot of Æneas:—

"Et statuent tumulum, et tumulo solemnia mittent;
Aeternumque locus Palinuri nomen habebit."—*Æn.* vi., 380.

Midway between Licosa and Palinuro, 2 miles from the mouth of the Alento, are the scanty remains of *Velia*, where Zeno founded the eleatic school of philosophy. The mildness of its climate attracted the Romans; Paulus Æmilius was ordered there for the sake of his health. S.S.E. of Cape Palinuro the coast continues bold to Capo degli Intreschi, where it opens into a gulf (*Sinus Laus*), which takes its name from Policastro (*Buxentum*), situated on its north shore, once a place of importance, but since its sack by the Turks in 1544 a miserable village. Eight miles S.E., at the head of the gulf, is the small anchorage of Sapri (*Scidra*), from which the coast, descending south, becomes bolder and more picturesque, and is clothed with vineyards, olives, mulberries, and orange groves, and scattered with villages and towns, of which the most important are Scalea, Diamante, Belvedere, Paola, and Amantea. At Cape Suvero (*Lampetes*), it opens into the Gulf of Sta. Eufemia (*Sinus Terinæus*), and becomes flat and marshy, and infested with malaria. A few miles east of the mouth of the Lamato, on a small isolated hill, is the town of Maida, the scene of the victory gained by our arms under Sir John Stuart over the French, under General Regnier, on the 4th July 1806. At Pizzo the coast rises again, and continues rocky and inaccessible round Cape Zambrone and Cape Vaticano, till it sinks into the low coast that encloses the Gulf of Gioia (*Sinus Bruttius*), on the N. and E. The lower spurs of the Aspromonte come near the sea at Palmi, whence the coast continues lofty and bold almost the whole way round the toe of Italy. At the southernmost end of the Gulf of Gioia is the town and rock of Scylla, where the celebrated straits called Faro di Messina are entered.

Scylla is situated on a small promontory, and is built in a series of terraces rising one above the other from the sandy bays on either side of it towards the castle, which stands on the bluff cliff at its extremity. It suffered awfully from the earthquakes of 1783, the first shocks having almost totally destroyed it. Afraid of a repetition, the old Prince of Scylla and most of the inhabitants, on the evening of the 5th February, took shelter in boats on the west beach. Towards dusk, however, another violent shock rent part of its promontory, and throwing it into the sea, caused the waters of the straits to rush back with overwhelming force on the beach, and sweep away 2500 persons. On the 6th of February more corpses were thrown back on the shore than there remained inhabitants at Scylla.

The Faro channel was depicted by the poets of antiquity in most terrific colours, but as the Athenians, the Syracusans, the Locrians, and the Rhegians, fought in it, it could not have been considered so horrible by ancient sailors as by ancient poets; though the passage through it might have been an affair of some moment with their small vessels and inexperienced seamen. Its horrors, however, have been much overcome by the progress of nautical science. Admiral W. H. Smyth, long occupied in surveying the Mediterranean, took accurate measurements by theodolite angles of the distance across this passage, at four different points. The shortest distance, from the village of Ganziri to Point Pezzo, is 3972 yards; the next in length is from Messina light-house to Point dell' Orso, 5427 yards; the next from Faro Point to the Castle of Scylla, is 6047 yards; and the last, from Messina light-house to the cathedral of Reggio, is 13,187 yards.

The currents in the straits are numerous and various. In settled seasons there is a central stream running north and south, at the rate of from 2 to 5 miles an hour, and which, though properly speaking only a current when uninfluenced by strong winds, is governed by the moon. On each shore there is a counter or returning set at uncertain distances from the beach, often forming eddies to the central current; but in very fresh breezes the lateral tides are scarcely perceptible, whilst the main one increases so as to send at intervals slight whirlpools to each shore. There is an uncertain rise and fall of a few inches in the tide, but at the vernal equinox it amounts to 18 or 20 inches. There is usually an interval of from fifteen to sixty minutes between the changes, and the tide runs six hours each way. In light breezes the current may be stronger than the ship's effort, and, by turning her round, often alarms a person unacquainted with the phenomenon, although there is no actual danger. The greatest risks, however, are occasioned by the heavy gusts of wind which at times, from the mountainous nature of the coasts, rush down the torrent-beds and prove dangerous to small vessels.

Nelson with his fleet passed through this channel; but, in attributing to him the merit of first attempting it, his biographers have overlooked, not only Ruggiero di Loria, who often passed through it, but our own Byng and the gallant Walton,[1] who had, nearly a century before, also achieved the passage.

Charybdis, which is on the Sicilian coast, will be noticed hereafter.

There is a curious aërial phenomenon in the Strait of Messina, noticed by the ancients, and called Fata Morgana by the Sicilians. Most extraordinary accounts of this singular phenomenon have been given by those who have witnessed it from the city of Reggio, but the best description of it is that given by the Domenican Minasi, towards the end of the last century, who had seen it three times in its most perfect state:—"When the rising sun shines from that point whence its incident ray forms an angle of 45° on the sea of Reggio, and the bright surface of the water in the bay is not disturbed either by the wind or the current, the spectator being placed on an eminence of the city, with his back to the sun and his face to the sea, on a sudden he sees appear in the water, as in a catoptric theatre, various multiplied objects, *i.e.*, numberless series of pilasters, arches, castles well delineated, regular columns, lofty towers, superb palaces with balconies and windows, extended alleys of trees, delightful plains with herds and flocks, &c., all in their natural colours and proper action, and passing rapidly in succession along the surface of the sea, during the whole period of time that the above-mentioned causes remain. But if, in addition to the circumstances before described, the atmosphere be highly impregnated

[1] This was the officer who, after the action between Sir George Byng and the Spanish fleet, was detached in pursuit of six sail of the line and some smaller ships, and reported his success in the following terms:—"Sir,—We have taken or destroyed all the enemy's ships and vessels on the coast, as per margin. 16th Aug. 1718," &c.

with vapour and exhalations not dispersed by the wind nor rarefied by the sun, it then happens that in this vapour, as in a curtain extended along the channel to the height of about 28 feet and nearly down to the sea, the observer will behold the scene of the same objects not only reflected from the surface of the sea, but likewise in the air, though not in so distinct and defined a manner as in the sea. And again, if the air be slightly hazy and opaque, and at the same time dewy and adapted to form the iris, then the objects will appear only at the surface of the sea, but they will be all vividly coloured or fringed with red, green, blue, and the other prismatic colours."

Admiral Smyth, however, doubts the accuracy of the description, and thinks that the imagination strongly assists these dioptric appearances, having never met a Sicilian who had actually seen anything more than the loom or *mirage* consequent on a peculiar state of the atmosphere, which he here observed many times to be unusually strong.

In the Faro of Messina, the only place of importance on the continental side is Reggio, the capital of Calabria Ultra I., well built, in a healthy spot, and surrounded by most beautiful scenery. Its climate is favourable to the cultivation of plants of both hemispheres. The environs abound in oranges, citrons, mulberries, grapes, figs, and a great variety of other fruits; the date-palm bears fruit, the castor-oil plant attains a great size, and the American aloe and cactus border the roads and supply the place of hedges.

On clearing the Faro and proceeding round to the Ionian Sea, Cape Pellaro (*Bruttium Prom.*), Capo dell' Armi (*Leucopetra*) and Capo Spartivento (*Promontorum Herculis*) are passed; the latter being the southernmost continental spot in Italy, in N. Lat. 37. 56. From thence to Cape Rizzuto the coast, always bold and rocky, forms two irregular concavities divided by a projecting offshoot of the Aspromonte, on which is the town of Stilo. In the centre of the south concavity, near the shore, are the ruins of Locri Epizephyrii, one of the most ancient cities of Magna Græcia, which had Zaleucus for her legislator, and was praised by Pindar for the hospitality, justice, and wisdom of her citizens. The town of Gerace, on a rising ground 5 miles inland, sprang from it. The north concavity, called the Gulf of Squillace, from a small town of that name (*Scylaceum*) standing on a steep rock, has several small villages and towers near the coast, but no harbour or anchoring place, except with the wind off land; the water is very deep close to the shore, but there is no secure part where vessels can find shelter, in case of finding themselves on a lee-shore with a strong gale of wind. Hence the ancient appellation of *navifragum Scylacæum* given to the gulf.

Rounding the Capes Castella, Rizzuto, and delle Cimiti (the *Tria Iapygum Promontoria* of Strabo), we find Cape Nau (*Prom. Lacinium*), called also Capo delle Colonne, from the ruins of the famous temple of Juno Lacinia that stood upon it.

"Hinc [the east entrance of the gulf] sinus Herculei, si vera est fama Tarenti
Cernitur. Adtollit se diva Lacinia contra,
Caulonisque arces, et navifragum Scylacæum."—*Æn.* iii., 551.

Six miles N.W. of Cape Nau are the port and town of Cotrone, surrounded by an unhealthy district, and remarkable only as standing on the site of *Croton*, once one of the most flourishing cities of Magna Græcia, the residence of Pythagoras, and the chief seat of his school.

Further east opens the great Gulf or Bay of Taranto, which, from the extreme points of Cape Alice (*Crimissa*) to the south-west, and Cape Santa Maria di-Leuca to the north-east, extends 66 miles across. No part of the west shore affords any harbour or shelter for a vessel with the wind blowing from the south or south-east. *Sybaris*, the earliest and one of the most celebrated cities of Magna Graecia; *Thurii*, that had among its colonists the orator Lysias and Herodotus the historian; *Heracleia*, a joint colony of the Thurians and Tarentines, and the place of meeting of the general assemblies of the Italiot Greeks; and *Metapontum*, where Pythagoras ended his days—all stood on the western shore, at present deserted, of this gulf. Taranto (*Tarentum*), in its N.W. angle, behind the small, low islands of S. Pietro and S. Paolo, was once the rival of Rome, and had an excellent port, which, becoming choked up from neglect, forms now what is called the *Mare Piccolo*, which is famous for its oysters and great variety of delicate fish. The city has a fort, and occupies the site of the ancient citadel, on a rocky isthmus, which, being cut through by Ferdinand I. of Aragon, is now an island connected with the mainland by two bridges. More than 50 miles south-east of Taranto, on a rocky island connected with the mainland by a causeway, stands Gallipoli (*Callipolis*), near to which is a roadstead, with good anchorage, within gun-shot of the town; but farther inshore the ground is rocky, and there are several shoals. The trade of this town consists chiefly in the export of oil, well known by its name. Thirty miles S.E. of Gallipoli is Cape Sta. Maria di Leuca (*Iapygium Prom.*), which marks the boundary between the Gulf of Taranto and the Adriatic; and upwards of 30 miles north of it is Cape Otranto, the easternmost point of land in Italy. Otranto (*Hydruntum*), has a port capable of affording shelter to vessels when the wind is south or south-west, but a northerly wind blows right into it. It admits vessels of 150 tons. About 40 miles north-west is Brindisi (*Brundusium*), from which the Romans usually crossed to *Dyrrachium*, the modern Durazzo, on their way to Greece. It was once the best harbour on this side of the Adriatic; but in the fifteenth century the Prince of Taranto sunk some ships in the middle of the passage to prevent his enemies from entering, and thereby formed a resting-place for sea-weeds and sand, an accumulation of which choked it up. Of late years the government has undertaken the work of clearing it up.

The coast from Brindisi proceeds north-west to Monopoli, Mola, Polignano, and Bari (*Barium*), the largest city on this side of the kingdom. It has good anchorage without, and a small haven into which vessels can enter. A new port is in progress of construction. It is a fine city, and exports large quantities of wine, oil, almonds, and soap. Beyond this are Giovenazzo, Molfetta, Bisceglie, Trani, and Barletta, all populous places, but not so flourishing as they were in the middle ages. Six miles N. of Barletta, beyond the mouth of the Ofanto, are the *Reali Saline*, the largest salt-works in the kingdom; and further north, at the bottom of the Gulf or Bay of Manfredonia, is the city of that name, founded in 1256, by Manfred, and celebrated for the excellence of its esculent vegetables.

Between Manfredonia and the boundary line towards the Papal territory there are no good ports or harbours, though there are some spots where there is tolerable anchorage. On our progress north, about 8 miles north-east of Manfredonia, on the shore at the foot of Mount Gargano, is the village and tower of Mattinata, supposed to mark the spot where Archytas of Tarentum was shipwrecked. Viesti, in the midst of orange groves on the slope of the easternmost spur of the Gargano, has a fair anchorage. On rounding the promontory, the Tremiti islands (*Diomedeæ*) come in view, the nearest of which is about 14 miles from the coast. They are four—S. Domenico, S. Nicola, Caprara, and Pianosa. The latter, which scarcely belongs to the group, is 11 miles north-east of Caprara. At San Domenico (*Trimerum*), the largest, Julia, the granddaughter of Augustus and wife of Lepidus, died in exile. On S. Nicola there is a prison for culprits from Naples.

North of the mouth of the Biferno is Termoli, the second port of the kingdom on the Adriatic, sheltered by a small headland, and affording safe anchorage. North-west of Termoli there are several towns and villages, along a coast generally low and sandy. The most important of them are—Vasto (*Histonium*); Ortona (*Orton*), on a projecting promontory commanding an extensive view of the coast, and with a small port from which the best wines in this part of Italy are exported; Pescara, the second fortress in the continental states, in a most unhealthy situation at the mouth of the river of that name; and Giulianova, where the Apennines come so near the coast as to leave only a narrow strip of lowland. Ten miles north of Giulianova is the Tronto.

The *Domini al di là del Faro*, or island part of the kingdom, comprises Sicily, the Lipari group, and other smaller islands.

Sicily (*Sicilia, Sicania, Trinacria*), next to Sardinia, the largest, and by far the richest and most important island in the Mediterranean, extends in N. Lat. from 36. 38. to 38. 18., and in E. Long. from 12. 25. to 15. 35, and has an area of about 7967 geographical square miles, and a population, in January 1855, of 2,231,020 inhabitants. It is separated from the continental Italian coast by the Straits of Messina, and from the headland of Cape Bon, in Africa, by 80 miles of the Mediterranean Sea. The appearance of the two coasts justifies the belief, that a violent disruption or subsidence of strata separated it from Italy at some remote period.

The name Trinacria was derived from its form of an irregular triangle, of which the shortest side faces the east, and the longest the north. The angles of the triangle are formed by Cape Torre di Faro (*Pelorus*) to the N.E.; Cape Boeo (*Lilybæum*) to the W.; and Cape Passaro (*Pachynus*) to the S. Though the topography of the island is not accurately known, no scientific survey of it having ever been made, yet the distance, in a direct line from Cape Boeo to Torre di Faro, the greatest length of the island, is estimated at about 198 miles; from the latter Cape to Cape Passaro, its breadth, 123 miles; and from Cape Passaro to Cape Boeo, 184 miles. Its circumference, including the windings of the coast, is estimated at upwards of 550 miles.

A considerable part of the surface of Sicily is rugged, and covered with mountains. The group of Mount Madonia (*Nebrodes*), whose highest peak rises to an elevation of 3765 feet, is the central nucleus from which the other mountains branch off. The western range surrounds the Bay of Palermo and the Gulf of Castellammare, and forming the almost detached mass of Mount St Giuliano (*Eryx*), 2184 feet high, sinks into the sea near Trapani. Another range trends east, encircles Mount Etna on the north, and approaches the sea at Taormina, whence it turns north-east, and, under the name of Nettuno Mountains, ends at the Faro Cape. The third range trends south-east through the heart of the island, forms the elevated group on which stands Castrogiovanni (*Enna*), and thence breaking up into irregular masses of lower hills, covers great part of the south-east corner of the island. Between the two latter ranges, but entirely detached from them by intervening valleys, stands the great mass of Mount Etna, called also Mongibello, the largest and most destructive volcano in Europe. It rises on the east coast, between Catania and Taormina, and attains an elevation of 10,874 feet, which, however, is subject to variations, in consequence of the changes caused by great eruptions. Its base has a circumference of upwards of 90 miles, of which no less than 30 are of sea-coast, formed by the streams of its lava. A more detailed account of ÆTNA will be found under its head in this work. At the south end of its base is the rich plain of Catania, and beyond it is an extensive volcanic formation, of a much older date than Ætna, which covers the tract from Palagonia and Scordia to Palazzolo and the neighbourhood of Syracuse.

The ranges of mountains we have noticed form three great natural divisions of the island—the Val Demona, on the north; the Val di Noto, on the east; and the Val di Mazzara on the south-west side; and till 1819 they combined with the administrative divisions, which at that time were altered and changed into seven provinces. The surface of Val Demona and Val di Noto is chiefly hilly and rugged, whilst Val di Mazzara is an undulatory plain, sloping gently from the mountains to the sea.

The rivers of Sicily are numerous, but none of them of any importance; most of them are mere mountain-torrents, nearly dry in summer. The most important of them will be noticed in our survey of the coasts. There is scarcely any mass of water considerable enough to deserve the name of a lake. The largest, however, is the Lake of Lentini (*Herculeus Lacus*), between the city of that name and Scordia, south of the Piana di Catania. A few miles south of Castrogiovanni is Lake Pergusa (*Pergus*), about 4 miles in circumference, which is associated with the mythological story of the rape of Proserpine.

> "Haud procul Enneis lacus est a moenibus altæ,
> Nomine *Pergus*, aquae. . . . . .
> Frigora dint rami, Tyraos humus humida flores;
> Perpetuum ver est. Ov. *Metam.*, v., 385.

The lakes of Camerana, Terranova, and Naftia, are mere ponds.

The first appearance of the coast of Sicily is strikingly picturesque. Vessels from the westward generally touch first at Cape St Vito, the northernmost point, in N. Lat. 38. 13. and E. Long. 12. 45. It forms the west point of the Gulf of Castellammare (*Sinus Segestanus*), an indentation about ten miles in depth, at the bottom of which is the town of the same name, in a highly cultivated district. Six miles south of it, inland, are the well-known remains of *Segesta*, consisting of a Doric temple, with vestiges of an ancient theatre. To the eastward of the Gulf of Castellammare, beyond the lofty promontories that bound it on that side, is the bay and city of Palermo (*Panormus*), sheltered on the east by Mount Catalfano. There is good anchoring ground in almost every part of this bay, near the shore. To the north-east of the city is a fine mole, nearly a quarter of a mile in length, extending into water of the depth of 9 or 10 fathoms; and it forms a noble port, capable of containing a great number of vessels. Along the whole, at the most favourable points, there are establishments for the tunny fisheries. The next point on the coast is Cape Zaffarana, which looks like an island, and forms the western boundary of the extensive bay of Termini, in the middle of which stands the city of Termini. During two-thirds of the year the anchorage is so exposed that the boats must be drawn up upon the beach.

Five miles to the eastward of Termini is the site of the ancient *Himæra*, the birth-place of the poet Stesichorus, and celebrated on account of one of the most disastrous battles that history has recorded. 300,000 Carthagenians under Hamilcar were routed with great slaughter by Gelon of Syracuse and Theron of Agrigentum, B.C. 480. Near to it the Fiume Grande (*Himera*) discharges its waters into the sea, through one of the most unhealthy, but most fertile districts of the island.

About 12 miles to the east stands the city of Cefalù (*Cephalædium*), on a low projecting point of land, under a conical mount, on the summit of which are the ruins of an ancient Phœnician edifice and a Saracenic castle. It has a fine cathedral. The district from Cefalù to Caronia (*Calactæ*) is the most extensively wooded with oak, elm, and ash trees of any in Sicily, and most of the trees are converted into charcoal. On the shore there is good an-

chorage, which continues by the towns of Santa Agata and San Marco, to Cape Orlando. Here is a dangerous reef of rocks; but between it and the shore there is good ground, where small vessels may anchor in safety. Cape Orlando (*Agathyrnum Pr.*) is distinguished by the Brolo Castle, a ruinous structure, and a rock between 16 and 17 feet in circumference, and 20 feet above the level of the water, behind which a ship may ride in safety, except when a southerly wind blows with great violence.

Next to Cape Orlando is Cape Calava, which bounds on the west the Bay of Patti, a perfectly safe anchorage in all parts except in the centre, where there is a large rock; but as it appears above water, all danger is easily avoided. In the middle of the bay is the lofty projecting headland of Cape Tindaro, on which the ancient *Tyndaris* was situated. East of it a sandy beach extends along a fertile plain studded with villages, and terminates at the promontory and city of Milazzo, the ancient *Mylæ*, situated on the southern part of the promontory facing the east. It consists of the upper and lower town, and a citadel commanding the city, the port, and the promontory. This northern coast terminates with Cape Rasaculmo, which is a deep sandy bay, with several small streams running into it. The banks are much infected by malaria, but the heights near them are thickly peopled. Off the cape is good anchorage ground, with from 12 to 20 fathoms depth of water.

The eastern coast of Sicily begins at the north with the Faro of Messina, and the city of that name. The celebrated vortex known to the ancients as *Charybdis*, but now called Galofaro, is formed at the back of the tongue of land named Braccio di San Raniere, which is one arm of the harbour of Messina. This whirlpool was said by the ancients to swallow up ships, and upon the return of the tide to throw them up again in broken pieces. Admiral Smyth describes it as an agitated water from 70 to 90 fathoms in depth, circling in quick eddies, which seem to be caused by the meeting of the harbour and of the lateral currents with the main current; the latter being forced over in this direction by the opposite point of Pezzo. The risk is proverbial; and at the present day small craft are sometimes endangered by it, and ships of war wheeled round upon its surface; but, with caution, very little danger or inconvenience is to be apprehended from it, especially since a lighthouse has been constructed.

In our progress westward, along a bold and fine coast, are Cape Grosso, Point St Alessio (*Argenum*), and Cape St Andrea, near to the last of which, in a bay of the same name, is the city of Taormina (*Tauromenium*), in one of the finest situations in the world, though at present not very healthy. It has good anchorage ground, in water from 8 to 30 fathoms in depth. About 2 miles beyond it, the Alcantara (*Onobalas* or *Acesines*), one of the most considerable rivers of Sicily, falls into the sea. Near to this is the most fertile district of Mascali, which, amongst other productions, yields annually about 90,000 pipes of excellent wine.

Beyond this, at the distance of 5 miles, is Point Tocco, a precipitous mass of basaltic lava, converted into a mole, and forming a small port called the Marina of Aci. Not far from it is the city of Aci Reale, standing on extensive streams of lava. It is in a healthy and fertile spot, and is clean and well built. Another promontory, 3 miles from it, Cape Molino, is formed of lava; and the town of La Trezza, near to it, is built wholly of that rock, the very dark hue of which, contrasted with the white-washed lintels and door-posts of the houses, has a singular appearance. Near La Trezza are the rocks called the *Cyclops*, which have a bold and striking appearance; for the basalts that form them are mostly vertical, and consist of prisms of from 4 to 8 sides.

The bay upon which Catania stands is $7\frac{1}{2}$ miles in extent from La Trezza to Cape Santa Croce; the ground is generally clean, and ships may anchor in any part of it during the fine season. The city, originally a Greek colony, has been most dreadfully ravaged by wars, earthquakes, and volcanic eruptions. By the great eruption of Etna, in 1693, which in great part filled up the port, more than 50,000 persons perished, and the whole of the buildings were destroyed, except a few which were subsequently taken down to carry on the plan laid down for rebuilding the new city. It stands close on the sea-shore, and is well built, regular, spacious, and handsome. The churches and other public buildings are magnificent, being for the most part constructed of lava, faced with magnesian limestone, and enriched with marble. It is the residence of many of the Sicilian nobility, and has many literary and charitable institutions. The environs are fertile and well cultivated. The harbour is generally filled with small craft, which repair to it for corn, macaroni, potatoes, olives, figs, silk, wine, almonds, cheese, oil, soda, manna, cantharides, amber, snow, and lava. The beauty of the situation exceeds all power of description. The city, close on the sea-shore, is overshadowed by the gigantic majesty of Ætna, whose summit is only $14\frac{1}{2}$ miles northward, and is encompassed by the several minor volcanic hills, which appear like so many branches arising from the parent stock; whilst the placid brilliancy of the sea-view in front, and the solemnity of the inland scenery behind, contribute to form as magnificent a prospect as any part of the island can exhibit.

A little to the south of Catania the Giarretta (*Symæthus*), the most important river on the eastern coast, enters the sea; and further south is the port of La Bruca, with a harbour looking like a work of art rather than of nature, as the rocks rise vertically to the height of 40 or 50 feet. After passing Capo Santa Croce, the spacious Bay of Augusta (*Xiphonius Portus*), bounded on the south by Cape Magnisi (*Tapsus*), opens to view. On a tongue of land projecting from the N. side of the bay stands the town of Augusta, whose inhabitants subsist chiefly by collecting salt from some salines near them, and by the export of oil and wine. There is a fort and a lighthouse, which, with the cathedral, form the marks for reaching the anchorages; the latter are good, although the inner one is deemed unhealthy. The western sides of the harbour are watered by several streams abounding with fish. On the same side are the mountains of Hybla, celebrated by the ancients on account of the honey produced on them, the sale of which still forms a most profitable trade.

The next place to Augusta is Syracuse, originally a Corinthian colony, and the birth-place of Empedocles, Theocritus, and Archimedes. In the days of its prosperity and power it is said to have contained half a million of inhabitants. The whole of the present city now scarcely covers the island of Ortygia. It suffered most dreadfully by an earthquake in 1693, which destroyed a great part of the population. It is a fortress of considerable strength; and the entrance of the harbour, which is half a mile wide, is defended by a fort on the south of the town. The adjacent country being copiously irrigated, and possessing a marly soil, is exuberantly fertile, producing wheat, oil, hemp, tobacco, fruit, pulse, and several kinds of delicious wines; but, from the marshes of the alluvial plains on the west side, pernicious and destructive miasmata have frequently arisen. The port is a very secure one, easy of access, and sufficiently capacious to admit a large fleet, with great facilities for shipping provisions and water, as was experienced by Lord Nelson, who, in five days, obtained supplies sufficient for his memorable pursuit of the French fleet in the year 1798.

Between Syracuse and Cape Passaro, the southernmost spot in Sicily, is the extensive bay, the northern point of

which is Cape Lungo. In the whole of it there is good shelter for large as well as small vessels, which may be compelled to bear up in the channel of Malta by a westerly gale of wind. The anchorage is good in from 9 to 30 fathoms of water, with a good holding ground of stiff clay. The town of Avola carries on some traffic in wine, corn, almonds, oil, honey, and sugar made from the only plantation of canes now left on the island. The city of Noto, within four miles of the shore, is finely situated and well built, and the country around is fertile. Seven miles south of it is the Abisso, the ancient *Helorus*, which winds through a rich but unhealthy plain.

That part of the coast of Sicily which extends from Cape Granatola in the west, to Cape Passaro in the east, is generally low and arid, and does not possess a single harbour for large ships, although there are several tolerable summer anchorages. The approaches towards the headlands are not so clear nor so deep as those of the northern shores; but ships are safe which by day are not in less than 12 fathoms water, or at night in about 20 fathoms.

From Cape Granatola to Cape St Marco there is a long but slender bay, called the Gulf of Tre Fontane, 20 miles deep. It is of easy access, but has no good shelter except for small vessels. In it, near to Port Paolo, are the solitary extensive ruins of *Selinus* or *Selinuntum*, appearing, at no great distance, like a large city; and 4 miles east of them the Belici (*Hypsa*), which rises near Corleone, and has a course of upwards of 30 miles, falls into the sea.

From St Marco to Cape Bianco a similar bay extends about 14 miles, in which there is good anchorage; but it is only safe in the summer months near the town of Sciacca, the *Thermæ Selinuntiæ* of antiquity; a poor but large place. The baths are supplied by two springs; one of which is sulphureous and hot, being about 126° of Fahr.; the other cool, being about 60°, and impregnated with the saline qualities of the rock from which it springs. The steam-baths of Dædalus are situated on an insulated rock, and have been in use upwards of three thousand years.

Close to the north of Cape Bianco the Platani (*Halycus*), next to the Salso, the largest river in Sicily, empties itself. On its left bank are the ruins of *Heracleia Minoa*, and 8 miles beyond it is the town of Siculiana, pleasantly situated, but in an unhealthy climate. The chief trade consists in the exportation of sulphur, of which there are some extensive mines in the neighbourhood. The city of Girgenti (*Agrigentum*), 10 miles farther east, stands on a hill at nearly 1200 feet above the level of the sea, and is so elevated that almost every house in it can be seen at once. It has a cathedral, a large and heavy structure of the thirteenth century; but it is irregularly built, dirty, and poor. *Agrigentum* was renowned for its power and commercial enterprise, and is said to have once contained 200,000 inhabitants. Most of the space which it occupied is now a continued range of orchards and gardens, and of groves of almond and olive trees. The vestiges of the city have been amply described by Admiral Smyth in his able and accurate account of the island. The port is formed by a mole, having on it a lighthouse; and outside of it there is good anchorage. At this port, also, large quantities of sulphur are shipped.

About 5 miles from Point Bianco, and 2 miles from the shore, is Palma, which overlooks one of the richest and best cultivated valleys in Sicily, and near to it many cattle are reared. About 10 miles from Palma, is Alicata (*Phintia*), at the mouth of the River Salso (*Himera*), the largest river of Sicily, which rises in the Madonia mountains, only 15 miles from the N. coast, and traverses most of the island in its course of more than 50 miles south. At the entrance there is a bar, on which the surf beats so heavily with southerly winds, that boats can only enter it by a narrow passage, which is always difficult, and sometimes dangerous.

At the distance of 14 miles from Alicata, along an open beach, is Terra Nova (*Gela*), where Æschylus ended his days. About a mile from the town there is good anchorage in from 7 to 10 fathoms water, but it is much exposed when the wind blows from the south-west. The town is situated on a table-land, considerably elevated; and it has a fine palace, but few other edifices worthy of notice. The country around abounds in corn.

The whole coast to Cape Scalambra is within a reef of rocks, always an object of peculiar dread to the ancients, and, notwithstanding all the improvements made in navigation, the cause of the loss of many ships. It is not safe to approach nearer the shore than a depth of water of 14 fathoms, nor, with a westerly wind, quite so near as that depth. The eastern side of Cape Scalambra has a small port for vessels of an easy draught of water. From Cape Scalambra the distance to Point Spina is 8 miles; at the latter place the coast is foul and rocky; but at three leagues farther is the town of Pozzallo, which is the chief shipping place for the produce of the district. The next point is Cape Passaro, the southernmost land of Sicily, being in north lat. 36. 41. 30. It is formed of bold projecting rocks, and immediately off it is the small island of Correnti. Near to it the water of the limpid stream of Busaidone irrigates the land of Spaccaforno, a town 3 miles from the shore. It trades with Malta, to which it exports grain, flax, carrubas, acorns, and live cattle.

The west shore, which extends from Cape St Vito to Cape Granatola, will require but a short description. Proceeding from Cape St Vito southwards, we come to Cape Emilia, opposite to which is the dangerous shoal of that name, on which there are only 2 fathoms of water, whilst everywhere around it there are from 6 to 10 fathoms. Immediately to the south-east of it rises Mount San Giuliano (*Eryx*), on whose summit, on the place now occupied by a prison, stood the famous temple of Venus, who derived from it the surname of *Erycina*. Only a few vestiges of it now remain, built up in the walls of the prison; but in the town of San Giuliano near it, which has about 7000 inhabitants, there are in the houses several fine granite columns, which undoubtedly belonged to the temple.

At the distance of 4 miles west of San Giuliano is the city of Trapani (*Drepanum*), which may be approached with safety by vessels of from 200 to 300 tons; though, as the ground is much broken, and there are many counter-currents, great care is required on the part of the pilot. Trapani is surrounded by a wall with bastions and ravelins, and among its inhabitants are some of the best artists, artificers, and sailors of the island. It is a place of considerable enterprise and industry; well built, and with a fine cathedral and senatorial palace. From Trapani southward to Capes Boëo and Marsala, a distance of 10 miles, the coast is low, irregular, and varied by numerous islets resting upon a base of shoal and rocky ground which in some parts extends 2 miles from the shore. The country on the main island is laid out in extensive saltworks, by the construction of causeways about a foot and a half high, enclosing square places which communicate by dams with each other. The salt is heaped up in a pyramidal form, at a distance resembling tents, and when quite dry, is exported chiefly to Marseilles.

Cape Boëo, the westernmost point of the island, and that nearest to Africa, from which it is only 80 miles distant, is a low rocky headland, above which, in a healthy situation, stands the city of Marsala, the ancient *Lilybæum*, founded by the Carthaginians in B.C. 397. Lilybæum had a good and much-frequented port, though neither spacious nor deep, but it was blocked up with sunken stones by order of the Emperor Charles V., to protect the place from the attacks

of the Algerine corsairs. The Saracens, during their domination in Sicily, attached so much importance to it, that they called it Massa Alla—the port of God—from whence the modern name of the city arose. Marsala is tolerably well-built and surrounded by a wall, and exports wine, fruits, and barilla. Near to it there is a large establishment for shipping its wine to England, where it is well known by the name of "Marsala." The ground on the beach is all shoal and foul, and large ships must anchor at nearly 2 miles from the mole, which has been constructed near the English wine-stores of the two houses of Bingham and Cumming Wood.

Off the coast, between Trapani and Marsala, lies a group of three small islands (*Ægates*), of which the westernmost and most distant, Maretimo (*Hiera*), is 22 miles from the coast of Sicily. Favignana (*Ægusa*), the largest and southernmost, and Levazzo (*Phorbantia*), the smallest and northernmost, are at about a distance of 6 and 8 miles off. On Maretimo and Favignana there are the worst dungeons in the kingdom for political and common criminals.

About 10 miles S.E. of Cape Boëo is Cape Feto, and 3 miles further S. the city of Mazzara, situated at the mouth of a small river of the same name, 6 miles north of Cape Granatola. It retains its ancient name (*Mazara*), and though the streets are narrow and dirty, its domes, rising above the houses, give it a respectable appearance from the sea. It is surrounded by a Saracenic wall, and has some trade in the exportation of grain, pulse, wine, fruit, barilla, madder-root, oil, and soap. Its little haven is formed by the entrance of the river, and is convenient for small craft, but larger vessels are obliged to lie at a very exposed anchorage without, in from 8 to 12 fathoms water, where the holding ground is a stiff clay.

The tides, or rather the currents, arising from the constant evaporation and the action of the winds, observe no regularity, rising a foot or two, according to the weather, and the peculiarities of locality and depth. Thus, the north-west winds, raking the shores, produce a strong set to the south-east, whilst the south-west wind, which is very sensibly felt during the vernal equinox, causes strong counter-currents; and at length, on a change of wind to the opposite quarter, the whole body of water rushes with great velocity to the westward. In settled weather, the currents between Sicily and the African shore run to the eastward at the rate of from half a mile to a mile an hour. In the channel of Malta, the current at south-east has been found so strong, that ships have found it difficult to beat up to Maritimo; whilst others, driven to leeward of Malta, have been obliged to carry a press of sail in order not to lose way, until a change of wind enabled them to make the island again.

An atmospheric phenomenon which deserves notice occurs principally on the southern coast of Sicily, but exhibits its greatest force in the neighbourhood of Mazzara. It commonly bears the name of *Marobia*, and is thus described by Admiral Smyth:—"Its approach is announced by a stillness in the atmosphere and a lurid sky, when suddenly the water rises nearly two feet above its usual level, and rushes into the creeks with amazing rapidity, but in a few minutes recedes again with equal velocity, disturbing the mud, tearing up the sea-weed, and occasioning a noisome effluvia. During its continuance the fish float quite helpless on the turbid surface, and are easily taken. These rapid changes generally continue from thirty minutes to two hours, and are succeeded by a breeze from the southward, which quickly increases to heavy gusts."

To the north of Sicily, between E. Long. 14. 13. and 15. 15., and N. Lat. 38. 20. and 38. 50., is the volcanic group of the Lipari Islands (*Insulæ Æoliæ*), consisting of Lipari (*Lipara*), the largest, and the seat of the local authorities; Vulcano (*Hiera*), the nearest to the Sicilian coast, from which it is only 12 miles off; Stromboli (*Strongylæ*), the northernmost; Salina (*Didyme*), next to Lipari in size; Felicudi (*Phœnicusa*); Alicudi (*Ericusa*), the westernmost of the group; Panaria (*Enonymus*), and some smaller islets. Vulcano and Stromboli are small but constantly active volcanoes. On Salina there are two conical mountains, which attain an elevation of 3500 feet above the level of the sea. More particulars about them will be found under the head LIPARI.

Ustica (*Ostœdes et Ustica*), and Pantellaria (*Cossura*), are two small islands of volcanic origin; the former, about 10 miles in circumference, is situated 60 miles west of Alicudi, and 40 miles north of the Cape di Gallo, and is a sort of beacon to ships going to Palermo from Naples. Pantellaria, west of Cape Granatola, and nearly half-way between Sicily and the African coast, from which it is only 38 miles, is 30 miles in circumference, and has nearly 6000 inhabitants.

Politically annexed to Sicily, but geographically belonging to Africa, are the small islands of Lampedusa (*Lopadussa*), Lalenusa, and Scola, situated almost midway between Malta and the African coast.

From the vast extent of sea-coast appertaining to the two divisions of the kingdom, the fishery naturally is, next to agriculture, the chief source of occupation to the inhabitants. Its principal branches are those for the tunny, or *scómber-thynnus*, the swordfish, the anchovy, and the sprat. The tunny was, according to Oppian, in the highest estimation with the Greeks, the Carthaginians, and the Romans, who made from it the sauce called *garum*. Shoals of them enter the Mediterranean in the spring, with an extended base for the tides to act upon, as they swim broad and deep in a conical form. In the progress of the shoal to the eastward it inclines over towards the European coasts, and is caught in great abundance in May, June, and July. The average length of the tunny is from 4 to 8 feet, and the girth from 2 to 5; yet there are many of still greater size, and the females are always the largest.

The manner of taking them is similar to that which was practised by the ancients. Large nets are spread out in the shape of a parallelogram, about 1500 feet in length, 300 in width, and from 40 to 100 in depth, divided into four quadrilateral rooms, having channels of communication with each other. These nets are moved east and west at about a mile distant from the shore, across the known route of the fish, with each of the spaces at right angles, and secured vertically by a number of anchors and stones at the bottom, whilst the upper edge of the net is floated by large logs of the cork-tree. The whole is connected with the shore by a stout single net of large meshes, called the wall, that arrests the progress of the tunny, and induces them to enter the outer room, which is thereupon raised a little and closed by the boatmen on the look-out. The fish, alarmed, and seeking to escape, swim from side to side, and thus enter the next room, when their retreat is again prevented, and thus finally they enter the fatal part, called *corpo*, where the meshes are smaller and stronger, and made of rope of superior quality. When this chamber is filled, large flat-floored boats, assisted by smaller ones, close round, and, weighing the net, secure the prey with harpoons struck into the head to prevent the fish from floundering. Although this fish has rather a coarse appearance, the flesh is agreeable to the taste, and very nutritious.

The sword-fish passes by the shores of Sicily, in its route to the Black Sea, about the time of the vernal equinox, and is often taken in the tunny nets; but in the Straits of Messina there is a particular fishery for them. It is taken by the harpoon, in a manner similar to that practised in the whale-fishery. When the fish is struck it immediately dives, and the long coil of rope fastened to the harpoon is suffered to run out till the animal becomes faint;

but it is sometimes so vigorous as to oblige the fishermen to cut it adrift, lest it should draw the boat under water. The length of this fish is from 7 to 13 feet, exclusive of a sword projecting from the snout, about 3 feet long and 3 or 4 inches broad. The flesh is esteemed delicate food, and, when broiled in slices, resembles veal.

The anchovy and the sprat are taken in shallow water in the months of March, April, and May, by means of nets 10 or 12 feet wide, and very long. The curing of them occupies about a month. The fish are first thrown into brine, to give the salters time to nip off their heads with the finger and thumb, and pack them with alternate layers of salt, in barrels about 200 pounds each. When the cask is filled, a round board is placed over the whole, and loaded with stones, by which the contents are sufficiently compressed in a few days to allow of the casks being properly coopered up for exportation.

Several parts of the coast swarm with barbel, whiting, red mullet, sole, white smelt, mackerel, seabasse, sturgeon, and gray mullets, the roes of which are converted into a sauce called *botarga*. A variety of testaceous and crustaceous fish, amongst which prawns of gigantic size are also taken along the shore. Coral yields considerable profit to the seamen of Trapani and Torre del Greco, who fish it on the African coast.

The geology and the mineral wealth of the country are scarcely known. In the Abruzzi some mines of anthracite and petrolium are worked on a very small scale. The largest iron-works are at La Serra, Mongiana, and Stilo, in Calabria Ultra I.; they are fed by the ore found in the surrounding mountains of the Aspromonte. There are mines of rock-salt, which are but slightly worked, that substance being instead largely collected on the sea-shore, especially of Apulia, where it is prepared by the operation of the sun alone both for domestic consumption and for exportation. Some alum is also collected; and in many parts quarries of marbles of various descriptions are worked, of which, however, none are exported. The mineral production of most importance, as an article of foreign trade, is sulphur, which is only found in large quantities in Sicily. The sulphur districts are principally in the central and south-western part of the island, and are calculated to extend over an area of about 2400 square miles. In 1858 there were more than 200 mines, capable of yielding upwards of 160,000 tons of mineral per year. From January 1858 to November 1859, the quantity exported amounted to 306,967 tons.

The climate is in general healthy, except in those districts where stagnant water produces malaria; but it varies considerably in the different parts of the kingdom. Whilst on the elevated mountain districts of the Abruzzi and Molise, especially near the Monte Corno, the Maiella, and the Monte Greco, there is a real Alpine climate, the snow lies several months on the ground, the thermometer falls below zero, and none of the plants of temperate latitude thrive; along the sea-coasts, on the contrary, the winters are mild, and the thermometer seldom or never falls to the freezing point. The contrast is peculiarly striking in Calabria, where, on the table-land of the Sila, the winters are intensely cold, the snow remains for a considerable part of the year on the higher peaks, and light frosts are not uncommon even in June and August; and yet, at a distance of a few miles on the sea-shore, orange and lemon trees attain a great size, the palm-tree, the sugar-cane, and other plants of tropical latitudes grow luxuriantly, and the cactus and American aloe are used for hedges. In summer the heat of the sun, tempered by the breezes from the sea, is never oppressive, except when the south wind, called *scirocco*, prevails. The scirocco is not actually unhealthy, but produces a general feeling of lassitude and depression, which however disappear without leaving any lasting effects as soon as the wind shifts to any other point of the compass. The quantity of rain which falls annually on the Tyrrhenian coast is about 29 inches, or one-third more than in Paris, yet the number of rainy days is greatly less than in that capital. On the eastern shores, both of Naples and of Sicily, the quantity of rain that falls, as well as the rainy days, are much less than on the western side. Sicily of course is, upon the whole, much warmer than the continental provinces; but even at Girgenti, or Syracuse, the glass seldom, and then only for a short time, rises above 90° in summer.

The Two Sicilies are essentially an agricultural country, the cultivation of the soil being the chief occupation of the people, and almost their only means of subsistence. Their agriculture may be classified under four different systems—the Mountain system, the Campanian system, the Apulian system, and the Sicilian system.

In the Mountain system, which applies to the cultivated districts of the northern and central provinces of the kingdom in general, except the higher range of the mountain-chain, the size of farms varies greatly from 6 to 200 English acres, and the rotation, generally, is as follows:—First year, fallow or potatoes, or a summer crop of maize, beans, or lupins, &c.; second year, wheat; third year, wheat; fourth year, oats or barley. In elevated situations the third year is a crop of barley, followed by two years of rest, during which sheep are driven to graze down the herbage. The ground is prepared in August, September, and October, and wheat, barley, or oats are sown in November.

The Campanian system prevails in the tract of country which extends from Gaeta to Salerno, and includes the rich Campanian plain. Farms are generally of a small size, from 2 to 50 acres, and are let for a period of from four to twelve years. The richness of the soil, and the abundance of manure, enable farmers to have no fallow in the rotation of crops, and to keep the ground in a constant state of high cultivation. A rotation in frequent use is—First year, hemp; second year, wheat; third year, spring wheat; fourth year, wheat. But the practice that more generally prevails, and which is the characteristic feature of the Campanian system, is to have the ground planted with rows of elms or poplars, and vines trained from tree to tree. Grain and other crops are raised under the shade of these trees—a practice which, far from being a proof of bad farming, in that climate is found to give crops of better quality, and though not so abundant as they might be if there were no trees, yet deficiency in quantity is more than made up by the variety of produce raised on the same soil. In the farms where this cultivation is adopted, artificial grasses or lupins are raised in October, to provide food for the cattle in winter. Early in the spring the ground is ploughed, and maize is sown in furrows, with beans, potatoes, melons, &c., in the spaces between the furrows; and when these summer crops are gathered in, the ground is ploughed again, and wheat sown. Sometimes, instead of elm or poplar trees with vines, olive or mulberry trees are planted in rows of from 30 to 40 feet apart; and green crops, hemp, maize, or wheat are also grown under them. Several farms are entirely laid out in orchards containing a great variety of fruit, such as apples, pears, apricots, peaches, figs, plums, almonds, walnuts, &c., with stone-pines towering over them all. Madder-root has of late years been introduced, and cultivated to a considerable extent in the plain on the S.E. slope of Vesuvius.

The Apulian system is peculiar to the great plain already described as extending from the Fortore to the Ofanto rivers, and from the foot of the Apennines to the shores of the Adriatic, and known by the local appellation of *Tavoliere di Puglia*. Nearly the whole of this vast treeless flat, parched up in summer, and clothed with luxuriant herbage in winter, belongs to the crown, and is chiefly laid out in pasturage. From the earliest times, the Marsican and Sam-

nite shepherds were in the habit of leading their flocks from their high mountains to this plain for the winter pasturage. This periodical migration greatly increased when the second Punic war had depopulated the few cities which existed on the plain; and the Romans, when masters of the country, imposed a *vectigal*, or fixed tribute, on the right of grazing upon it—a tax more or less enforced during the middle ages. Till the fifteenth century the winter migration of the flocks was voluntary; but, in 1442, Alfonso I. of Aragon made it compulsory, and established the system of the Tavoliere, which, with some alterations, lasts to the present day. Alfonso appropriated to the crown all commons and waste lands to which no good title could be shown, and divided them into *Locazioni*. To give greater accommodation to the flocks, which his laws compelled to resort to Apulia, he bought from several feudal barons and convents the right of grazing on their adjoining lands, which he designated by the name of *Ristori*. To convey the flocks to and from the plain, several great roads, called *Tratturi delle Pecore*, were traced, with some adjacent tracts of land, called *Riposi laterali*, on which the flocks were allowed to rest and graze for twenty-four hours on their march. Two general *Riposi*, or resting-places, were also provided at two extremities of the plain, on which the sheep might stop till the proprietors declared the number of their respective flocks, and the crown officers verified them, and apportioned to them their pastures. The farmers were compelled to sell the produce of their stock at Foggia, where the tax was paid into an office called the *Dagana di Foggia*, and they were not allowed to leave the Tavoliere without a passport, which of course was not granted until the taxes were paid.

Under the Spanish viceroys the system became so odious and oppressive that Charles III., on his gaining possession of the kingdom, made the Tavoliere the subject of an official inquiry; but no great changes were effected till 1806. In that year, by a law of Joseph Buonaparte, farms held under the crown were declared freeholds of those who were in possession of them; and the occupants of lands assigned to them for grazing were declared owners of such lands, on payment to the crown of a certain rent, which was fixed according to the number of their flocks, and was redeemable at will. After the restoration of the Bourbons, however, Ferdinand I., with the exception of compulsory migration, which is at an end, re-established the old system, by taking the land from those who had been in full possession of it for ten years, by making rents and charges irredeemable, and by forbidding the ploughing up or planting of any part of the land without an express licence from the crown. The collection of the taxes, which are calculated to bring about L.70,000 a year, is confided to a magistrate called the *Direttore del Tavoliere*, who is also the governor of the province of Capitanata.

The Sicilian system prevails in Sicily, and the continental provinces of Bari, Otranto, and Calabria. The general rotation is—First year, fallow or summer crop; second year, hard wheat (*grano rosso*); third year, a lighter kind of wheat (*maiolica*); fourth year, oats. Cotton is sometimes planted the fourth year; and of late years rice has been introduced in the marshy districts. But olive, almond, fig, and orange trees, and vines, form a more important branch of the cultivation. More than one-half of Terra di Bari and Terra d'Otranto, and great tracts of the western shores of Calabria, are covered with olive-trees, which are propagated by slips, by shoots, and chiefly by grafting the wild olive either *in situ*, or, if transplanted, a couple of years after it has taken root. It takes at least twenty years before an olive plantation begins to bear a satisfactory return. The flowering of the olive-trees begins towards the end of May, but the fruit is not ripe till November. Except in very few favourite spots, the olive-tree does not give a yearly return. A plantation is considered very good if it brings a tolerable quantity of fruit every other year; generally a good return is only every third year. The vineyards are very extensive, but the vines are not trained in festoons, as in the provinces of Naples, Terra di Lavoro, &c., but low, as they are in the south of France.

The area of the continental provinces is supposed to contain about 20,220,516 English acres, of which only 11,430,972 acres are reduced under cultivation; the remaining 8,789,544 acres being occupied by waste land, lakes, rivers, buildings, roads, &c. The peasants who cultivate the land, though receiving on the whole small wages, are not badly off, except in Capitanata, in Basilicata, and in some other mountain districts. In many districts they are commonly *metayers*, dividing equally with the lord or the farmer the annual produce; but where the soil is peculiarly fertile, the peasant has but one-third of the harvest for his share. Most of the soil was formerly owned by the crown, the king, the higher aristocracy, and the religious houses; but a great change has taken place since most of the mortmain lands were seized by the state on the suppression of convents and nunneries in 1806, and afterwards sold. The abolition at the same time of entails and the new laws of succession increased the number of landowners, by the breaking up of large estates; the tendency at present seems rather to be towards too great a subdivision of property, particularly near the large towns.

The principal productions of the country include all those of the temperate, and several of the torrid zone. In most years more corn is grown than is required for the consumption of the inhabitants—the full year's average of the crop being estimated at about 14,000,000 English quarters. It might, however, be tenfold increased by bringing into cultivation some of the rich land of the plains which are now a waste, if the constant practice of the government of prohibiting exportation of corn whenever its price is not low, did not effectually check that branch of agricultural industry. Oil is, next to corn, the most important agricultural production. It is the substitute for the butter made in northern Italy, and enters largely into all the edible preparations of the inhabitants. It is generally used in lamps, to supply the place of candles, and a large quantity of it is converted into soap. The best oil for culinary purposes is made out of the olives before they turn black; that of Vico and Massa near Naples, of Venafro in Campania, of Trani and Monopoli in Apulia, and of several other places in Calabria and Sicily, is in high repute. The oil-mills are the same as those used in ancient times, and are generally at work from November to March, and in years of great returns even till May. The oil, as it is prepared, is sent to different places of depôt along the coast, where it is collected for exportation, and is deposited in large subterranean tanks excavated in the limestone rock, where it clears, and keeps, if necessary, for many years. The quantity of oil deposited by a proprietor is guaranteed by a ticket which is given to him, and upon which he may borrow money, and eventually effect the sale of the article.

The vine is extensively cultivated, but so little care is bestowed in the selection of the varieties in planting it, and so little skill is exercised in the preparation and treatment of the wines, that a large quantity of the produce is only fit to be converted into brandy. Under different circumstances the Two Sicilies might supply the whole market of Europe with wine, as vineyards might be increased to any extent, and capital and skill are all that are required to produce excellent wines. An illustration of this is given by two English houses established at Marsala, in Sicily, that prepare wine of tolerable quality and flavour, and of durable strength, which, under the name of Marsala, has found its way in considerable quantity into the English market. Several local wines, however, in spite of the unskilful way in which they are prepared, are excellent, and strong

enough to bear a sea-passage, and only require to be known to be appreciated. Such are the Pellagrello of Piedimonte, the red and white Gerace, the red Taranto, the Muscat of Trani, the Aleatico of Bari, the red Arpino, the Capo di Lecce, the Monte di Procida, the Syracuse, the red Cirò, the white Torre del Greco, the red Somma, &c. &c.

Both on the continent and in Sicily much silk is produced, but little beyond what is required for domestic consumption. In late years the cultivation of the mulberry-tree has increased, but the same skill and diligence is not applied to it as in Lombardy and Piedmont. Figs are extensively cultivated, and their fruit, dried in the sun in September, and in some places, baked afterwards in an oven, is an article of winter food to the lower classes. Another article of food are chestnuts, which are supplied by the sweet chestnut-forests that clothe extensive tracts of the mountain districts. Almonds form an important item of the productions of the province of Bari. The liquorice-juice brought to the English and French markets is extracted from the liquorice-root that grows wild in many districts of Calabria. The average annual growth of cotton wool is about 80,000 bags, a quantity far below the home consumption. Flax and hemp, wool, cheese, tobacco, saffron, manna, raisins and currants, oranges, lemons, capers, caroubas, sumac, madder-root, castor-oil, beans, rice, honey, &c., are the other principal agricultural productions of the kingdom.

The live stock is supposed to be nearly as follows:—sheep, 4,700,000; goats, 720,000; oxen and cows, 360,000; buffaloes, 50,000; horses, 110,000; mules and asses, 890,000; pigs, 2,400,000. About two-thirds of the whole number of sheep are migratory, being kept, as already stated, in the mountains in summer, and in the plain of the Tavoliere in winter. They are shorn twice a year, totally in the spring, and only partially in the summer. The wool varies in quality, but is in general good, and most of it is exported. But the chief return to the farmer is from a kind of ordinary cheese made from the milk of the ewes. Cows' milk is made into butter only near Naples, Palermo, and a few other large towns; generally it is converted into a kind of cheese called *Caciocavallo* and *Provole.* The oxen are commonly used to plough the land, and to draw waggons or carts. The horned cattle in the Terra di Lavoro, in Terra d'Otranto, and the S.W. of Sicily, are white, very large and splendid-looking animals. Buffaloes are used as beasts of draught, and their milk is made into a kind of very ordinary cheese. Mules abound in the provinces of Otranto, Abruzzi, Principato Ultra, and Sicily; they are used for ploughing, for drawing carts, but chiefly for the internal traffic over paths across mountains; in some of the provinces they are even used in the carriages of the upper classes and the clergy. Some of the breeds of horses are fine, especially those reared in the Tavoliere, in the plain of Pæstum, and in Calabria; but they have much fallen off in consequence of a heavy tax laid on their exportation in the last century, and the present prohibition of importing foreign horses. The swine are generally black, though the white are not uncommon; at Sorrento, and in other places further south, they are devoid of bristles.

The manufactures of the kingdom are for the most part of the domestic kind. The females spin the flax, hemp, wool, or cotton, and make coarse cloths, with which the condition of the great body of the lower classes compels them to be satisfied. Within the last forty years, however, considerable progress has been made, and large manufactories of various kinds have been established in different parts of the country. At San Leucio, at Catanzaro, at Reggio, at Naples, and at Catania, silk goods are made, which are in great demand, and Sorrento is celebrated for its silk socks. Arpino, Sora, and Isola have paper-mills and manufactories of woollen cloths, made of Apulian wool. Near Salerno, at Sarno, at Scafati, &c., there are cotton-mills, linen and calicut manufactories, &c. Carpets are made at Ischia, and in the neighbourhood of Naples. Amalfi, Gragnano, and Torre Annunziata are celebrated for their macaroni. The best quality of it is made from the hard wheat grown on the Tavoliere (the *grano rosso* of Barletta), which is reduced to flour by the usual process of grinding. At Atripalda there are iron-foundries, fulling and paper mills. Leather, hardware, glass, earthenware, porcelain, ropes and cordage, hats, gloves, artificial flowers, &c., though of indifferent workmanship, are also made in several towns.

Many of the continental provinces have *Monti Frumentarii*, which, in aid of agriculture, lend wheat to farmers at the sowing time on a small return in kind after the harvest. In most large towns there is also a *Monte di Pietà*, or government pawn-bank, which lends small sums at 5 per cent. to the poor; but there are no saving banks, as their operations would interfere with the Lottery revenue. The only saving bank in the kingdom was opened at Naples in 1855, and in 1857 it had L.1525 of deposits in 479 accounts. It receives sums from 4d. upwards, and when they reach 3s. 4d. it allows an interest of 3 per cent.

Accounts are kept in ducats of 10 *carlini* or 100 *grani* each; but the currency is in *piastre* of 12 carlini. The carlino, at the exchange of 600 grani to L.1, is equal to 4d. The *palmo*, equal to 10·35 inches, is the unit of the measures of length. 10 palmi form the new *canna*, and 8 the old canna, still in common use. The mile is the geographical mile of 60 to a degree. The measures of capacity vary almost in every province, the standard measures of late years prescribed by government not being yet in general use.

No country in Europe has so little foreign trade, in proportion to its extent and population, as the Two Sicilies; but the absence of any official statistical returns renders it impossible to give a correct account of its nature and amount.

The mercantile navy of the continental possessions, in 1825, consisted of 5008 ships, and 107,938 tons; in 1855 it had increased to 8988 ships, and 212,965 tons. The chief emporium of the trade is Naples, to which the greater portion of the spare products are brought by small coasting-vessels, and whence also are dispensed what foreign commodities are required. The other principal places where there is some foreign trade are—Castellammare, Reggio, Taranto, Gallipoli, Bari, Molfetta, Barletta, Manfredonia, and Termoli. Sicily in 1856 had 2300 ships, and 123,775 tons, of which the greatest portion belonged to Messina and Palermo. Next in importance are Catania, Trapani, Marsala, and Castellammare.

The imports of the continental provinces, in 1856, were estimated at about L.2,744,760; and the exports at L.3,353,513, showing a surplus of 808,753 in favour of the latter. The principal articles of importation were—cotton yarn and cotton wool, sugar, woollen manufactures, tobacco, coffee; and the chief articles exported—oil, corn, wheat, silk, madder-root, wool, almonds, and fresh and dried fruits. With respect to the various countries, and in the order of their respective importance, the largest imports were—from England, France, America, Holland, Sardinia, &c. And the exports to France, England, Austria, Russia, Holland, Sardinia, &c.

We have more reliable information with regard to the existing trade between this country and the Two Sicilies, the nature and extent of which will be shown by the subjoined abstract tables, from the official statistical returns of the trade and navigation of the United Kingdom, presented to both Houses of Parliament by command of her Majesty. It will be seen that the imports from the Two Sicilies, which in 1854 were of a computed real value of L.1,411,457, in 1858 had risen to L.1,656,523. The increase of the exports thereto is even more remarkable. From L.672,291 in 1854, they had steadily risen in 1858 to L.1,787,300.

Sicilies.

The most important articles of importation, in 1858, were—oil, L.601,651; brimstone, L.452,202; sumac, L.121,179; madder-root, L.103,386; oranges and lemons, L.72,044; wine, L.41,585; and the principal articles of exportation—cotton yarn, L.489,686; ditto, by the yard, L.352,068; ditto, at value, L.13,601; iron, wrought and unwrought, L.228,850; woollens by the yard, by the piece, and at value, L.165,070; hides, not tanned, L.74,791; indigo, L.73,474; coals, cinders, and culm, L.52,420; linen by the yard, L.38,220; linen yarn, L.22,949; steam-engines and machinery, L.41,088.

Imports from the Two Sicilies into the United Kingdom.

Articles.	Quantities.	Computed Real Value.		
	1858.	1854.	1856.	1858.
		L.	L.	L.
Argol ... Cwts.	2,079	4,555	8,211	7,368
Barilla ... Tons	688	1,160	4,426	12,039
Bones ... „	931	6,205	4,618	5,043
Brimstone ... Cwts.	1,067,387	364,753	366,519	452,202
Corn—Wheat ... Qrs.	...	4	69,120	...
„ Beans ... „	12,290	...	4,872	21,652
„ Maize ... „	97	...	...	158
Cream of Tartar ... Cwts.	9,250	118,387	53,090	38,210
Hemp, undressed ... „	12	79,460	6,740	20
Juice of Lemons, Limes & Oranges ... Galls.	163,493	9,484	10,848	11,466
Liquorice-Juice & Paste ... Cwts.	7,010	30,043	31,566	31,909
Madder-Root ... „	55,198	71,580	132,187	103,386
Nuts, small ... Bushels	13,728	6,285	8,592	9,105
Oil, Olive ... Tuns	12,912	303,105	313,789	601,651
Oil, Essent.—Bergam. Lbs.	36,254	9,866	17,352	13,512
„ „ Lemon „	60,939	15,202	20,864	18,659
Oranges & Lemons ... Bush.	145,967	39,079	63,296	72,044
Seeds, flax & linseed ... Qrs.	2,796	38,113	1,381	7,451
Shumac ... Tons	11,019	135,984	184,680	121,179
Silk, Raw ... Lbs.	8,503	11,264	2,519	12,104
„ Waste, Knubs, and Husks ... Cwt.	128	1,979	12,394	1,655
„ Thrown ... Lbs.	8,933	31,484	23,821	15,083
Vermicelli & Macaroni ... Cwts.	1,066	448	3,136	2,671
Wine ... Gallons	184,060	77,985	56,051	41,585
Wool, Sheep & Lambs' Lbs.	84,985	7,894	14,993	3,705
All other articles ... Value	...	47,238	90,517	52,666
Total ...	...	1,411,457	1,505,582	1,656,523

Exports from the United Kingdom to the Two Sicilies.

Home Produce and Manufactures.	Quantities.	Declared Real Value.		
	1858.	1854.	1856.	1858.
		L.	L.	L.
Apothecary Wares ... Cwts.	Value	1,650	2,790	4,233
Apparel, Slops, & Haberdashery ... Value	...	1,892	6,327	10,582
Coal, Cinders, & Culm Tons	106,973	29,495	41,048	52,420
Copper, wrought & unwrought ... Cwts.	6,393	9,491	18,488	34,108
Cottons—				
Entered by the Yard Yds.	21,571,582	137,800	286,088	352,068
„ at Value ... Value	...	6,392	8,668	13,601
Cotton Yarn ... Lbs.	13,420,717	165,140	329,621	489,646
Earthenware and Porcelain ... Value	...	4,603	7,558	7,815
Fish, Herrings ... Barrels	4,240	52	3,370	4,240
„ Pilchards ... Hhds.	4,526	...	4,375	11,631
Hardwares & Cutlery Cwts.	4,450	10,897	22,282	23,615
Iron, wrought and unwrought ... Tons	31,246	83,757	194,471	228,850
Linens ... Yds.	848,699	16,612	29,954	38,220
Linen Yarn ... Lbs.	333,010	5,816	13,682	22,949
Machinery—				
Steam-Engines ... Value	...	3,550	1,741	28,045
All other sorts ... „	...	5,767	6,482	13,043
Saltpetre ... Cwts.	1,742	974	3,338	3,558
Silk Manufactures ... Value	...	5,125	14,069	8,251
Sugar, refined ... Cwts.	2,581	...	52,144	7,683
Tin Plates and Tin ...	...	7,508	16,068	19,373
Woollens—				
Entered by Pieces ... Pieces	40,283	22,861	40,227	73,480
„ by the Yard Yds.	1,691,947	30,258	63,556	81,840
„ at Value ... Value	...	1,588	8,102	9,750
All other articles ... „	...	11,805	27,734	30,165
Total ...	...	563,033	1,202,183	1,569,166

Exports from the United Kingdom to the Two Sicilies.

Foreign and Colonial Produce and Manufactures.	Quantities.	Computed Real Value.		
	1858.	1854.	1856.	1858.
		L.	L.	L.
Cochineal ... Cwts.	98	789	648	2,065
Cocoa ... Lbs.	293,034	456	802	7,326
Coffee ... „	76,985	1,522	4,534	2,168
Cotton, Raw ... Cwts.	362	...	1,308	1,213
Hides, not tanned ... „	21,306	26,065	62,013	74,791
Indigo ... „	2,122	15,018	50,392	73,474
Spirits, Rum ... Proof Galls.	148,207	18,887	23,714	15,716
Sugar, Unrefined ... Cwts.	676	7,410	146	1,114
Tobacco, Unmanufactured ... Lbs.	122,535	14,718	9,621	4,430
Wax, Bees' ... Cwts.	860	12,167	13,941	7,192
All other articles ... Value	...	12,226	30,806	28,645
Total ...	...	109,258	197,925	218,134
Grand Total ...	...	672,291	1,400,108	1,787,300

The internal trade of the country has increased considerably since the opening of many excellent carriage-roads. In the beginning of this century there were only the post-road from Naples to Terracina, the roads from Naples to the royal hunting-parks of Venafro, Bovino, and Eboli, and the road from Palermo to Bagheria. Several roads were projected and begun under the French, chiefly with a view to military operations; but most of the great roads now open have been constructed since 1815.

Five high post-roads start from Naples for Terracina, the Abruzzi, Molise, Puglia, and Calabria, reaching, with their main trunk or their branches, the capitals of all the fifteen continental provinces, and some of the capitals of the districts. The road of the Abruzzi branches at Popoli into two main lines, both of which enter the Papal territory; one inland, by Civitaducale and Rieti, the other along the Adriatic by Porto-di-Fermo and Ancona. Another inland road, by San Germano, enters the Papal States at Ceprano. All these roads are constructed with remarkable engineering skill, and are in excellent condition. They are kept up at the expense of the state. The provincial roads which start from the capital of the province to the chief town of the district, are open and kept up at the expense of the provincial funds, and the communal roads at the expense of the different communes interested in them. There are no tolls of any kind. There are many provincial roads projected, but not even begun, and the communal roads open are very few, except in the province of Terra-di-Bari, where internal roads open communications among the principal towns. As an illustration of the great want of roads still existing, it may be mentioned that there is no direct road connecting Brindisi to Taranto, the two principal ports on the Adriatic and the Ionian; none from Taranto along the shore of the Ionian Sea to Castrovillari and Cosenza; none from the eastern to the western shores of the province of Basilicata; none from Foggia to Melfi, &c. &c. In Sicily, the only public roads open to traffic are—from Palermo to Messina, with a branch to Catania; to Castrogiovanni; to Marsala by Alcamo; to Castellammare, along the coast; to Termini and Cefalù; to Girgenti by Caltanissetta; and from Messina, along the eastern base of Ætna, to Catania and Syracuse, with a continuation from the latter place inland to Noto. The only railways open are, from Naples—a line of 26 miles to Cava, with a branch of 4 miles to Castellammare; a line of 22 miles to Caserta and Capua, with a branch of 8 miles to Nola and Sarno.

Till January 1848, the government of the Two Sicilies was, in theory as well as in practice, an unmixed absolute monarchy; but on the 10th of February of that year, a constitutional charter was freely granted by the late king Ferdinand II., which restrained the previously unlimited

 powers of the sovereign. The principal provisions of the charter are—

The Two Sicilies will be a *constitutional hereditary monarchy*, in which the executive power belongs exclusively to the king, and the legislative power is collectively exercised by the king, and a Parliament, composed of two houses, an upper and a lower one.

The king has the command of the army, declares war, and makes peace; he also negotiates treaties of commerce and alliance, subject, however, to the approval of parliament previous to their ratification. All his acts must be countersigned by a responsible minister.

The Upper House, or *Camera de' Pari*, is composed of an unlimited number of members nominated for life by the king, from among persons at least thirty years old, who either are in possession of a net income of L.500 a year, or belong to one of the ten categories enumerated by the charter. The princes of the royal family are peers by right at the age of twenty-five, but have no vote till they are thirty years old. The upper house is the high court to try any member of parliament for high treason.

The Lower House, or *Camera de' Deputati*, is composed of deputies returned by the electoral districts into which the kingdom is divided; there is a deputy returned for every forty thousand inhabitants. Both the deputies and their electors must be at least twenty-five years old. They must have from landed property, from mortgages, or in the public funds, a net yearly income, fixed by the electoral law of May 24, 1848, at two pounds for the electors, and at twenty pounds for the deputies; or, in the absence of such an income, they must be members of one of the royal academies, professors in one of the universities or public colleges, &c. The duration of the lower house, unless dissolved sooner, is five years.

Parliament is to meet every year, and in case of a dissolution of the lower house, a new house must be summoned within three months. Neither peers nor deputies receive any salary or indemnity. The sittings of the chambers are public; no sitting is valid unless an absolute majority of their members are present. Each of the three powers of the state has a right of introducing bills, but all money bills must first be introduced in the Lower House. No tax can be imposed or levied without its having previously been assented to by the houses and sanctioned by the king.

No other religion but the Roman Catholic is to be allowed a free exercise. The charter guarantees individual liberty and property; any person imprisoned as a precautionary measure must, within twenty-four hours, be brought before the proper judicial authority, and acquainted with the motives of his imprisonment. No one's domicile can be entered without a warrant of the judicial authority. The press is to be free, but subject to a repressive law for any attacks against religion, morality, public order, the royal family, foreign sovereigns and their families, and the honour and interest of any private person. Judges are irremovable after they have exercised their functions for three years under the constitution. The ministers of the crown are entitled to attend the debates and speak in either house, whenever they deem it expedient; but they have no vote unless they are members. Any member of the lower house who takes office under government vacates his seat, but may be re-elected.

A parliament was summoned, and met under this constitution, in June 1848; it was prorogued in September, and met again in February 1849. On the 13th of the following March, however, a royal decree dissolved the lower house, reserving the naming of a day for proceeding to the new elections, according to the charter. From that time parliament has never been summoned; the constitution, without being formally annulled, or even suspended, has remained in abeyance, and the old despotic practices have been resorted to. The kingdom of the Two Sicilies is thus in the anomalous and perhaps unique position of being in theory a constitutional government, in practice and *de facto* the most thoroughly despotic and arbitrary government in Europe.

The administration, as it was previous to 1848, and as, in defiance of the constitution, it has been ever since March 1849, consists of—a council of state (*Consiglio di Stato*), a council of ministers (*Consiglio de' Ministri*), and a council general for the kingdom (*Consulta Generale del Regno*). The *Consiglio di Stato* has an unlimited number of members, appointed directly by the king, in order to give their opinion, when required, on any subject relating to the internal affairs or foreign relations of the country. Their meetings are presided over by the king, or the heir-apparent, if of age, or the president of the council of ministers. The functions of this council, which has a certain resemblance to our privy council, are merely consultative, and do not in any way bind the king or his ministers to any course of policy.

The *Consiglio de' Ministri*, which answers to our Cabinet, consists of the ministers-secretaries of state, and is presided over by the president of the cabinet. Their resolutions are submitted to the king, in a conference between him and each minister within whose department the respective subject under discussion lies, and cannot be carried out until they have received his royal sanction. In the absence, or non-appointment of a minister, the corresponding director takes his place at the council, and in the conference with the king. There are ten ministries, each of them called *Real Secreteria di Stato*:—Presidency of the Council, Foreign Affairs, Grace and Justice, Ecclesiastical Affairs and Public Instruction, Finances, Public Works, War and Navy, Home, Police, Affairs of Sicily.

The *Consulta Generale del Regno* is divided into a consulta for Naples, with 16 members; and a consulta for Sicily, with 8 members. Each consulta has a president, and meets separately; but on affairs affecting the whole kingdom they meet together under the senior president. They examine and give an opinion on projects of law, or on such other matters as may be referred to them by the king or any of the ministers. The consulta was established in 1822, as a security for the good government of the country; but like all such half or evasive measures, it neither had any legislative influence, nor produced any good results whatever.

The supreme executive power of the king is carried out through two distinct branches—the *Administrative* and the *Judiciary* power. Their different attributions and respective limits were defined by the organic law of 1817. The system is in substance the same as the French; the difference is chiefly in the details.

In the provinces the former power is represented by a governor, called *Intendente*, who is appointed by the king, and has in his hands the civil, military, and financial administration of the province over which he presides. He is assisted by a secretary-general and a council called *Consiglio d'Intendenza*, and has under him sub-governors, called *Sottintendenti*, in each district into which the provinces are divided. The secretary-general, the members of the council, and the sottintendenti, are also appointed by the king. A provincial council, *Consiglio Provinciale*, consisting of members selected by the king out of lists of landed proprietors, submitted to him by the communal councils, assemble once a year to examine the provincial accounts, recommend local improvements, and praise or censure the conduct of the Intendente.

The *Sottintendenti* of the districts carry out the ordinances and instructions of the Intendente, to whom they report on the petitions or grievances of the comuni, and correspond both with the intendente and the home minister. A district council (*Consiglio Distrettuale*), composed as the pro-

vincial council, meets once a year in order to examine and report to the provincial council on all matters of local interest.

The *Comuni*, into which each district is divided, are arranged in three classes, with a view to their administration. Towns which have at least 6000 inhabitants, or a revenue of L.833 per annum, or are the provincial capital, or the seat of the law-courts, rank in the first class. In the second are those with a population of from 4000 to 6000 souls, or the chief town of the district. In the third, those that have less than 4000 inhabitants. A comune is either a single town, or an aggregate of two or more towns or villages; there are comuni whose population is made up by as many as 24 villages. Each comune is governed by a corporation of very ancient institution, consisting of a *Sindaco*, two assistants called *Eletti*, and a communal council called *Decurionato*. The sindaco superintends the registration of marriages, births, and deaths, which are entered by a communal registrar (*Cancelliere Comunale*), under his orders; has the control of the public establishments, and the management of minor communal affairs; has to provide the commissariat of the troops passing through, and, in the absence of a military commissary, even of those quartered in, the comune; has jurisdiction in some minor causes of communal police, obstructions of roads, occupation of public ground, &c., presides over the decurionato, and corresponds with the Sottintendente and the Intendente. The eletti act as his deputies, and as commissioners of the communal police; the prices and order of the daily market are under the vigilance of the first eletto. The decurionato, which meets once a month, unless specially summoned by the sindaco, forms (subject to the approval of the king in comuni of the first, of the home minister in comuni of the second, and of the Intendente in comuni of the third class) the communal budget, fixes the local rates and taxes for communal purposes, gives the three names out of which the sindaco and the eletti are to be appointed, and submits to the king the names of the proprietors whom they consider eligible for the provincial and district councils. Two-thirds of its members must be present to deliberate.

The sindaco and the eletti are selected by the king or the home minister, according as the comuni belong to the first and second, or to the third class, out of three names (*Terna*) submitted by the decurionato for each of them. If the names are not satisfactory to the authority, the decurionato is directed to submit a new terna. The decurionato is generally composed of three members for every thousand inhabitants, but their number must never in the large cities exceed thirty, and in the small comuni be less than five. Landholders, farmers, artisans, &c., are all eligible, provided they are possessed of a rateable annual income of L.4, or have exercised a liberal profession for 8 years consecutively, in the comuni of the first class; or have an income of L.3 and L.2 respectively, or occupy a farm of a certain size, or exercise a profession or trade in the comuni of the second and the third class. One-third of them at least must be able to write and read. One-fourth of them go out annually, and the lists for the new members (with three names for each member) are formed by the decurionato itself, by ballot, and submitted for selection to the king or the home minister.

Questions relating to commons, communal property, public roads, rivers, lakes, and the sea-shores; questions concerning taxes and excises, or the accounts of their collectors, or of communal and provincial cashiers, &c., all fall within the attribution of the administrative power, and are decided in the first instance by the *Consiglio d'Intendenza* of the province in which the question arises, and in appeal by the Court of Accounts of Naples or that of Palermo, as the case may be. The decision of the latter court, however, cannot be carried into execution unless it is approved by the king in council, who sometimes, before sanctioning or modifying the decision, sends it, on the application of one of the interested parties, to the *Consulta del Regno* for their opinion.

All other matters and questions whatsoever affecting things and persons fall within the attribution of the judiciary power, and are regulated by a Code of Laws (*Codice pel Regno delle Due Sicilie*) promulgated by Ferdinand I. in 1819. It is, in substance, the *Code Napoleon*, which Joseph Buonaparte introduced into the continental part of the kingdom in 1807. Divorce, recognised by the *Code Napoleon*, is expunged from the Neapolitan Code, and marriage is regulated according to the canons of the Council of Trent. The other principal changes are with regard to parental authority, the relations between husband and wife, legitimate succession, and mortgages. With respect to succession, any person who has issue is allowed to dispose by will only of one-half of his whole estate, including both real and personal property; the other half must be equally divided among his, or her, children or grandchildren. With this difference, however, that, if any of the children are alive, the grandchildren succeed *per stirpes*—that is to say, they altogether take and divide among themselves the share which their parent would have been entitled to; but if the children are all dead, and there are surviving only grandchildren, the latter succeed *per capita*—that is, they take an equal share each of their grandfather's inheritance. Natural children are entitled only to two-thirds of what as legitimate children they would have taken; adulterine issue is only entitled to alimony. In case of intestate succession, the whole property is equally divided, according to the same rules and proportions.

The magistrates appointed to administer justice are very numerous, and their respective jurisdiction is defined by the organic law of 1817 (*Legge Organica del Potere Giudiziario*). They are all appointed by the king, badly paid, and, in the present illegal suspension of the constitution, removable at his pleasure. The lowest among them is the *Conciliatore*, who is appointed in each comune from among the inhabitants, including ecclesiastics, receives no salary, and, acting as an umpire, decides without appeal all actions for sums below L.1. In each district there is a judge (*Giudice d'Istruzione*), whose duty it is to collect evidence against criminals, and transmit it to the local courts for prosecution. The districts are divided into Circondarii, of which there are 720 in the kingdom; and in each of them there is a justice of the peace (*Giudice di Circondario*), whose salary, besides some small fees, is from L.4 to L.6 a month, and is paid by the comunes of the Circondario. He decides all civil actions, without appeal, to the amount of L.3, 7s., and subject to appeal to the amount of L.50; all questions arising in a market, or regarding trespasses; all infractions of the revenue laws; and all cases of correctional police, whose punishment does not exceed two years' imprisonment. He also collects and reports upon the evidence of local crimes, and has the general control of the police, where there is no police inspector. In each province there is a civil court (*Tribunale Civile*), and a criminal court (*Gran Corte Criminale*). The civil court, composed of a president, two other judges, a royal procurator, and a chancellor, takes cognizance in first instance, and subject to appeal, of all civil actions exceeding L.50; of questions affecting the state of persons, and of mercantile actions in those provinces that have no commercial tribunal; it also decides, as a court of appeal from the justices of the peace. The criminal court, composed of a president, five judges, a procurator-general, and a chancellor, decides upon graver criminal cases, except military offences, and revises, on appeal, the judgments of the justices of the peace in cases of correctional police. In the provinces of Naples, Capitanata, Calabria Ultra I., Messina, and Palermo, there are commercial courts (*Tribunali di*

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Commercio), having a president and three judges, chosen from the class of merchants, and a royal procurator and a chancellor. They have jurisdiction in commercial cases, without appeal, up to L.4, and subject to appeal beyond that amount. There are six civil courts of appeal (*Gran Corti Civili*) sitting at Naples, Aquila, Trani, Catanzaro, Messina, and Palermo, and consisting of a president, six judges, a procurator-general, and a chancellor. They decide, in the last instance, upon the appeals from the judgments of the civil and commercial courts which fall under their jurisdiction. Above all these courts is a Court of Cassation, called *Corte Suprema di Giustizia*, which for Sicily is held at Palermo, and for the continental provinces at Naples, and consists of a president, two vice-presidents, sixteen judges, a procurator-general, two advocates-general, a chancellor, and two vice-chancellors. It is divided into a civil and a criminal chamber, each with a president, eight judges, an advocate-general, and a chancellor. All judgments from which there is no appeal may be denounced by the interested party to the Supreme Court, on the plea of their being against the law, whose articles alleged to have been infringed must be specified. The court, if there is any violation of the law, quashes the judgment, and sends the contending parties before another judge of circondario, civil or commercial tribunal, criminal court, or civil court of appeal, as the case may be, for a new hearing and a new judgment upon the question. For certain particular criminal cases, eight judges of the ordinary criminal courts are by royal commission invested with special powers, and formed into a special court (*Gran Corte Speciale*), from whose judgment there is neither an appeal to a superior court nor a recourse to the Court of Cassation. There are also a military court (*Alta Corte Militare*), composed of generals appointed by the king, and an admiralty court (*Commissione delle Prede Marittime*).

From this long list it might be inferred that justice has a fair chance in the Two Sicilies, and yet nothing would be farther from the truth. The total absence of a jury, in civil as well as criminal cases, leaves both the finding of the fact and the application of the law in the uncontrolled hands of the judge. But the evil is to be traced to other causes. Ever since the establishment of the present system, the smallness of the salaries, as compared with the profits made at the bar, had contributed to keep away from the bench the best legal minds, whose absence, however, was often made up by common sense and moral principles. Whilst the leading lawyers are likely to make from L.2000 to L.4000 a year, the salary of the President of the Supreme Court, who is the chief-justice of the kingdom, is only L.650 a year! Nothing but death stops the prosperous career of an honest barrister or chamber counsel who has once established a reputation; a judge, even after having through many years toiled his way up to the highest courts, may be, and often is, turned out and left unprovided for whenever individually or collectively he pronounces a judgment distasteful to the government. Of late years the political troubles have increased the evil to an incalculable degree. The criminal courts receive from the head of the police, or from the king's private cabinet, the list of obnoxious persons who are to be condemned for state crimes, irrespective of any evidence. Any resistance to their bidding is visited with immediate destitution. The *Official* Neapolitan newspaper teems with instances of it. Thus, in 1850, the Criminal Court of Cosenza was broken up, and recomposed twice before the government could obtain the conviction of several hundred prisoners against whom there was no evidence; and in the trial of Poerio and his friends, a trial so well known in this country, conviction was secured only by the substitution of several judges. Nor is this all. After the abolition of the constitution of 1821, a circular from the minister of justice inculcated on all the judges in the kingdom that, in the decision of all civil questions, a deference should be shown towards the parties who were loyal to the despotic system. This injunction, against which the moral sense of the country had rebelled and had caused it to be forgotten, was reiterated in 1851. The result of all this has been, that men with any sense of morality, of self-respect, and of independence, keep away from an office which would ruin them in every way. Only a set of poor, unprincipled, ignorant men, who have nothing to lose and all to gain, have consented to be the tools of the government. The scum of the bar has filled the bench. Many an upright man in his old age has been placed in the fearful dilemma of either departing from justice or meeting starvation to himself and his family. Under these circumstances a set of Jeffreys might be found in any country; and the paternal government of Ferdinand II. so well fostered them that Neapolitan justice is become a byeword among nations, and a disgrace to civilised Europe.

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A large army, in part of foreign mercenaries, naturally is required to maintain this outrageous system. On the 1st of January 1859, the military establishment, including the reserve, the marines and the veterans, numbered 2825 officers, 96,805 soldiers, of whom about 14,000 were Swiss mercenaries, and 8843 horses. The effective part of the army consisted of 2509 officers, 80,029 soldiers, and 8543 horses. The national regiments are raised by conscription from 18 to 25; a substitute may be obtained by a payment of L.40 to the government. The period of forced service is eight years in the cavalry, artillery, and gendarme regiments; five years in the line, with three years' liability to be called again in case of emergency. The Swiss regiments were recruited in Switzerland in force of a stipulation passed with some of the Cantons in 1827. When that stipulation expired, the enlistment took place on the Swiss frontiers. In the course of 1859, a spirit of insubordination having appeared among them in consequence of their being deprived of their national flag, many of them were dismissed and sent home; but as many other foreign cut-throats were enlisted to fill their ranks in the regiments, which have received different names. They receive one-third more than the Neapolitans, and have mattrasses, which are not given to the latter.

The navy has of late years been increased and much attended to. It consists of 2 ships of the line of 80 guns each; 5 frigates of from 60 to 40 guns; 2 corvettes of 22 guns; 5 brigs of 18, and two sloops of 14 guns; and a steam squadron composed of 2 frigates of 400 horse-power each, 10 of 300, 4 of 200, and about 20 more of less power. The number of seamen is about 5000, and that of the marines and artillerymen about 7400.

As no regular budget is ever published by the Neapolitan government, the real financial state of the country is in great part a matter of conjecture. The following particulars, however, without laying claim to strict accuracy, are as near an approximation to it as, in the absence of all official returns, it is possible to obtain.

Under the French rule, 1806–15, all the creditors of the state who were not paid by the sale of public domains or monastic property, were entered into a registry called *Gran Libro del Debito Publico*, and allowed an interest of 3 per cent. on what was due to them. Such was the origin of the funded debt of the country, which, when the French left the kingdom in 1815, was only L.4,666,680, paying an annual interest of L.140,000. The restoration of the Bourbons increased this debt by more than L.3,500,000, L.1,000,000 of which were paid for an Austrian army of occupation from 1815 to 1817. In consequence of the political events of 1821, two new loans were contracted amounting to about L.15,000,000, of which L.14,000,000 were required to pay the expenses of an Austrian army

which entered the kingdom and put down the constitution. On the 1st of January 1848, the savings effected by the late king during many years of peace had reduced the public debt, by means of the sinking fund, to L.13,526,836, paying an annual interest of L.674,800; but in the course of that and the following year the government, without the concurrence of parliament, issued L.5.749,334 of fresh stock, bearing interest at 5 per cent., of which L.2,416,000 were for Naples, and L.3,333,334 for Sicily. The whole funded debt of the kingdom in 1859 may be set down at L.16,959,000 for Naples, and L.3,316,000 for Sicily; total, L.20,315,000, bearing an annual interest of L.960,000.

The revenue in 1858 was reckoned about L.5,300,866, the expenditure about L.5,410,680, leaving a deficit of L.109,814, which was met by various schemes. In 1831 the revenue was L.4,441,667, and the expenditure L.4,976,000. In 1847 the former was L.4,657,171, and the latter L.4,604,868, leaving a surplus of L.52,303. The subjoined table will give an idea of the

Chief Items of the Public Revenue and Expenditure in 1858.

REVENUE.

Land-tax	L.1,205,670
Communal, Twentieth	23,560
Customs, excise, tobacco, salt, snow, gunpowder, playing cards, etc.	2,186,560
Stamps and registers	232,450
Lottery	325,447
Game licences	5,220
Post-office	30,226
Mint and coinage	14,800
Public domains, sinking fund, discount bank	206,500
Royal printing office	2,500
Railroads	39,120
Percentage on salaries of civil and military officers	159,000
Passports	1,050
Charitable trusts' property	164,500
Share of Sicily towards the common expenses	674,263
Miscellaneous	30,000
Total	L.5,300,866

EXPENDITURE.

Presidency.	Office expenses	L.5,500	L.14,300
	Private secretaryship of the king	800	
	Royal printing office	4,500	
	Orders of knighthood	3,500	
Foreign Affairs.	Office expenses	7,050	49,350
	Salaries of ministers and consuls abroad	35,500	
	Cabinet messengers	1,800	
	Miscellaneous & unforeseen	5,000	
Grace and Justice.	Office expenses	8,200	130,300
	Supreme Court of Justice	10,500	
	Courts of appeal	15,500	
	Criminal courts	33,000	
	Civil tribunals	17,000	
	Offices of the courts and tribunals	26,600	
	Tribunals of commerce	600	
	Consulta of state	11,400	
	Miscellaneous	6,500	
Ecclesiastic Affairs.	Office expenses	5,500	8,530
	Support of churches and curates	1,000	
	Charities to religious orders	720	
	Repairs of churches	650	
	Festivals, missions, etc.	660	
Public Instruction.	Office expenses	3,260	48,420
	Theatres & public spectacles	11,800	
	Royal Museum, public libraries, institutes of the fine arts	18,240	
	Public instruction, universities, colleges, etc.	10,320	
	Provincial instruction expenses	4,800	
Finances.	Office expenses	6,475	2,254,420
	Civil list and royal household (without including income from crown lands)	307,040	
	Interest of public debt	960,000	
	Pensions, etc.	278,420	
	Custom-house, excise, and other indirect taxes	256,540	
	Stamp and registration offices	84,560	
	Post-office	38,650	
	Lottery	32,500	
	Railway	16,800	
	Sinking fund and domains	16,580	
	Mint	15,200	
	Miscellaneous (chiefly for collection of taxes)	241,655	
Public Works.	Office expenses	4,800	324,120
	Prisons, dungeons, and *Ergastoli*	108,250	
	Public roads and bridges' department	130,530	
	Harbours, etc.	22,850	
	Land improvement department	15,860	
	Provincial public works	30,680	
	Miscellaneous	10,150	
Home Office.	Office expenses	9,100	221,220
	Civil administration, viz., intendenti, sotto-intendenti, etc.	28,500	
	Charitable trusts	42,150	
	Public health	5,120	
	Scientific and artistic establishments	1,450	
	Woods & forests, & game	8,340	
	Miscellaneous and extraordinary	126,560	
Police			32,860
Navy			372,820
Army			1,954,340
	Total		L.5,410,680
	Revenue		5,300,866
	Deficit		L.109,814

These tables, even if they were less accurate than we take them to be, would always give a great insight into the state of the country, and the moral principles which guide its government. It will be seen that nearly one-sixteenth part of the whole revenue is derived from that most objectionable of all indirect taxes, lottery. The charitable trusts' property (*Fondi della Publica Beneficenza*), which in the course of ages has accrued from donations or bequests intended to be employed for the relief of the poor, gave an income of L.164,500; but of this sum only L.42,150, or less than one-third, were invested according to the original intentions of the donors and testators. More than one-sixth of the revenue goes to pay the interest of a public debt, chiefly incurred for the support of a foreign army called in to check the liberal aspirations of the people.

The army and navy expenses absorb L.2,327,160, or more than one-half of the whole revenue, whilst only L.324,120 are spent for public works, and L.48,120 for public instruction. In the department of public works, however, are included prisons and dungeons, the maintenance of which costs the country L.108,500, or a third of the amount classed under that head, and nearly as much as is spent in the salaries of all the judicial bench in the kingdom. And what is even more remarkable, among the expenses for public instruction we find an item of L.11,800 for theatres and public spectacles, leaving for the purposes of the public instruction only a sum of L.36,620, in which the expenses for the maintenance of the Museo Borbonico, the public libraries, and the Institute of the Fine Arts, as well as the office expenses, are included! The expenses of col-

lection and administration of the revenue amount altogether to about $14\frac{8}{10}$ths per cent.

By the Concordat of 1818 between Pius VII. and Ferdinand I., it was stipulated that no other religion but the Roman Catholic should be allowed a free exercise. There are about 2400 Jews, but they are allowed neither to hold property nor to acquire a domicile. The ecclesiastical establishment, which was formerly very extensive, having been somewhat reduced by the Concordat by the union of several of the smaller sees, consists at present of 22 archbishoprics, 19 on the continent and 3 in Sicily; 85 bishoprics, 72 in the continental and 13 in the Sicilian provinces; 5 abbacies, and 88 clerical seminaries. The archiepiscopal sees are, in Naples—Acerenza and Matera, Amalfi, Bari, Benevento, Brindisi, Chieti and Vasto, Capua, Conza, Cosenza, Gaeta, Lanciano, Manfredonia, Napoli, Otranto, Reggio, Rossano, Salerno, San Severino, Sorrento, Taranto, Trani; in Sicily, Messina, Monreale, Palermo. The abbacies are, in Naples, Monte Casino, Trinità della Cava, Montevergine; in Sicily, Monreale, San Martino. The archbishops of Naples, Capua, and Palermo, on being appointed to their sees, receive a cardinal's hat. Each diocese has its own administration, composed of the bishop as president, two senior canons, elected every three years by the chapter of the diocese, and an assessor. In every diocese there is a seminary for the education of young men intended for the church.

The monastic and mendicant orders, which were partially suppressed in 1807, were restored by Ferdinand I. on his return in 1815. Their numbers, of both sexes, are reckoned at present about 40,000.

The Concordat of 1818 received several important modifications in June 1857; not, however, by a new concordat, but by royal decrees revocable at pleasure. The jurisdiction of bishops was greatly extended; the trial of ecclesiastics for ordinary crimes was given to their respective ecclesiastical court; members of collegiate or cathedral chapters, curates, and members of religious communities, were granted the privilege of being buried in their own churches; article 826 of the code of civil laws, requiring the royal assent to any bequest in favour of a religious corporation, was abrogated, and public instruction was more completely placed under the control of ordinaries.

Public education is entirely in the hands of the priests, and is at a lower stand in the Two Sicilies than in any part of Italy; the attention of the government being directed not to foster, but to check it in every way. It has already been noticed that the item for public education in the budget is L.48,420, out of which L.11,800 are spent on theatres and other amusements.

By a law of Murat, in 1810, elementary schools were established in all the communes, for the sake of the primary education of boys and girls, who were taught reading, writing, arithmetic, geography, and the principles of religion; the girls also knitting and sewing. Since 1821, and more since 1848, most of those schools have been closed, or placed under the care of the parish priest, who entirely neglects them. In the capitals of some of the provinces there are royal colleges, superintended by the Jesuits, in which young men of the middle classes are educated. The course of studies consists of Latin, and sometimes Greek, mathematics, and elements of history and geography. In the seminaries young men intended for the church are taught Latin, metaphysics, and theology. The professors are all priests, and under the vigilance of the ordinary. Private teaching is forbidden, unless the teacher satisfies the ordinary, and the head of the local police, of his attachment to the throne and his abhorrence of new ideas, and receives from each of them an express permission to give lessons. Till very recently, there were four universities, at Naples, Palermo, Messina, and Catania, all of old foundation, for the higher branches of knowledge, and the conferment of academical degrees; the former frequented by the young men of the continental provinces, the three latter by the Sicilians. But as the concourse of many youths to Naples was a subject of alarm to the government, by a royal decree of April 1857, it was provided that only the young men of the two provinces of Naples and Terra di Lavoro should be allowed to go and take their degrees at the university of Naples; the others are compelled to take them in the colleges of their respective provinces. This decree, somewhat justifiable in principle, if there was no compulsion, and if there were means of obtaining a suitable education in the provinces, is calculated greatly to lower the standard of learning in the country; for it is only in Naples that able professors for the higher branches of knowledge can be obtained.

The superintendence of the public instruction of the whole kingdom is vested in two boards, *Giunte della Publica Istruzione*, one of them at Palermo, the other at Naples, and both under the control of the minister of religion and public instruction. Each *Giunta* is composed of a president, generally a bishop, and six members appointed by the king from among the professors of the university.

The whole kingdom is divided into 22 provinces, of which 15 include the continental possessions, and 7 the island of Sicily. Each province is divided into districts, *distretti*, and each district into *circondarii;* a circondario consists of one or more communes; some communes are an aggregate of several villages. The city of Naples is divided into 12 and Palermo into 6 circondarii. There are altogether 77 districts, 720 circondarii, and 2210 communes. There is no reliable census of the kingdom, the official returns that are occasionally published being very unsatisfactory. The last returns were published in 1856. A survey of the kingdom, begun under the French, having made as yet but little progress, the numbers given as the area of each province must be considered as merely an approximation.

The following table shows the name, extent, and population of each province, and the population of the chief towns:—

Provinces.	Area in square miles.	Population of 1856.	Capitals.	Population of 1856.
NAPLES.				
1. Naples	326	850,450	Napoli	409,658
2. Terra di Lavoro	1,959	774,523	Caserta	15,800
3. Abruzzo Ultra I.	976	239,429	Teramo	8,600
4. Abruzzo Ultra II.	1,908	355,683	Aquila	9,700
5. Abruzzo Citra	840	323,574	Chieti	17,000
6. Molise, or Sannio	1,422	376,935	Campobasso	10,400
7. Principato Citra	1,670	580,660	Salerno	18,000
8. Principato Ultra	1,064	373,736	Avellino	23,000
9. Capitanata	2,359	332,294	Foggia	24,000
10. Terra di Bari	1,743	538,103	Bari	28,000
11. Terra d'Otranto	2,504	431,949	Lecce	19,400
12. Basilicata	3,134	517,354	Potenza	12,000
13. Calabria Citra	2,160	452,766	Cosenza	14,000
14. Calabria Ultra II.	1,704	395,029	Catanzaro	13,200
15. Calabria Ultra I.	1,152	334,872	Reggio	16,000
Total	24,921	6,877,357		
SICILY.				
16. Palermo	1,500	541,326	Palermo	200,000
17. Messina	1,048	384,664	Messina	108,000
18. Catania	1,332	411,832	Catania	60,000
19. Noto	1,120	254,593	Noto	14,200
20. Caltanissetta	900	185,531	Caltanissetta	18,500
21. Girgenti	1,040	250,795	Girgenti	22,400
22. Trapani	1,027	202,279	Trapani	26,000
	7,967	2,231,020		
Naples	24,971	6,857,357		
Total	32,938	9,088,377		

The first enumeration of the inhabitants of the conti-

nental part of the kingdom was ordered by Alfonso I. of Aragon, for the purposes of taxation, and was finished in 1465. It was found that there were 232,896 *fires*, or families, which, calculated at the rate of six heads per family, gave 1,397,376 souls, and with the addition of 250,000 for the city of Naples and its suburbs, a total of 1,647,376. The increase from that time, as far as it can be ascertained, was as follows:—

1595.	1768.	1788.	1816.
3,628,500	4,029,620	4,815,000	5,114,613
1825.	1835.	1845.	1855.
5,545,804	6,013,171	6,451,406	6,858,357

By comparing these numbers, it will be seen, that in 40 years, from 1816 to 1855, it has increased a little more than one-third, and that it would, therefore, take about 120 years to double it. During that period, however, the steady, though slow, increase was checked three times, in 1817, when an epidemic spotted fever caused the number of deaths to exceed that of births by 142,887, and in 1836-37, and 1854-55, when the cholera caused altogether a diminution of 82,964 in the births, as compared to the deaths. The slow increase from 1788 to 1816, being only 1-16th in 28 years, is accounted for by the civil and foreign wars, and the revolutions to which the country was a prey during part of that time. The population of Sicily in 1505 was reckoned at about 600,000. In 1615 it had nearly doubled, being 1,107,234; but after a century, in 1714, it was only 1,133,163. In 1825 it was 1,714,000, and in 1854, 2,231,020, showing an increase of about one-third in thirty years, which would cause it to double in less than a century. On the 1st of January 1856, the population of the whole kingdom was 9,088,377.

The various states which form the kingdom of the Two Sicilies played an important part previous to the rise of the Roman power. Though the existing records of their early history are very scanty and unsatisfactory, yet enough remains to prove that some of the small independent states into which Southern Italy was divided had attained great intellectual development and material prosperity. Some antiquaries have seen traces of Phœnician settlers in several places at a very remote period; but there is no doubt that that high degree of civilisation in the country was owing to the numerous Greek colonies which, between the eighth and the seventh centuries B.C., if not earlier, had settled in Sicily, and on the shores of the Tyrrhenian, the Ionian, and the Adriatic Sea, which hence had the name of Magna Græcia. An account of those colonies, and an admirable relation of the great Athenian expedition against Syracuse in B.C. 427, and its disastrous results, may be found in Grote's *History of Greece*, vols. iii. and viii. The conquest of the continental provinces by the Romans, which may be said to have begun with the first Samnite war in B.C. 343, was completed with the final defeat of Pyrrhus, near Beneventum, in 225, who had been called in to their assistance by the Tarentines, and the fall of Tarentum three years later. The possession of Sicily was the subject of a long and obstinate contest between the Romans and the Carthaginians; its total submission and reduction into a Roman province was only accomplished by the taking of Syracuse by Marcellus in B.C. 212, and the surrender of Agrigentum to the Consul Lævinus in 210.

At the dissolution of the Western Roman empire, Sicily and Naples fell first under Genseric and Odoacer, and at the defeat of the latter by Theodoric, under the Goths, until Justinian, through his generals Belisarius and Narsis, regained the whole of Italy, and put an end to the Gothic kingdom in 553. The Greeks, however, did not long enjoy their conquest. The Longobards descended into Italy under Alboin, in 568, and extended their conquests into Southern Italy, where they founded the powerful duchy of Benevento. The whole of the present kingdom of Naples with the exception of a few cities along the coast which remained under the Greeks, and the towns of Naples, Gaeta, and Amalfi, that erected themselves into independent republics under dukes appointed by the Greek emperors, fell under the dukes of Benevento for nearly 200 years. In the ninth century, whilst that Duchy was weakened by internal feuds, and by the erection of the independent Longobard principalities of Capua and Salerno, there was added a new element of confusion and disorder, in the depredations that were carried on by the Saracens, who had first landed in Sicily in 827, and in a few years conquered the whole island from the Greeks. From Sicily the Saracens began their attacks on the continental shores, seized Bari and other important cities, and strongly fortified themselves in several places. The incursions of the Hungarians, and the occasional arrival of German hordes under the successors of Charlemagne, contributed to increase the state of general confusion, constant warfare, and anarchy.

In the midst of these struggles a new element appeared in the field. The Normans, who had already made themselves conspicuous in the north of Europe, found their way to the south. The two conquering races of the middle ages, and the representatives of the Roman empire in the East, the Saracens, the Normans, and the Greeks, first met on the classic soil of southern Italy, and northern strength and daring gained the victory.

In the beginning of the eleventh century a body of Normans offered their assistance to Sergius, the Greek duke of the city of Naples, against Pandulf, the Longobard prince of Capua. As a reward for their past and a guarantee for their future services, they received a tract of land midway between those two cities, where, in 1030, they established themselves and built the city of Aversa, of which their leader Rainulf was the first count. The news of their success soon brought other bodies of bold and greedy adventurers from Normandy, with the twelve sons of Tancred, Count of Hauteville, at their head. After at first joining sometimes the Longobards and sometimes the Greeks against each other, or against the Saracens, at length they began to fight on their own account, and soon acquired such power that, at a general assembly they held in the city of Matera in 1042, they proclaimed William Bras-de-Fer, eldest son of Tancred, *Comes Apuliæ*. He was succeeded in 1046 by Drogo, and in 1050 by Humphrey, his brothers.

The successes and the rapacity of the Normans, who did not respect the property of churches and monasteries, alarmed Pope Leo IX., who proclaimed a sort of crusade, and led in person against them a large army of Italians, and some Germans contributed by the Emperor Henry III. Leo began his campaign by a pilgrimage to the monastery of Montecasino, whence he descended into the Apulian plains. In vain the Normans, who were but few in number, sued for peace; the Pope was inexorable. The two armies met on the plain near Civitate, on the right bank of the Fortore, on the 18th of June 1053. Despair gave the Norman arm additional strength; the motley crowd brought together by the preaching of the monks fled in utter disorder; Leo himself fled to Civitate, but, being refused shelter by the inhabitants, fell into the hands of his enemies. The crafty Normans, however, far from making him a prisoner, knelt as they approached, imploring his pardon and benediction, and treated him in their camp with so much respect that Leo soon was reconciled to the race, and, as if the kingdoms of the earth were the Pope's, granted to the brothers Humphrey and Guiscard, their leaders, an investiture not only of what they were already masters of, but of the whole of Apulia, Calabria, and Sicily, which they might wrest from the Greeks and the Saracens. Leo was canonized at his death.

The battle of Civitate is a most important event in Italian

history. It not only firmly established the Norman power, and led to the foundation of the kingdoms of Naples and Sicily, but originated that memorable investiture, which, by causing the Popes to claim Naples and Sicily as *fiefs* of the Holy See, and apply to them the rules of feudal law, led to their constant interference in the affairs of the country, and to the changes of dynasties through their instrumentality; it became, in short, the clue to great part of the history of the Two Sicilies. It was also owing to the alliance of interests formed after that battle, that, when Pope Gregory VII., in his famous contest with the Emperor Henry IV., was defeated, and besieged in the castle of St Angelo, Robert Guiscard went with his Normans to release him, and pillaged and burned the whole of Rome from the Lateran to the Capitol.

Robert Guiscard, who succeeded Humphrey in 1057, having conquered Calabria from the Saracens and the Greeks, in 1059 assumed the title of Duke of Apulia and Calabria, and in 1085 transmitted his power to his son, Roger Bursa, whose son William died without issue in 1127. Meanwhile Roger, a younger son of Tancred of Hauteville, had conquered the island of Sicily from the Saracens, and assumed the name of Great Count, which he transmitted to his son Roger, who became the founder of the monarchy. Roger, on the death of William in 1127, succeeded to the dukedom of Apulia and Calabria, of which he obtained the investiture from Pope Honorius, by confirming to the Holy See the possession of Benevento, which Leo IX. had obtained from the Emperor Henry III. in 1050, in exchange for Bamberg. In 1130, on making himself master of Naples, at a general parliament assembled at Salerno, he resolved to assume the title of King of Sicily and Apulia; and the antipope Anacletus, who was anxious to secure Roger's support against his competitor, Pope Innocent II., with a bull of September 1130, gave him the corresponding investiture.

As a summary of the whole history of the country, into the details of which the limits of this article forbid us to enter, we give at the end a chronological table, showing the various dynasties from the establishment of the monarchy to the present day, the duration of the reign of each sovereign, and when Naples and Sicily were united under the same ruler, and when governed by different kings.

Roger made Palermo the royal residence, and at his death transmitted the crown to his son William, surnamed the Bad, who was succeeded by his son William, surnamed the Good. At the death of the latter in 1190 without issue, the Emperor Henry VI., of the house of Hohenstaufen, claimed the kingdom in right of his wife Constance, the daughter of Roger. The Sicilians, however, abhorring German rule, chose Tancred, a natural son of a son of Roger, and, on his premature demise, his son William, a minor. Henry invaded the country, and exercising great severity, reduced it to his authority, and compelled William III., in whom the Norman dynasty ended, to abdicate. Henry did not enjoy long his conquest; his widow, Constance, governed the country for a year, and at her death, in 1198, she left her son, afterwards emperor of Germany (as Frederick II.), then only three years old, under the regency of Pope Innocent III., who entrusted the education of Frederick to four national bishops, and checked several attempts at insurrection of the powerful barons. At the death of Innocent III., in 1215, the strange alliance between a Pope and the head of a Ghibeline family was broken, and a long contest began, which ended in the extinction of the house of Hohenstaufen, and the establishment of the Angevine dynasty at Naples.

Frederick was born at Iesi, and though of a German family, he was in language, character, and affections an Italian. He encouraged learning, and founded schools and universities. He was fond of literature and poetry, and spoke with equal facility Latin, Greek, Italian, German, French, and Arabic. It was at his court in Sicily that the Italian language, hitherto regarded only as a corruption of Latin, first rose to importance, and was polished by the poets, who were encouraged by him to make use of it. Some of the earliest poetry in Italian is by Frederick himself, and his sons Manfred and Enzo. He had a taste for philosophy, and great independence of opinion; but his want of faith in the sacred character of the Roman Church and the sanctity of popes, whose temporal encroachments he was compelled constantly to withstand, countenanced the attack of infidelity brought against him by the Guelf party. Cruelty, though not more than usual at that age, ambition, a suspicious disposition, and great partiality for the Saracens, whom he found useful in opposing the Court of Rome, were the leading faults of his character. He restored order in the Two Sicilies, and established a prosperity not to be found elsewhere in Europe at that time.

The *Constitutiones Siciliæ*, a body of statutes, which he enacted at different times, chiefly by the advice of his famous secretary, the great and unfortunate Pier delle Vigne, to whom refer these beautiful lines of Dante—

> "Io son colui che tenni ambo le chiavi
> Del cor di Federico, e che le volsi,
> Serrando e disserrando, sì soavi
> Che dal segreto suo ogni altro uom tolsi"—
> (*Inferno*, xiii., 58)

are a monument of legislative wisdom far beyond his age. We find him, among other things, abolishing as a barbarous custom the *droit d'aubaine*, or seizure by the state of the property of a stranger, not naturalized, at his death—a practice abolished only in our own times by some of the most civilized nations.

In 1225 Frederick married Iolanda de Lusignan, heiress of the kingdom of Jerusalem, from whom the kings of Naples inherited the title of kings of Jerusalem. After thirty years of almost unremitting contest with the popes and the Guelf party, which wore out his bodily as well as mental energy, Frederick died, only fifty-six years old, in December 1250, in the castle of Fiorentino in Capitanata, anathematized by the church, and broken-hearted at the treason of many whom he believed his friends, the disasters of his party, the decline of his power, and the refusal of the Bolognese to set at liberty his favourite natural son Enzo, whom they had made a prisoner in 1249.

Conrad, his son, had a very short reign, and died in 1254, leaving an only child, Conradin, in Germany. Manfred, another natural son of Frederick, assumed then the government of the country, at first as guardian of Conradin, and afterwards, on the false reports of Conradin's death, in his own name.

Manfred became the leader of the Ghibeline party, and more obnoxious than ever to the Popes, who resolved to get rid of such an unfriendly neighbour. At length, Urban IV., who was raised to the Papal chair in 1261, and was an inveterate enemy of the house of Suabia, excommunicated and deposed Manfred as a usurper, and, availing himself of the feudal authority claimed by the Holy See, offered the Sicilian crown for sale among the princes of Europe. It was ultimately handed over as a fief, on a yearly tribute of 8000 ounces of gold, to Charles of Anjou, the brother of Louis IX. of France.

Urban did not live to see the fulfilment of this arrangement, which however, after his death was furthered by every temporal and spiritual means at his disposal, by his successor, Clerment IV., who was by birth a provençal, and greatly devoted to the house of Anjou. Urged on by the restless ambition of his wife Beatrice, a daughter of Raymond Berenger, last Count of Provence, whose three elder sisters were married to the sovereigns of England, France, and Germany, Charles arrived in Rome in December 1265,

with an army composed of the flower of the knights of France, and on the 1st of January 1266, was crowned by the cardinals as king of the Two Sicilies. After a short stay he entered the kingdom; and having had the frontier strongholds of Ceprano, Arce, and San Germano surrendered by the treachery of their commanders, he marched upon Benevento, where Manfred was encamped with his army. Charles gave battle the same day, February 26. The valour of the Swabian and Saracen followers of Manfred was not proof against the impetuous attack of the French and the treacherous desertion of his Apulian barons. Manfred fell in battle, and his remains, on account of the anathema against him, being denied Christian burial, were at first buried under the bridge of Benevento, and afterwards, at the instigation of the Archbishop of Cosenza, removed into a lonely valley of the Tronto, beyond the frontier of the kingdom. Every reader of Dante is familiar with the beautiful passage alluding to Manfred in *Purgatorio*, iii., 124.

Scarcely had Charles been two years in the possession of his throne when young Conradin, the son of Conrad, advanced at the head of an army from Germany, and supported by the Ghibeline cities of Lombardy, to attack him. The hostile armies met on the plain of Tagliacozzo on the 22d of August 1268. Victory seemed at first to be for Conradin; but whilst the youth was rejoicing in the camp over his success, Charles sent against him a fresh detachment which he had kept in reserve, and the day was completely lost. Conradin succeeded in escaping, but was betrayed into the hands of Charles by a Frangipani, an old follower of the Hohenstaufen, with whom he had sought refuge. Taken to Naples, and subjected to a mock trial, Conradin, the last scion of the Hohenstaufens, the descendant of emperors, at the age of seventeen, by the advice of the Pope, perished, together with his cousin Frederick of Austria, by the hand of the executioner, in the Piazza del Mercato at Naples, on the 29th of October 1268. From his scaffold he called his heir Constance, daughter of Manfred; and, challenging an avenger, he flung his glove among the crowd, which was picked up and faithfully conveyed to Peter of Aragon, her husband. Charles disgraced himself by personally assisting at the execution. By such means was the Angevine race established in the Two Sicilies.

After the utter annihilation of the Swabian party on the continent, Charles wreaked his vengeance upon the island of Sicily, which had declared in favour of Conradin. Augusta and other towns, which offered some resistance, were destroyed and all their inhabitants slaughtered, and the whole island was ruled with an iron sceptre. The oppressed and discontented people applied to the Pope for redress, but without effect. Upon this John of Procida, a nobleman from Salerno, whose estate had been confiscated on account of his strong attachment to the Hohenstaufens, resolved to put an end to the sufferings of Sicily. In execution of his plans of revenge, he first applied to Peter of Aragon, who showed a disposition to assist him, but could do nothing from the want of pecuniary means. Procida undertook to procure those means, and first visited Sicily, where he found all prepared to resist Charles, and where he encouraged the hope of revenge. He then proceeded to Constantinople, and presented himself to the Emperor Michael Palæologus, who had been alarmed by Charles with threats of invasion, and from whom he obtained promises of a large sum to be sent to Aragon. Having received the money, he returned to Peter, who immediately commenced warlike preparations, on the pretext of making an attack upon the Moors in Africa.

Whilst these warlike preparations were going on, the arrogant and oppressive behaviour of the French gave rise to a sudden outburst of popular indignation, which put an end to their misrule in Sicily. On the afternoon of Easter Tuesday, the 31st of March 1282, the inhabitants of Palermo went, according to their custom, to hear vespers at a church outside the town, where they gathered in great numbers, and, with a mixture of gaiety and religion, enjoyed dancing and eating. Among them was a girl of great beauty, with her parents and her acknowledged lover. A Frenchman, called Drouet, under pretext that she carried arms concealed under her dress, seized her, and thrust his hands into her bosom. The girl fainted away in the arms of her betrothed, who, enraged, exclaimed, "Oh, let us kill these French!" His voice was not raised in vain. An unknown youth fell upon Drouet and killed him, and he himself was instantly put to death by the other Frenchmen. A thousand voices from the assembled crowd exclaimed, "Death to the French!" and the fight became general. A dreadful massacre ensued, in which all the French were put to death. In their rage the inhabitants sacrificed all, not excepting the aged, the females, and the children; and even those women who had connected themselves with Frenchmen were likewise murdered. This horrible event has ever since been known by the name of the Sicilian Vespers. The other cities of Sicily, with the exception of Sperlinga, followed the example set at Palermo, and wherever a Frenchman could be found he was instantly put to death.

Charles, on receiving the horrible intelligence, hastened from Orvieto, where he was on a visit to the pope, to Naples, and having collected his whole forces, prepared to pass over to Sicily. In July he appeared before Messina, and at first gained some advantages; but the spirit of the inhabitants was so roused that they defended themselves with the most energetic courage, even the women and children partaking with the men in the dangers as well as the privations and sufferings of a siege.

Soon after the breaking out of the insurrection, a kind of federal republic had been proclaimed under the patronage of the Church of Rome; but the hostility of the Pope, who lent spiritual and temporal support to Charles, and the news of the first reverses at Messina, caused the parliament assembled at Palermo to offer the Sicilian crown to Peter of Aragon, who was with a considerable army on the African coast. Peter at once accepted the offer, and on the 30th of August landed at Trapani, and thence proceeded to Palermo, where he was received with rapturous joy. Charles, disturbed by this occurrence, became also alarmed for the state of Calabria, and having instantly embarked his troops, leaving his military stores behind him, sailed across the strait; but before he reached the continent his fleet was attacked by that of Peter, under the command of his admiral, Roger de Loria, who captured twenty-nine of his vessels, and then ravaged the coast of Naples. Peter was received with exultation in Messina, and assumed the government, although the pope issued a bull, placing him and the Sicilians under the ban of the church. The next year Constance arrived with her sons, and was acknowledged as the legitimate inheritor of the crown. Although Charles continued to make attempts to regain his authority in Sicily, they were all unavailing; and the two kingdoms were separately ruled during a hundred and sixty years.

Robert, the grandson of Charles, who in succession filled the throne of Naples in the year 1309, was a patron of letters, and the friend of Petrarch and Boccacio. After his death, in 1343, in the reign of his granddaughter Joanna, great commotions broke out in Naples. She had married Andrew of Hungary, who was murdered at Aversa, not without strong suspicion that his wife had been participator in the crime. Owing to this charge, the Pope, Urban VI., conferred the crown of Naples upon Charles of Durazzo, a Hungarian, who had married a sister of Joanna. He was a short time acknowledged as king of Naples and Hungary; but was assassinated in the latter kingdom in 1386.

At his death, two competitors for the crown appeared in Naples; Ladislaus, his son, and Louis of Anjou, an adopted or illegitimate son of Joanna. Ladislaus, after some struggles, conquered Louis. He also made himself at one time master of Rome, and aimed at the sovereignty of all Italy; but his projects were terminated by death in the year 1414. His sister, Queen Joanna II., at first adopted King Alfonso of Aragon as her heir, but afterwards by her will called to the throne René of Anjou, who succeeded her. Alfonso, however, who was the heir of the Hohenstaufens through the female line, and was already king of Sicily, attacked and expelled René from the kingdom, put an end to the Angevine dynasty, and reunited Sicily and Naples.

The dominion of the house of Aragon, after the death of Alfonso, was a period of misery to the country. Wars were frequent and destructive, the exchequer was impoverished, and the most noble and influential families were crushed, especially after the conspiracy of the barons, headed by the Count of Sarno and Antonello Petrucci. The descent of Charles VIII. into Italy gave the first blow to the dynasty of Aragon, which was at length overthrown by a combination of France and Spain.

By the treaty of Granada, signed November 11, 1500, and confirmed by Pope Alexander VI. and a conclave of cardinals in the following year, Ferdinand the Catholic of Spain, and Louis XII. of France, agreed to divide the kingdom of Naples between them. The treaty provided that the King of France should possess the city of Naples, the Terra di Lavoro, the three Abruzzi, and half the revenue produced by the Tavoliere di Puglia, with a confirmation of the title of King of Naples and Jerusalem, which he had previously assumed. On the other hand, the King of Spain, who had for many years been king of Sicily as the successor of his father John II., was to possess the three Calabrias and Apulia, and the remaining half of the revenue of the Tavoliere, with the title of Duke of Calabria and Apulia. The possession of the provinces not mentioned in the treaty soon led to a war between the contracting parties. Hostilities commenced in June 1502, and in little more than eighteen months the French were defeated in four battles, and the whole kingdom, by the military genius of Gonsalvo de Cordova, became, like Sicily, a Spanish possession.

During the two succeeding centuries, both portions of the kingdom of Naples remained under the government of the kings of Spain. The parliaments, which had originated with the Normans, and were occasionally convened both in Naples and in Sicily, fell into desuetude, or were only summoned to vote money. The feudal system grew worse, an extension of their privileges, especially the power of life and death over their vassals, being granted to the barons with a view of securing their service in the wars, and their votes of money. The city of Naples had almost the whole administration of the kingdom centred within itself, but under the absolute control of the viceroy. By such means the power of the crown was gradually extended. The imposition of new taxes, and the oppressive modes of enforcing the payment of them, led sometimes to turbulent scenes in the capital, most of which were speedily suppressed; but one of them was of so singular a character as to deserve a short relation.

In the year 1647 it was thought necessary to impose some tax upon all fruit sold in the city; which, being in summer the chief food of the poor, caused great uneasiness, but no immediate insurrection. A fisherman, named Masaniello, whose wife had been recently detected in smuggling some flour into the city, and fined for it, had conceived an implacable hatred against the suggesters, the farmers, and the collectors of the new tax. He was a powerful speaker, and a leader of one of the parties of the populace who had agreed to have a sham fight upon a festival. On that day, the 7th of July, in consequence of a quarrel between the tax-collectors and some fruit-sellers from Pozzuoli, one of whom was a brother-in-law of Masaniello, the latter first roused the populace, and excited them to destroy the office where the tax was collected, and the dwellings of those who had proposed or farmed it. In the course of the rioting, the viceroy, instead of ordering the Spanish guards to suppress the disturbance, fled, and was personally insulted; but at length he escaped to a sanctuary, where the archbishop joined him, and they conjointly issued a notice that all taxes on provisions should be abolished. Besides this, an attempt was made to gain Masaniello by an offer of a pension. But he refused to accept the offer, declaring that if the viceroy kept his word he would find the people obedient subjects.

On the following day, however, no taxes being abolished, the followers of Masaniello committed some violent outrages, which induced the viceroy to enter into a kind of treaty with this leader, who, though half naked and in rags, found himself at the head of 100,000 armed men, filled with fury. Some of his followers having been bought over by the court, agreed to kill him; and whilst he was in treaty with the archbishop, in the church of the Carmire, the attempt was made; but it failed, and those who were thus shown to be traitors to their chief were instantly put to death. The failure of the attempt greatly strengthened the power of Masaniello, who exercised it with much appearance of fairness and impartiality. The viceroy was fearful that the French might take advantage of the commotion, and create some annoyance, and therefore hastened to make peace with the leader of the insurrection. On the fifth day after it broke out, a treaty was concluded, by which it was stipulated that the taxes imposed since the reign of Charles V. should all be abolished; that in future no new taxes should be levied except by electors; that the people were to elect as well as the nobles; that an act of oblivion should be passed, and the people remain in arms till the ratification of the treaty was completed.

Great rejoicing followed this arrangement. Masaniello having repaired to the viceroy, was appointed captain-general, and induced to change his dress for more appropriate apparel; he also received a present of a gold chain. The following day he began to exercise the authority of a sovereign, judging all crimes, whether civil or military, and ordering to instant execution, on a gallows he had erected, those whom he had doomed to death. It is said that in these summary proceedings no innocent person suffered, and no guilty person escaped. His grandeur was but of short duration. In two or three days he became distracted and delirious, and committed some most extravagant actions; and on the 18th of July he was put to death, with the consent, if not by the orders, of the viceroy.

The tumult did not, however, terminate with the death of its author. In the capital, as well as in all the other cities of the kingdom, the people rose and drove out those Spaniards who were found in them. The Duke of Guise, who happened to be at Rome, was induced, at the instigation of the pope, to offer his services to the Neapolitans against the Spaniards; and to this he was further encouraged by having some distant pretensions to the throne. The Spaniards, in the meantime, made a vigorous attack on the city of Naples, but were repulsed by the people, who thereupon formally renounced their allegiance to the Spanish family. In a short time, however, a new viceroy, Count d'Oniate, arrived from Spain. He took the city by surprise, made the Duke of Guise prisoner, and thus frustrated all the designs of France against the Spanish power in Naples.

But the rule of Spain, which neither the popular movement of Masaniello, nor an aristocratic conspiracy at the beginning of the eighteenth century planned by the Prince of Macchia, succeeded in overthrowing, was

brought to an end by the war of the Spanish Succession. In 1707, after the defeat of the French army in Lombardy by Prince Eugene, a body of 5000 infantry and 3000 German cavalry, under the command of Count Daun, entered the Neapolitan frontier by Palestrina, and without encountering any resistance from the Spanish viceroy, took possession of the kingdom. By the treaties of Utrecht (April 1713), and Rastadt (March 1714), the Emperor Charles VI. was maintained in the possession of Naples, and Sicily was ceded by Spain to Victor Amadeus, Duke of Savoy. The latter part of this arrangement, however, was altered after the death of Louis XIV., when Cardinal Alberoni, in endeavouring to retrieve the Spanish loss, seized upon Sardinia and Sicily, and thereby gave origin to the quadruple alliance of Austria, England, Holland, and France. After two years' war, by a peace made in 1720, Sicily was also given to the emperor, and Amadeus of Savoy received a poor compensation in Sardinia.

The contest for the Spanish Succession had only substituted an imperial for a Spanish viceroy over the Two Sicilies; but the war for the succession of Poland (1733–1738) gave them national independence. The Spanish Infant Don Carlos, a younger son of Philip V., by his second wife Elizabeth Farnese, with an army of 16,000 infantry and 5000 cavalry, under the command of Count de Montemar, entered the kingdom in 1734, and having defeated the Austrians near Bitonto on the 24th of the following May, seized also upon Sicily, where, on the 3d of June 1735, he was crowned at Palermo as king of Naples and Sicily, and founded the Bourbon dynasty still reigning over the country.

Charles had not been long acknowledged as king by the treaty of Vienna of November 1735, when he had to defend his possessions in the war that broke out in 1743 on the death of the Emperor Charles VI. for the Austrian succession. But the defeat of the Austrians at Velletri in August 1744, and afterwards the treaty of Aix-la-Chapelle in 1748, firmly established him on the throne.

The reign of Charles, through the wise administration of his minister Tanucci, a Tuscan advocate who had followed him to the conquest of the kingdom, was marked by great reforms in every branch of the administration, and by attempts to raise the moral character of the nation from the low ebb into which it had fallen under the viceroys. The state of the country was such, that the judicial census gave 30,000 thieves in the city of Naples alone, and poisoning was so prevalent, especially by women, that Charles deemed it necessary to institute a special court, called *Giunta de' Veleni*, for their punishment. Charles founded a naval college, a tribunal of commerce, a vast house of refuge for the reception of the poor of all the kingdom, and the knightly order of St Januarius. He opened the first roads in the kingdom, built several military barracks, and the large theatre called from him San Carlo; and began and partly built the royal palaces of Caserta, Capodimonte, and Portici. He attempted to mitigate the barbarity of the criminal laws, and to check the abuses of the feudal system; and by a Concordat, agreed upon in 1741 with Pope Benedict XIV., established on a better footing the ecclesiastical hierarchy and policy in the country. He also promoted and encouraged learning in every way, and on the discovery of Pompeii, Herculaneum, and Stabiæ, he founded the Ercolenese Academy for the explanation of the antiques brought to light, and began the vast collection called afterwards Museo Borbonico.

Whilst carrying on these reforms, Charles was called to the throne of Spain by the death of Ferdinand VI. without issue in 1759. Before leaving Naples he regulated the royal succession, and excluding his eldest son Philip on account of imbecility, and his second son Charles, who was to succeed him in Spain, he called to the throne of the Two Sicilies Ferdinand, his third son, then only eight years old, and appointed a regency for the government of the country. Charles, who was VII. of that name in Naples and III. in Spain, is generally known in Neapolitan history as Charles III.

Ferdinand IV. followed under the regency the steps of his father. On attaining his majority, his first act was the expulsion of the Jesuits from the kingdom in 1767, in compliance with the orders from Spain. The following year he married Caroline, a daughter of the Empress Maria Theresa, and a sister of Mary Antoinette of France. Caroline, who was beautiful, clever, and fond of power, soon acquired great influence over her indolent and uneducated husband, and being admitted into the council of state by an express stipulation in the marriage articles, she became the chief ruler of the whole policy of the government. The liberal and enlightened reforms initiated by Charles were, however, continued, and the royal attention was particularly turned to public education. The University of Naples, founded by Frederick II., was re-constituted on a better plan, and the chairs filled with the most able men in the country. The statutes of the Academy of Science and Literature were altered and remodelled. A college of nobles was founded in every province, in which the lectures were public, and the professors chosen by public examination; and every commune was ordered to appoint masters for primary instruction. These schools were all secular, and the ordinaries had neither voice nor power of interfering in them. Men of learning were encouraged; Pagano published his *Political Essays;* Filangieri his *Science of Legislation;* Genovesi his *Metaphysics, and Lessons on Political Economy*, works very remarkable for their age. At the same time, to encourage agriculture, the mortmain laws were promulgated, which prohibited any increase of the landed property of religious corporations, and favoured the passage of the lands they were possessed of into secular hands.

These improvements, however, were counterbalanced by some evils. Tanucci lost all influence, and the personal favourites of the queen, Chevalier Medici and Sir John Acton, who had settled at Naples and attained the rank of general and minister of marine, governed the country at their will. The personal conduct of the queen, and the example of the whole court, greatly lowered the moral tone of society, and made the Neapolitan aristocracy proverbial for their profligacy.

Such was the state of the country at the breaking out of the French Revolution in 1789. As a narrative of the occupation of Italy by the French has been given in this work under the heads FRANCE and GREAT BRITAIN, it is not necessary here to do more than briefly notice the principal events from that time to the restoration of the Bourbons in 1815.

The French Revolution effected an entire change in the course hitherto pursued by the Neapolitan government; which, as French affairs became worse, so grew more suspicious and watchful, till at length, after the execution of the royal family, it burst forth into open persecution against any one who had shown enthusiasm for the new doctrines.

In July 1793, Ferdinand entered into a secret treaty with England, which being acceded to by other powers, the Two Sicilies found themselves included in the vast European confederation against France. To meet the expenses of the war, the government resorted to extraordinary means and taxes. Subsidies were demanded and enforced from every community, corporation, and wealthy proprietor; a tax of 10 per cent. was imposed upon predial revenues; a large amount of church property was seized upon and sold; and all churches, monasteries, and private citizens were ordered to deliver over their plate, and receive in return bank certificates, payable after some years. To avoid any evasion of this law, buried treasures were

declared confiscated, and one-fourth of them awarded to the discoverer. The bank certificates were, however, rendered a mockery by a most disgraceful act of spoliation. There were in Naples seven banks, belonging to corporations, in which people were in the habit of placing their money, and receiving in return a promissory-note, which, being payable on presentation, circulated like cash, and often even at a premium, from its convenience and safety in carrying large sums. The cash deposited in these banks was gradually and secretly seized by the government, and the theft concealed some time by causing the bank officials to fabricate fresh paper. Suspicion having arisen of what was going on, the depositors hastened to claim payment; but the coffers being drained, payments were refused, and the promissory-notes at once fell to a discount of 85 per cent. More than L.12,000,000 of hard cash had been purloined, and thousands of families reduced to beggary.

Extraordinary measures were also adopted, both to silence the general indignation caused by such steps as these, and to smother the spreading of the new French ideas. An exceptional tribunal was created, called *Giunta di Stato*, for the trial of persons accused of treason. The proceedings in it were inquisitorial and secret; the proofs given in writing; secret and anonymous denunciations accepted as evidence; paid spies, servants, and even children, admitted as witnesses. The king appointed the advocate for the prisoner, who was not allowed to speak in his own defence; and the sentence—pronounced with closed doors, and not subject to appeal—was carried into immediate execution. Vincenzo Vitaliano, Emmanuele de Deo, and Vincenzo Galiani—three youths of good family, 22, 20, and 19 years old—fell the first victims to the cause of Neapolitan freedom, a cause which gathered strength from persecution; for though thousands have since died for it on the scaffold, in dungeons, and in exile, the aspirations for a liberal government are as ardent as they were more than half a century ago.

These measures were chiefly, if not entirely, the work of the queen and her favourite ministers, Acton and Medici, whilst the indolent king spent his time in hunting and carousing. But hard times were at hand. The events of the war were not favourable to the Bourbons. After some checks and a hollow peace, signed at Paris, with Buonaparte and the Directory in October 1796, Ferdinand raised a new levy of 40,000 conscripts, and, joining a new confederation against France, poured with a large army, under General Mack, into the Papal States, then occupied by the French, and, without encountering the enemy, entered Rome on the 29th of November 1798, and committed all sorts of excesses. In a few days the Neapolitan army was routed; Ferdinand fled in disguise to Caserta; and on the 20th December the French, under General Championnet, crossed the Neapolitan frontier. Such terror seized the king and the royal family, that, in spite of the advice of Sir William Hamilton and Nelson, on the morning of the 21st, they all sailed for Sicily. Championnet, with 22,000 French, after a week of desperate resistance from the lazzaroni, roused by the friars and priests, entered Naples on the 23d January 1799, and proclaimed the Parthenopean Republic.

The various acts of the republican government during its short existence; its overthrow by Cardinal Ruffo on the 14th of June 1799; the unutterable horrors, in the name of religion and loyalty, committed by the undisciplined masses under the cardinal's flag in their progress from Calabria to Naples; the wholesale massacre and pillage on the taking of Naples; and the state trials and executions that followed them, as well as the other events down to 1825—are graphically and touchingly related by a national historian, Pietro Colletta, who was partly an eye-witness and partly an actor in them, to whose work any one who takes an interest in them may refer with pleasure.[1]

When the royalist army entered Naples, the leading men who had taken a part in the republican government sought refuge in the castles Nuovo and Dell' Uovo, and entered into negotiations with the king's lieutenant, Cardinal Ruffo; but not trusting to him alone, they required that the capitulation should also be agreed to and signed by Captain Foote, in command of the British fleet in the harbour, and by the leaders of the Russian and Turkish forces. By the terms of the capitulation, the republican garrison might either embark for Toulon, or remain in the kingdom, secure from molestation for themselves and their families. When Queen Caroline read in Palermo these terms, and saw her hopes of vengeance frustrated, she entreated Lady Hamilton to go in pursuit of Nelson, who was sailing towards Naples, with letters to him from herself and the king, and to prevail upon him to revoke the treaty, as sovereigns could not stoop to capitulate with rebellious subjects. Nelson at first shrank with horror from the demand, but, unfortunately for his name, he yielded at last to the allurements of Lady Hamilton, and broke the capitulation. Cardinal Ruffo himself was disgusted at the violation of public faith. Admiral Caracciolo was subjected to a mock trial by court-martial, and hung on board Nelson's flag-ship. The republicans, who had embarked in several ships, and were sailing for Toulon, were stopped; eighty-four, marked as victims, were taken out of their number, chained two and two, subjected to a mock trial, and eventually executed. Mario Pagano, Logoteta, Conforti, Cirillo, Baffi, and many others of the most eminent men of the time, even the beautiful and accomplished Leonora Pimentel and Luigia Sanfelice, perished by the hand of the executioner. Naples has not yet recovered the blow, and the British name has ever since remained taxed by the Neapolitans with want of faith.

Ferdinand returned to Naples, and increased the prosecutions. The monasteries of the order of St Benedict, and of the Carthusians, who had taken no part in the revolution, but had the misfortune of having great wealth, were suppressed, and their property confiscated to the exchequer. Another decree abolished the *Sedili*, a sort of municipal corporation of Naples, which represented, and in part sustained, the ancient rights and privileges of the kingdom, and the influence of the aristocracy.

Six years after these events, Ferdinand, on the 23d Jan. 1806, was compelled again to seek refuge in Sicily. After the battle of Austerlitz, the peace of Presburg, Dec. 26, 1805, between France and Austria, having left Naples to her fate, a French army, under General Massena, marched upon the kingdom, and entered Naples on the 14th February. A decree of Napoleon, dated Paris, March 30, 1806, proclaimed Joseph Buonaparte king of Naples. After two years, however, another imperial decree, of July 15, 1808, calling Joseph to the throne of Spain, appointed king of Naples Joachim Murat, who had married Caroline, a sister of Napoleon.

It would be long to enter into an account of the new institutions and laws introduced under the French rule into the kingdom. Suffice it to mention that the Code Napoleon was adopted, the Tavoliere system was improved, a tax called *Fondiaria*, of one-fifth part of the revenue from real property, was introduced, the remnants of the feudal system were destroyed, and every sort of jurisdiction restored to the crown; feudal burdens were abolished; serfdom done away with; the use of rivers, lakes, and sea-shores restored

[1] *History of the Kingdom of Naples*, 1734–1825, by General P. Colletta. Translated from the Italian by S. Horner, with a Supplementary Chapter, 1825–1856. Edinburgh, 1858. 2 vols. 8vo.

to all; mixed properties, upon which the feudal lords and the peasantry had certain defined rights in common, were dissolved and divided; the aristocratic order preserved only by titles; monasteries suppressed; privileges of any kind abolished, and all the inhabitants made equal before the law.

Important events were at the same time taking place in Sicily. After the whole of Italy had been occupied by Napoleon, England felt the necessity of strengthening her alliance with King Ferdinand, and securing her retreat into the island. With that view she engaged to pay him subsidies of from L.300,000 to L.400,000 per annum, and to protect the island by an army of at least 10,000 men; the king, on his part, promised to exempt from customs' duties all the provisions required for her army in the Mediterranean, and to close the ports of Sicily against her enemies. In 1810, however, Queen Caroline, being displeased at the English not using all the efforts which she desired to reconquer Naples for her dynasty, opened communications with Napoleon, who having become her kinsman by his marriage with Maria Louisa, gave her hope of regaining that kingdom. Hence she began to make every exertion to create mutual mistrust between the Sicilians and the English, and to drive the latter out of the island. These intrigues on the part of the queen being backed by an attempt from the king to destroy the constitution of the island, rendered an intervention necessary on the part of our government in the affairs of the country.

The Sicilian constitution had undergone but slight alteration during the Spanish dominion. Its parliament consisted of three *braccia* or estates, in the first of which, at the time these events happened, sat 66 prelates and abbots; in the second, or military braccio, 227 noblemen; and in the third, or braccio demaniale, 43 representatives of as many free towns. It met only every four years, but was permanently represented by a committee of 12 members, appointed by the three Chambers, who administered the finances, and were the guardians of the public liberties during the intervals between its sessions. In February 1810, the hereditary prince opened it in the name of the king, and demanded an extraordinary supply of L.180,000 per annum; but parliament having refused to vote more than L.50,000, the Crown, by several edicts of February 1811, ordered some communal and public lands to be sold, and a tax of 1 per cent. to be levied upon the value of every contract. The braccio militare having presented a protest to the king against these unconstitutional proceedings, four of the leading peers, who had signed it, were arrested on the night of the 19th July, and transported to different islets off the coast.

On these occurrences becoming known in this country, our government furnished Lord William Bentinck, who was then commander-in-chief of the British forces in the island, with full powers for intervening in the contest which had arisen between the Crown and the Sicilian nation. The results of Lord William Bentinck's intervention were —1st, The removal of the queen from all concern with public affairs, and eventually her departure from the island; 2d, The recall of the peers who had been deported; 3d, The revocation of the unconstitutional edicts; 4th, The appointment of the hereditary prince as vicar-general of the kingdom; 5th, The consent of the king to a reform of the constitution.

Parliament was accordingly summoned by the Prince Royal, and in November 1812 concluded its reform of the constitution, which, in February 1813, was sanctioned by the king. The new constitution was framed on the model of that of England, the legislative power being vested conjointly in the king, in an Upper House, consisting of barons and bishops, and a Lower House of representatives, elected by the people, and the executive power being exclusively in the hands of the king.

The new Sicilian constitution, however, was not destined to have a long existence, for the fall of Napoleon brought on the restoration of the Bourbons at Naples, who forgot the asylum they had twice found in the island. Whilst the Congress at Vienna was considering whether Naples was to be left to Murat or restored to Ferdinand, the escape of Napoleon from Elba changed the state of affairs. Joachim, who was distrustful of the Congress, in March 1815, declared war against Austria, and entered the Papal territory; whereupon the Congress sitting at Vienna declared him fallen from the throne, and the dynasty of the Bourbons reinstated. After various engagements, the battle of Tolentino, and the treachery of many of Murat's generals, decided the contest. Joachim retired in disorder, and the Austrians entered the kingdom, and encamped round Capua. On the 20th of May the Neapolitan generals Carrascosa and Colletta, the Austrian generals Bianchi and Neipperg, and Lord Burghersh, on the part of England, met at Casalanza, a small house three miles from that fortress, and concluded a treaty, which put an end to the war and to the kingdom of Murat.

Ferdinand returned to Naples in the beginning of June; not Queen Caroline, who had died suddenly in the Castle of Hetzendorf on the 7th September 1814.

Murat ended his days in a rash attempt to recover the kingdom. In the island of Corsica, where after the battle of Waterloo he had sought refuge, he collected a band of two hundred and fifty followers, all personally attached to him, and ready for adventure; and having freighted six vessels, on the night of the 28th September 1815 weighed anchor from Aiaccio, and directed his course to Salerno, where three thousand of his former soldiers, supposed to be discontented with the Bourbons, were stationed. His preparations, however, had been watched by a certain Carabelli, a Corsican, who, though formerly covered with favours by Murat, had volunteered to act as a spy; and the Neapolitan government, being by him informed of Murat's movements, kept a look-out along the coasts. The small fleet sailed prosperously for six days, but on the 7th it was assailed and scattered by a storm, which drove the vessel in which the ex-king himself was near the shore of Pizzo in Calabria. After some hesitation Murat resolved to land at that place; and on the 8th of October, a feast-day, he appeared in the market-place of Pizzo, with twenty-eight followers, who, raising his standard, shouted, "Long live King Murat!" All persons present having remained silent, Murat perceiving how cold his reception was, hastened to go to Monteleone, a populous city, in which he expected to find many warm friends; but being followed up and attacked by a number of devoted adherents of the Bourbons, he gallantly dashed through them, and made for the shore, to regain his vessel. But the vessel was at some distance, and Murat in vain shouted for her, for the captain sailed, carrying away the rich booty he had on board. Murat tried to push off a skiff which lay upon the shore, but at length surrounded and seized, he had the jewels he wore on his cap and breast torn off, was struck in the face and insulted, and, with his companions, dragged into the dungeon of the castle.

The news of the events at Pizzo being transmitted to Naples by telegraph, the government sent stringent orders for Murat's trial and immediate execution. A court-martial, composed of seven officers, three of whom and the attorney-general had been raised by Murat from humble stations, assembled on the 13th, and by a law which he himself had passed seven years before, and which now became the instrument of his own death, condemned him to die as a public enemy, for having attempted to excite the people to rebellion against their lawful sovereign. He was shot the same day in a small court of the castle. He refused to have his eyes bound, and calmly placing himself

in a posture to receive the balls," said to the soldiers, "Spare my face, and aim at my heart." He fell, in his forty-eighth year, grasping in his hands the miniature portraits of his children; and his remains were buried in the church of Pizzo, towards the erection of which he had liberally contributed.

Once firmly re-established on the throne of Naples, Ferdinand began his attack on the liberties of Sicily. Article 104 of the treaty of Vienna recognised him as "king of the *kingdom* of the Two Sicilies." The word kingdom therein introduced, though apparently insignificant, aimed, as it will be seen, at important changes in the government of the country.

By a secret article of a treaty, signed at Vienna on the 14th of June 1815, Ferdinand had bound himself, in resuming the government of his kingdom, "not to admit of any innovation not in accordance either with the ancient monarchical institutions, or with the principles adopted by his imperial and royal majesty in the internal government of his Italian provinces." In conformity with this engagement, in 1816 he promulgated three royal edicts, by which he assumed the new title of Ferdinand I., King of the Kingdom of the Two Sicilies; and on the grounds that the privileges enjoyed by the Sicilians were to be combined with the *unity* of the political institutions, which were to form the public law of the *kingdom*, he united the *two* kingdoms of Naples and Sicily, took the whole of the government into his hands, and virtually and *de facto* annulled both the ancient and the new constitution of Sicily. The Sicilians were only granted the privilege, that all offices and employments, civil and ecclesiastical, in the island should be conferred exclusively upon them. From that time dates the despotic rule of both the continental and the insular divisions of the kingdom.

A summary of the principal events, from 1815 to 1850 having been already given under ITALY, it remains only to add that the condition of the country has not since improved in any degree. A series of state trials, familiar in this country through the powerful appeal against them to the public opinion of all civilised nations by one of our most able statesmen,[1] initiated, in 1850, a system of ferocious reaction, which, far from abating, seems to grow worse with time. Ferdinand II., in 1859, was succeeded by his eldest son Francis II., who is faithfully treading in the footsteps of his father. The supreme and irresponsible authority of the police, and its natural offsprings, want of personal security, persecutions, injustice, terror, and general dismay, are still the order of the day in the Two Sicilies.

CHRONOLOGICAL TABLES.

THE NORMANS, A.D. 1130–1194.

1130. Roger, a grandson of Tancred of Hauteville, is proclaimed King at Salerno.
1154. William I. (the Bad), son of Roger.
1166. William II. (the Good), son of William I.; leaves no issue.
1190. Tancred, Count of Lecce, a natural son of a son of Roger.
1194. William III., son of Tancred.

THE SUABIANS, 1194–1266.

1194. Henry VI., Emperor of Germany, the son of Frederick Barbarossa, having married Constance, the daughter of Roger, claimed the crown, and compelled William III. to abdicate.
1197. Constance reigns alone in the name of her son.
1198. Frederick II. of Hohenstaufen, Emperor of Germany.
1250. Conrad, the second son of Frederick II.
1254. Manfred, a natural son of Frederick II., at first as guardian of Conradin, the only son of Conrad, and afterwards, on the false report of Conradin's death, in his own name.

THE ANGEVINES, 1266–1442.

1266. Charles I. of Anjou, Count of Provence, brother of Louis IX. (St Louis).

KINGDOM OF NAPLES.

House of Anjou.

1282. Charles I. having lost Sicily, remains King of Naples.
1285. Charles II., the Lame (Carlo il Zoppo), son of Charles I.
1309. Robert the Wise, third son of Charles II.
1343. Joanna I., daughter of Charles, only son of Robert.
1381. Charles III. of Durazzo, son of Louis Count of Gravina, and grandson of Charles II.
1386. Ladislaus, son of Charles III.
1414. Joanna II., sister of Ladislaus.
1435. René of Anjou, Duke of Lorraine, called by Joanna II.'s will in opposition to her previous adoption of Alfonso of Aragon. The Angevine dynasty ended in him.

KINGDOM OF SICILY.

House of Aragon, 1282–1501.

1282. Peter, King of Aragon, the husband of Constance, the daughter of Manfred.
1285. James I., the Just, son of Peter; on succeeding to Aragon in 1291, abdicated in favour of his brother.
1291. Interregnum.
1296. Frederick II., brother of James I.
1337. Peter II., son of Frederick, to whom he had been associated on the throne since 1321.
1342. Louis, son of Peter.
1355. Frederick III., a younger brother of Louis.
1377. Mary, daughter of Frederick III., and her husband, Martin of Aragon.
1402. Martin I., on the death of Mary without issue.
1409. Martin II. (I. of Aragon), the father of the last king. Sicily was united to Aragon.
1412. Ferdinand the Just, King of Aragon and Sicily.
1416. Alfonso V., son of Ferdinand, King of Aragon and Sicily.

King of Naples and Sicily.

1442. Alfonso V., called the Magnanimous, having expelled Renato of Anjou from Naples, united the two kingdoms, and assumed the name of Alfonso I. At his death the two countries were again separated.

Kingdom of Naples.

1458. Ferdinand I., a natural son of Alfonso, legitimated by the Pope in 1444.
1494. Alfonso II., Duke of Calabria, son of Ferdinand I., who, on being attacked by Charles VIII. of France, abdicated in favour of his son,
1495. Ferdinand II., who recovered the kingdom from the French, and died at twenty-nine.
1496. Frederick, Prince of Altamura, second son of Ferdinand I. Attacked by Louis XII. of France, and betrayed by his cousin Ferdinand the Catholic, he lost the kingdom in 1501. The Aragonese dynasty ended with him.

Kingdom of Sicily.

1458. John II., a brother of Alfonso, and King of Aragon and Navarre.
1479. Ferdinand II. (Ferdinand the Catholic), son of John II.

THE SPANISH DOMINION, 1501–1707.

Kingdoms of Naples and Sicily.

By the treaty of Granada, November 1500, Louis XII. and Ferdinand the Catholic, agreed to divide Naples; but dissensions having arisen between them, Ferdinand drove the French away, and in 1504 united the whole of Naples to Sicily, already a Spanish possession.

1504. Ferdinand the Catholic, King of Spain.
1515. Joanna of Castile, daughter of Ferdinand and Isabella, who abdicated in favour of her son,
1516. Charles IV., afterwards the Emperor Charles V.
1554. Philip II. of Spain, the husband of Queen Mary of England.
1598. Philip III. of Spain, son of Philip II.
1621. Philip IV., the son of Philip III., by Margaret of Austria.
1665. Charles II., son of Philip IV., by his second wife, Mary Anne of Austria.
1700. Philip V., Duke of Anjou, and grandson of Louis XIV. of France, called by Charles II.'s will to the thrones of Spain, Naples, and Sicily.

[1] *Two Letters to the Earl of Aberdeen on the State Prosecutions at Naples*, by W. E. Gladstone. London: Murray.

THE AUSTRIAN DOMINION, 1707–1734.

Naples.

1707. Charles, Archduke of Austria, second son of Leopold I., and afterwards Emperor, as Charles VI.

1720. Charles VI., Emperor of Germany, and King of Naples and Sicily.

Sicily.

1713. By the treaty of Utrecht, Spain ceded Sicily to the Duke of Savoy.

1718. Spain seized upon Sicily, but in 1720 gave it up to Austria.

THE BOURBONS.

Kings of Naples and Sicily.

1734. Charles of Bourbon, VII. of Naples, a younger son of Philip V. of Spain, by his second wife, Elizabeth Farnese. Succeeded in 1759 to the throne of Spain as Charles III.

1759. Ferdinand III. of Sicily, and IV. of Naples, third son of Charles III. by Amelia Walburga, daughter of Frederick Augustus, king of Poland.

Naples.

1799. After five months of Republican government, Ferdinand retook possession of the kingdom.

Sicily.

The Bourbon dynasty continued without any interruption.

THE FRENCH DOMINION, 1806–1815.

1806. Joseph Buonaparte proclaimed king on the 14th of January.

1808. Joachim Murat, proclaimed king of Naples by a decree of Napoleon, of 15th July.

THE BOURBONS (continued).

Kingdom of the Two Sicilies.

1815. Ferdinand IV., by the treaty of Casalanza, May 20, 1815, obtains possession of Naples. In 1816 he assumed the name of—

1816. Ferdinand I., King of the Kingdom of the Two Sicilies.

1825. Francis I., his son by Caroline of Austria, sister of the Emperor Joseph II.

1830. Ferdinand II., son of Francis, by his second wife, the Infanta Isabella of Spain.

1859. Francis II., the reigning king, eldest son of Ferdinand II., by his first wife, Maria Christina, daughter of Victor Emmanuel I., king of Sardinia. He succeeded his father on the 22d of May 1859. (* * *)

SICULIANA, a town of Sicily, in the province and 9 miles N.N.W. of Girgenti. It occupies an unhealthy situation, in the neighbourhood of the most considerable sulphur mines in the island. Some trade is carried on in corn and sulphur. The ancient Camicus is supposed to have been situated near this town. Pop. 6000.

SICYON (Σικυών, modern *Vasilika*), a celebrated city of ancient Greece, in Achaia, about 2 miles from the south shore of the Corinthian Gulf, and about 10 N.W. of Corinth. The situation is one of the finest of any of the cities of Greece. It stands on a hill between the rivers Helisson and Asopus, and commands a wide prospect over the fertile plain of Achaia on the west; on the east, as far as the lofty hill that sustained the citadel of Corinth; while, on the north, the eye ranges over the waters of the gulf to the mountains of Parnassus, Helicon, and Cithaeron beyond. The hill is triangular, and round its edges ran the walls of the city. Its southern portion being slightly elevated above the rest, formed the Acropolis. Like most other large Greek cities, Sicyon contained an agora or market-place. a theatre, a gymnasium, and innumerable temples. Of the last, the most important seems to have been that of Apollo, the patron of the city, in the market-place. The streets were regularly laid out, crossing one another at right angles, These may still be traced; but very few of the buildings have been preserved. There are, however, some remains of the theatre, and also of a *stadium* or race-course, both for the most part cut out of the ledge of rock between the upper and lower city. Sicyon is said to have been one of the most ancient cities in Greece; and there are many legends more or less improbable concerning its early history. During all the time when anything definite can be known about it, the town seems to have been peopled partly with Dorians and partly with Ionians; and for the greater part by far of this period the former race were the dominant party. The chief exception to this was an interval of more than 100 years, from about B.C. 676 to 560, during which it was governed by successive tyrants of the house of Orthagoras. an Ionian family. The last of these was Cleisthenes, whose daughter Agarista was married into the illustrious Athenian family of the Alemaeonidæ, and became the mother of a more famous Cleisthenes, the consolidator of democratic power at Athens. During the most stirring times of Greek history, Sicyon makes no great figure. In all the wars it was a steady adherent to Sparta, and opposed to Athens. It was more famous for its painting and sculpture than for political influence, and the city was rich in works of art. It gave its name to one of the great schools of painters in Greece, which was founded by Eupompus, and distinguished by the genius of Apelles. Sicyon was also the birthplace of the sculptor Lysippus. After the Roman conquest of Greece it fell into decay, though it continued to exist down to the Christian era.

SIDDONS, MRS (whose maiden name was Sarah Kemble), the greatest actress that ever trode the stage, was born at Brecon, in South Wales, on the 5th of July 1755. Roger Kemble, her father, was manager of a provincial company of players, and amongst this class of persons he seems to have held a highly respectable rank. Sarah, who was his eldest daughter, appeared very early on the stage, and went the usual round of juvenile characters without exciting much expectation. At the age of eighteen she married Mr Siddons, an actor in her father's company, soon after which event she removed to Cheltenham, where she attracted some attention, and was recommended to Garrick. Her first appearance on the London boards was not successful, simply because she never had a proper part assigned her. Mrs Siddons accordingly returned to the provinces much mortified; but the praises showered upon her by such audiences as those of York, Manchester, and Bath, induced the managers of Drury Lane to re-invite her to the metropolis. Her re-appearance took place on the 10th October 1782. The character which she chose was that of Isabella in *The Fatal Marriage*. The effect of that performance was extraordinary and unparalleled. It gave a shock of wonder and delight to the public mind, like the news of some great and unexpected victory. On that night, Mrs Siddons at once took possession of the tragic throne, on which, for thirty years, she reigned without a rival. Some idea of the excitement which she created may be learned from the fact, that "the grave and reverend seignors" of the English bar presented her with a purse of one hundred guineas. During the season Mrs Siddons played Euphrasia, Jane Shore, Calista, and for her two benefits, Belvidera and Zara. In all of these characters she greatly added to her fame; the public were astonished at the vastness of her powers, and tragedy became the fashion. In subsequent seasons she increased her circle of characters, adding from Shakspeare those of Lady Macbeth, Constance, Isabella, Queen Katherine (the most chaste, beautiful, and perfect performance that ever drew a tear), Rosalind (not in her line, for she was altogether too stately and heroic for comedy), Desdemona, Volumnia, Portia, Hermione, Imogene, and a few others. This list shows that her range was surprising, but she was not equally excellent in all her parts. Her comedy never gave great satisfaction, although there was occasionally much to admire in it. When the metropolitan season closed, it was the custom of this, as it is of every great actor, to visit the principal cities of Ireland, Scotland, and the provinces of England. Everywhere she enchanted the lovers of the drama. She became a favourite with their majesties, and was in the habit of read-

ing plays to them, an occupation of more honour than emolument. However, Mrs Siddons, by her professional exertions, realized a fortune equal to her wishes, and retired from the stage in 1812. Her death took place on the 8th of June 1831, in her seventy-sixth year.

The symmetry of this great actress's person was most captivating. Her features were strongly marked, but finely harmonized; the flexibility of her countenance was extraordinary, yielding instantaneously to every change of passion; her voice was plaintive, yet capable of firmness and exertion; her articulation was clear, penetrating, and distinct; above all, she was completely mistress of her powers, and possessed that high judgment which enabled her to display all her other qualifications to the greatest advantage. One of Mrs Siddons' highest endowments, if not her very highest, was the power of identifying herself with the character which she personated. The scenes in which she acted were to her far from being a mere mimic show; so powerfully did her imagination conjure up the reality, that the tears which she shed were those of bitterness felt at the moment. From her frown of proud disdain and scorn, the very actors themselves shrank with something like terror. Her greatest characters were Katherine in *Henry VIII.*, and Lady Macbeth, in which she manifested a dignity and a sensibility, a power and a pathos, never equalled by any female performer. Lastly, Mrs Siddons was truly an original; she copied no one, living or dead, but acted from nature and herself. In all the relations of life her conduct was most exemplary. "She was more than a woman of genius," says the poet Campbell, who knew her well, "for the additional benevolence of her heart made her an honour to her sex, and to human nature." (J. F. S.)

SIDNEY, or SYDNEY, ALGERNON, a noble English patriot, who fell a victim to the judicial tyranny of the Second Charles, was distinguished alike by the superiority of his mind, and by the excellence of his public and private character; was grand-nephew to the illustrious Sir Philip Sidney, second son of the second Earl of Leicester, and of Dorothy, eldest daughter of Henry, earl of Northumberland, and was born in 1622. After receiving as careful an education as the time could bestow, he was, while still a child, taken by his father, in 1632, who had been appointed ambassador extraordinary to the court of Denmark, in conjunction with his elder brother, Lord Lisle, to the place of his father's embassage. Accustomed from his tenderest years to the gaiety and splendour of courts, and educated in the largest and most liberal sense, he grew up a most accomplished youth, endowed with all the dignity and worth which can give weight to a man's character, and with all the gentler graces which lend to his manners the quality of fascination. Four years after he had visited Copenhagen, he accompanied his father to Paris, where he gained the esteem of many of the principal personages about the French court, and his mother had the gratification of having his good repute wafted to her ears again and again in England. In 1641 he did good service in Ireland, where he commanded a troop of horse in his father's regiment. Returning along with his brother, Lord Lisle, in the autumn of 1643, on their way to join the royal standard at Oxford, they were injudiciously detained by the royalists at Liverpool. Insulted by this apparent jealousy of their characters, the youths immediately set spurs to their horses, and joined the parliamentary army. Sidney entered with the rank of a captain in the Earl of Manchester's army on the 10th of May 1644. He was raised to be lieutenant-colonel before the summer was done, and fought and bled profusely at the battle of Long Marston Moor, on the 2d July 1644. Sidney having now vindicated his claims to the rank of a soldier, rose afterwards with much rapidity, till, in 1646, we find him lieutenant-general of the horse in Ireland, and governor of the city of Dublin. He had been returned member for Cardiff in the beginning of the same year, and in May 1647 he received the thanks of the House for his services in Ireland, and was made governor of Dover Castle. Next year he acted as one of the judges of the king, but withheld his presence on the signing of the warrant for his execution. This was possibly through respect for his father's convictions, who was a royalist. It certainly was not through any dislike which he entertained to the shedding of royal blood, for on being challenged, many years after, by his father as to whether he was guilty of the late king's death, "Guilty!" said he, "do you call that guilt? Why, it was the justest and bravest action that ever was done in England or anywhere else." Sidney, while advocating with all his might the erection of a free legislature over a free people, was not prepared for the ambitious step taken by Cromwell in accepting the Protectorship of the Commonwealth. He used all his influence in opposing his election, and had for his pains the misfortune to hear the Protector insist twice upon his quitting the House of Commons. This occurred on the 19th of April 1653. He indignantly retired to his father's residence, at Penshurst in Kent, where, in the bosom of his family, he could nurse the wounds which his pride had sustained in his late contest with the Lord-Protector. He preserved his retirement for the next six years, when the restoration of the long parliament again summoned him to London.

On the 13th of May 1659, Sidney was appointed a councillor of state, and was despatched on the 2d of June, with other ambassadors, to negotiate a peace between Denmark and Sweden. While he was absent on this mission, King Charles II. was restored. Sidney, who had heartily acquiesced in the first resolution of the long parliament, which was "to secure the liberty and property of the people, without the government of a single person, kingship, or a House of Lords," was of opinion that that resolution was still binding on his conscience, and that he could forego it only at the risk of public perjury. He accordingly resolved to stay out of England, and watch for fairer weather. This is not the place to follow him in his sad wanderings through Holland, Germany, Rome, Switzerland, and France, until his return to England in 1677. Here is an extract or two from a very noble letter of Sidney's, written to a friend a little before the Restoration, which must here suffice for a partial delineation of his mental character. "I have," he says, "in my life been guilty of many follies; but, as I think, of no meanness. I have ever had in my mind, that when God should cast me into such a condition as that I cannot save my life but by doing an indecent thing, He shows me the time is come wherein I should resign it; and when I cannot live in my own country but by such means as are worse than dying in it, I think He shows me I ought to keep myself out of it." He further adds, "My thoughts as to king and state depending upon their actions, no man shall be a more faithful servant to him than I, if he make the good and prosperity of his people his glory; none more his enemy if he doth the contrary." Tired out with waiting and watching, and no appearance of dawn on the western horizon, Sidney concurred with some of his companions in exile in urging on the Dutch government the invasion of England in 1665. Disappointed in this attempt, we next find him at Paris, whither he had been induced to go in expectation of a French insurrection in England. He submitted his plans to the government, but that wily body thought 100,000 crowns too great a stake to be thrown away upon the faith of an exile. At length, after a long interval, Sidney was induced to set foot upon English soil. His father, the Earl of Leicester, declining in health and strength, wished to see his outcast son, Algernon, before he died, and busied himself to obtain a passport from the king, which was granted

in 1677. The father died shortly after, leaving the vagabond rebel L.5100. Sidney was afterwards detained in England by a tedious suit in Chancery, occasioned by his elder brother disputing his father's will. There are various references to Sidney in Barillon, the French minister's despatches, of this date; and among the disbursements of French money to English patriots, we find 500 guineas, alleged to have been paid by that functionary to Algernon Sidney. Without attaching too great importance to the statement of this intriguing Frenchman, it is not very improbable that Sidney's hands may have been soiled by the taint of French gold. If he did receive money from Barillon, as is alleged, he could doubtless satisfy his conscience that the taking of it was no crime. He twice failed to obtain a seat in parliament, once at Guildford in 1678, and once at Bramber in 1679. He was no doubt eagerly watched by the party in power, and it is well known that Charles II. both feared and hated him. Sidney leagued himself in opposition to the court with Monmouth, Shaftesbury, Russell, and Essex. No doubt he sought his own time and way to introduce an entire change in the existing system of government. The Rye-House Plot of June 1683 was made the signal for his arrest. Sidney was dragged to the Tower, along with Lord William Russell, on a charge of high treason, where, with the notorious Jeffreys for a judge and the abandoned Howard for sole witness, his examination must have been a mere mockery. No legal evidence could be found of his guilt, yet "in defiance of law and justice," he was summarily beheaded on Tower Hill on Friday the 7th December 1683. (See Lord Macaulay's *Hist. of Eng.* vol. i.) Sidney died as he had lived, with all the Christian firmness, and with little of the pride of suffering usually ascribed to the Stoics. He did not even address the mob congregated to witness his execution. On being asked to speak, he replied he had made his peace with God, and had nothing to say to man. A truly valorous and right noble man, who both in life and death showed that he possessed many of the qualities which go to make up a hero, both in largeness of soul and in loftiness of purpose. His is a name that England will not willingly let die: his is a death that she would gladly wipe from the pages of her history. Yet, perhaps, it is better so, for it endears to an English memory the records of his country, the thought that they have been consecrated by a heroic and innocent death.

Sidney had studied more deeply perhaps than any other man of his time the history of government in all its aspects. He has left us a short treatise on that subject, which was published in 1698, under the title of *Discourses concerning Government*, by John Toland. Again it appeared with his *Apology*, and a life of the author, in 1751, by Thomas Hollis. The whole of his works which have yet been published were brought out in 1772 by Brand Hollis. This edition omits his *Essay on Love*, said to be still in manuscript at Penshurst. There is also a careful *Life of Algernon Sidney*, by G. W. Meadley, 8vo, London, 1813. The trial of Sidney was printed in 1684, but it is said to have been first cooked by Jeffreys. (See Howel's *State Trials*, vol. ix. pp. 357–1000.)

Sidney, *Sir Philip*, one of the brightest ornaments of the reign of Queen Elizabeth, was born at Penshurst, in the county of Kent, on the 29th day of November 1554. By both parents his descent was illustrious. The Sidney family came over from Anjou with Henry II., to whom William de Sidney acted as chamberlain. Sir William, Philip's grandfather, was chamberlain and steward of the household to Henry VIII., and his father, Sir Henry, was companion and bosom friend of Edward VI. The latter was a man of great ability and accomplishments. At court he was distinguished for his wit, gallantry, and manly bearing, and was universally beloved. He was appointed Lord President of Wales, and afterwards Lord-Deputy of Ireland. The latter was at that time a post of great difficulty and danger; but he acquitted himself in it with great credit, bringing subordination and order out of anarchy and confusion. He was, besides, a man of exemplary piety; and his letters to his sons show, that while anxious for their advancement in secular learning, he was most of all solicitous for their religious and moral up-bringing. Philip's mother was Mary, eldest daughter of John, Duke of Northumberland; and at the time of his birth she was mourning the untimely deaths of her father and brother. She was a woman of very superior character, and devoted herself chiefly to the education of her family, superintending not less their amusements than their studies, and instilling into their minds the principles of religion and virtue. Young Sidney remained at home till the age of twelve, when he was sent to a school in Shrewsbury: and by this time he had made considerable progress in various branches of knowledge, and was able to write letters to his father in Latin and French. From Shrewsbury he proceeded to Christ Church, Oxford, where he distinguished himself by his assiduity and diligence. "He aspired," says Fuller, "to pre-eminence in every part of knowledge;" and "such was his appetite for learning, that he never could be fed fast enough therewith, and so quick and strong his digestion, that he soon turned it into wholesome nourishment, and thrived healthfully thereon." In early life he seems to have been of a weakly constitution; and there exists a letter, written, when he was fifteen years of age, by his uncle, the Earl of Leicester, to the Archbishop of Canterbury, craving a licence for him to eat flesh during Lent, on account of the delicate state of his health. By judicious exercise, however, he strengthened his physical nature so, that at length he became distinguished for his bodily, not less than for his mental, accomplishments. Spenser describes him as—

> "In wrestling nimble, and in running swift;
> In shooting steady, and in swimming strong;
> Well made to strike, to throw, to leap, to lift,
> And all the sports that shepherds are among.
> In every one he vanquished every one.
> He vanquished all, and vanquished was of none."

From Oxford he proceeded to Cambridge, where he spent some time, and then set out for foreign travel, in the eighteenth year of his age. Queen Elizabeth granted a licence "to her trusty and well-beloved Philip Sidney, Esquire, to go out of England into parts beyond the seas, with three servants and four horses, to remain during the space of two years immediately following his departure out of the realm, for his attaining the knowledge of foreign languages." He set out for Paris in May 1572, and was specially recommended by the Earl of Leicester to Mr (afterwards Sir Francis) Walsingham, the English ambassador there. The French king, Charles IX., being, or pretending to be, captivated by his manners and conversation, showed him special marks of favour, and conferred on him the office of gentleman ordinary of his chamber. Scarcely had he held this office a fortnight, when the dreadful massacre of St Bartholomew took place (24th August 1572), and Sidney with difficulty saved his life by taking refuge in the house of the English ambassador. He was now urged to return home; but he chose rather to proceed on his travels. He spent some time in Frankfort, in the house of Wechel the printer, where he had the good fortune to make the acquaintance of the esteemed and learned Hubert Languet, who had also escaped from the massacre of St Bartholomew. Languet ever after manifested the deepest interest in the young Englishman. His letters to him fill a volume; and it is affecting to observe the extreme solicitude shown by the old diplomatist for his young friend. "Our friendship," he writes on one occasion, "and the hopes I have conceived

of vour character, are my only comfort; if any misfortune befal you, I shall be the most unhappy of men." He so longed for letters from him after his return to England, that he requested that even a servant might write him, so that he should hear often of the son of his adoption.

Languet being appointed to represent the Elector of Saxony at the court of Vienna, Sidney accompanied him to that capital, and remained there for some time. From Vienna he went to Venice, and thence to Padua, where he spent some time, visiting also Milan and Genoa. It may seem remarkable that he did not also, at this time, visit Rome,—a city which, to him, would have presented so many objects of interest; but he denied himself the pleasure at the earnest request of Languet, who was afraid that his Protestant principles might be contaminated in the Romish capital,—surely a groundless fear for one of Sidney's character, who had, moreover, so recently witnessed the massacre of St Bartholomew. Returning to Venice, he thence proceeded to Poland, and took part in some skirmishes between the Poles and Russians. He then went to Vienna, and resumed his studies under the direction of Languet. In the spring of 1575, the emperor went to Prague to open the Bohemian Diet; Languet and Sidney accompanied the court, saw the ceremony, and then parted.

Sidney arrived in England in the end of May 1575, and was now the pride and admiration of the English court. The queen herself treated him with marked kindness, and called him "her Philip." The beauty and gracefulness of his person, the benignity of his disposition, his pleasing manners and insinuating address, all served to endear him to all that knew him. His form was tall and manly, his complexion fair, and his features beautiful, regular, and of rather a feminine cast. His expression was mild and thoughtful, approaching even to sadness, while at the same time he was not devoid of a certain degree of sprightliness in conversation, and abounded in a playful kind of humour. In 1576 he was sent as ambassador to the court of Vienna, accompanied by a pompous retinue, worthy alike of his office and his sovereign, to condole with the Emperor Rodolph on the death of his father. His mission had also a more important object in view—the union of all the Protestant states in a common league in defence of their religion against the ambition and intolerance of Rome and Spain. He likewise visited the court of the Count Palatine of the Rhine, and gained the friendship of Prince John Casimir. But the highest testimony to his merits was his having won the esteem and affection of William Prince of Orange, probably the most wise and politic chief of his time in Europe. He enjoined it to be told to the queen, that if he were a judge, she had in Philip Sidney one of ripest and greatest counsellors of state in that day in Europe. Even Don Juan of Austria, in spite of his national pride and religious bigotry, was compelled to admire and applaud the talents and graces of the young Englishman. Sidney returned to England in 1577, having successfully accomplished his mission, and gained golden opinions wherever he went. Till the occasion in which he lost his life he was little employed in public service, but kept principally about the court; and in the tilts and tournaments of the period he was ever among the most distinguished for his skill and daring. He did not, however, relish the life of a courtier, and desired nothing more than to spend his days in studious retirement in the society of a few select friends. Soon after his return to England, he was called upon to defend his father, who, in his endeavours to settle the government of Ireland, met with a great amount of opposition and misrepresentation at court. Philip warmly espoused his cause, demonstrated the falsehood of the various charges brought against him, and succeeded in reinstating him in royal favour. He was once or twice on this occasion betrayed into an impetuosity of temper not to be expected from his general character, but excusable from the times in which he lived, and the circumstances which called them forth. His father's letters had been betrayed, Sidney's suspicions fell upon his secretary, Mr Molyneux, to whom he wrote a very intemperate and violent letter; but as soon as he found that his suspicions were groundless, he amply apologised. The Earl of Ormond, too, fell under his displeasure from having attacked his father in the House of Lords. Though allied to the queen, and high in her favour, Sidney scrupled not to attack him in his defence, and afterwards refused to speak to him. To the credit of the earl, however, he refused to accept a "quarrel from a gentleman that is bound by nature to defend his father's cause, and who is otherwise furnished with so many virtues as he knows Mr Philip to be." The proposed marriage of the queen with the Duke of Anjou was creating a great excitement in Protestant England, and was said to be favourably looked upon by her Majesty, when Sidney addressed to her a letter upon the subject, characterized by its boldness and freedom. The *Remonstrance* was well received, and probably induced her Majesty to decline the alliance. A dispute between him and the young Earl of Oxford led to his withdrawing himself from court for a time. While he was playing at tennis the earl came forward and insulted him; and having afterwards refused to apologise, the matter was likely to become serious, when the queen herself interposed, and admonished Sidney, reminding him of the difference between lords and gentlemen. Sidney replied, "That although he was a great lord by birth, alliance, and grace, yet he was no lord over him," and that "the difference of degrees between free men could not challenge any other homage than that of precedence." Though the boldness of these sentiments did not displease the queen, Sidney retired to Wilton, the residence of his sister, the Countess of Pembroke, to recover his composure and serenity of mind. It was while there that he composed his *Arcadia*, chiefly for the amusement of the countess.

He had early become attached to the beautiful and accomplished Lady Penelope, daughter of the Earl of Essex, but to the great disappointment of Sidney, the match was broken off, and the lady was married to Lord Rich, afterwards Earl of Warwick. He, however, married in 1583 Frances, only surviving daughter and heiress of his early friend Sir Francis Walsingham, a lady of great beauty and worth. The same year the queen conferred upon him the honour of knighthood. Sidney, however, was becoming more and more disgusted with the inactive life of a courtier. He secretly planned to accompany Drake on an expedition against the Spanish settlements in America. The expedition was on the point of starting when the queen heard of it, and Sidney was commanded not to go. About the same time he is said to have been invited to become a competitor for the kingdom of Poland, but the queen refused to part "with the jewel of her crown." She however nominated him governor of Flushing, one of the towns committed for security to the English by the Dutch in their war with Spain. He arrived there on 18th November 1585. The Earl of Leicester followed shortly after with an English army of 5000 foot and 1000 horse, and Sir Philip was entrusted with the command of the horse under his uncle. His wise counsels and conduct served in some measure to conceal the incompetence and mismanagement of Leicester, while his kindness and moderation smoothed the dissensions that prevailed in the camp. In the early part of 1586 he suffered a severe affliction in the death of both his parents within a short time of each other. After some successes, in which he greatly distinguished himself, he accidentally came upon a body of 3000 Spaniards marching to the relief of Zutphen, a town of Guelderland. At the head of 200 horse he immediately attacked them, and a desperate conflict took place on the 22d September 1586. Sidney had his

Sidon.

horse killed under him, but mounting another, he continued to charge the enemy. In the third charge he received a wound from a musket-ball in the thigh. It was then that the incident occurred which has done more to immortalize Sidney than all his other acts. When leaving the field, faint and thirsty through loss of blood, he called for some drink, which was presently brought him. As he was putting the bottle to his mouth, he saw a poor soldier carried along, bleeding and ghastly, wistfully cast his eyes at the bottle. He immediately took it, untasted, from his lips, and presented it to the poor man, saying, "Thy necessity is yet greater than mine." He lingered for sixteen days in great agony, and during all that time he exhibited the greatest composure and resignation to the will of God. Yet scarcely can we suppose circumstances more calculated to call forth repining and regret. He was yet in the early vigour of manhood, with talents and accomplishments of a high order, the beloved of his queen, and the most esteemed of her courtiers both at home and abroad, and he might naturally have looked forward to a long and brilliant career of happiness and usefulness. But, believing in the principles of the Christianity which he professed, he had listened to the reiterations of the Preacher, that all is vanity, and had learned, from a higher than the Preacher, to say, Not my will, but thine be done; and so he thanked God that he did not strike him dead at once, but gave him space to seek repentance and reconciliation. He died on the 7th of October 1586, in the thirty-second year of his age. His body was brought to England, and, after lying many days in state, was interred in Old St Paul's Cathedral on the 16th of February 1587. His death was lamented throughout Europe; in England a general mourning was observed, a respect, it is believed, never before shown to the memory of a private individual. Sir Philip left an only child, Elizabeth, afterwards married to Rogers Manners, fifth Earl of Rutland; but she died without issue. His widow was afterwards twice married; first to the famous Earl of Essex, and then to Richard de Burgh, fourth Earl of Clanricarde.

His literary works were not published till after his death. His *Arcadia* was left incomplete, and he is said, before his death, to have requested it to be destroyed. Though now little known, except by name, it long enjoyed an immense popularity. As a whole it is tedious, and abounds in extravagant pictures and improbable events; but it contains numerous passages of exquisite beauty, and "animated descriptions, equal to any that occur in the ancient or modern poets." The language is natural, elegant, and copious, above that of any other author of that period. His *Defence of Poesy*, published also after his death, was composed to repel the objections of the Puritans of that period upon poetry. It is a masterly production, displaying both erudition and taste, and abounding in gentle touches of humour. He likewise wrote some poems and sonnets, which are now little known. Sidney was a generous patron of learned men; and learned foreigners, as well as Englishmen, sought his acquaintance. Spenser, in particular, was much indebted to him, and has taken many opportunities of introducing him into his poetry as a model of virtue, honour, and learning. On his death he sang his praises in a pastoral elegy, entitled "Astrophel." (See *Memoirs of the Life and Writings of Sir Philip Sidney*, by Dr Thomas Zouch, 1808.)

SIDON, an ancient and important city of Phœnicia, is situated on a little promontory which juts out into the Mediterranean, in Lat. 33. 34. N., and Long. 35. 22. E. from Greenwich. Josephus states that Sidonius, the eldest son of Canaan, built a city which the Greeks called *Sidon*. This statement accords with the language of Scripture, which, though it does not expressly say, yet it plainly implies that the city was founded by Canaan's son (Joseph. *Anti.* i. 6. 2; Gen. x. 15, 19). It is worthy of remark, however, that the name is descriptive of the site. The word צידון signifies "fishing," and the position of the town on a coast abounding in fish would seem to indicate that this circumstance had suggested the appellation. In fact, Justin affirms that the name was derived from the peculiarity of the site,—"Condita ibi urbe quam a piscium ubertate Sidona appellaverunt, nam pisces Phœnices Sidon vocant" (18. 3). It is also remarkable, that we find a like correspondence between the names of others of the early patriarchs and the physical character of the countries they colonized; *Aram*, for example, and *Canaan*, the former signifying a "plateau," or "high region," and the latter a "lowland." This could not have been accidental. But we are by no means justified in adopting the theory of Mr Kenrick, which Professor Stanley has indorsed (*Sinai* and *Pal.* 267), that Sidon is called the eldest born of Canaan, figuratively as being the oldest and most important city of the Canaanites. The fact may be satisfactorily explained in one of two ways. Either the names were given to the Patriarchs in prophetic allusion to their subsequent history, as in the case of Abraham; or they were adopted by them after taking possession of their selected territories. When the Israelites conquered Palestine, their historians applied to Sidon the term רבה, "Great;" in allusion, doubtless, to its strength and populousness (Josh. xi. 8).

Topography and antiquities.

The plain of Phœnicia, at Sidon, is a little more than a mile in breadth, and is covered with luxuriant gardens and orchards of the choicest fruits. The ridge of Lebanon rises abruptly over it, its rocky sides here and there diversified by terraced vineyards and mulberry plantations. The plain is flat and low; but near the coast-line rises a little hill, a spur from which shoots out a few hundred yards into the sea in a south-western direction. On the northern slope of the promontory thus formed, stands the old city of Sidon. The hill behind on the south is crowned by the citadel,—a heavy square tower built by Louis IX., in 1253, and half ruined by the fire of the British fleet under Commodore Napier in 1841. A substantial modern wall, running across the peninsula from sea to sea, defends the town on the land side. The streets are of the usual eastern type, narrow and crooked, encumbered with dirt and rubbish; the houses, however, are large, and some of them even elegant, especially those built on the wall overlooking the lovely plain. Within the town are six great khans or caravanserais, which owe their origin to the enterprise of Fakhr ed-Dîn. They are quadrangular structures, with courts in the centre, and ranges of small cell-like chambers all round, to serve as stores for merchandise, and lodgings for merchants. The largest of them formerly belonged to the French consulate and factory. The ancient architectural remains in the town are few and insignificant. None of the buildings are of an earlier date than the crusades. Some marble and granite columns are here and there seen in the modern walls and houses, and there are also a few fragments of Mosaic pavement remaining.

The ancient harbour was formed by three irregular ridges of rocks, which run northward from the promontory parallel to the coast line. They are partly under water and partly above it; and upon them may be seen some massive fragments of ancient masonry. Old writers mention two harbours, an outer and an inner, the latter being enclosed. Tatius describes them with some minuteness. Scylax also speaks of the closed port of Sidon. The position of the two can be easily traced. The outer harbour lay towards the west, extending from near the apex of the promontory northwards, and defended by a ridge of rocks. The inner lay in the curve of the bay, between the former and the shore. On an isolated rock, some distance from the beach, stand the picturesque ruins of a crusader's castle. It is connected with the town by a long causeway sup-

Sidon.

ported upon nine arches. This causeway formed the division between the outer and the inner harbours.

On looking at the port and site of Sidon, one is especially struck with their diminutive size as compared with their ancient fame and commercial greatness. One of our ordinary ocean steamers would have completely filled the little harbour, though it was sufficient to contain a considerable fleet of such vessels as the ancients possessed. In the seventeenth century it was blocked up by Fakhr ed-Dîn, and now it is only accessible to small boats, while the open roadstead on the north is extremely dangerous.

The Cemetery.

On the east of the town, at the base of the mountains, are many rock-tombs of somewhat singular form and character. In places they are hewn out in tiers along the face of the cliff, and have stairs cut in the rock leading up to them. Their internal arrangements, like many of those in Petra, resemble houses for the living more than tombs for the dead. In various parts of the adjoining plain sepulchral caves have been found. In January 1855, one was accidentally opened at a spot about a mile S.E. of the city; and in it was discovered one of the most beautiful and interesting Phœnician monuments in existence. It is a sarcophagus of black marble, the lid of which is hewn in the form of a mummy, with the face bare. Upon the upper part of the lid is a perfect Phœnician inscription in twenty-two lines, and on the head of the sarcophagus itself is another almost as long. These record the fact, that the body of a certain Eshmonasar, king of Sidon, was once entombed within it. It is now in the Louvre at Paris. A short time previously, a vase was dug up in a field near Sidon, containing a large number of gold coins, chiefly of the times of Philip and Alexander the Great. There is scarcely a doubt that a rich harvest of Phœnician antiquities awaits the labours of some diligent excavator round the sites of Sidon and Tyre.

Arts and sciences.

Sidon is justly celebrated as the most ancient, and one of the most enterprising, commercial capitals in the world; but its early proficiency in science, art, and manufacture, perhaps entitles it still more to the admiration of mankind. Herodotus begins his history with these words:—"The Phœnicians, who had formerly dwelt on the shores of the Erythrean Sea, having migrated to the Mediterranean, and settled in the parts which they now inhabit, began *at once* to adventure on long voyages, freighting their vessels with the wares of Egypt and Assyria. They landed at many places on the coast, and among the rest at Argos." From this little harbour of Sidon, in all probability, went out the first ship that crossed the Mediterranean. The enterprise of the Phœnicians thus supplied the link to connect the civilized east with the barbarous west, and initiated a system which has raised Europe to its present state of intellectual, moral, and commercial greatness. The skill of the Sidonians in the science of navigation is celebrated by Ezekiel (xxvii. 8), and by the earliest classic writers. They first discovered the pole-star, and directed their ships by it; the constellation of the Little Bear was hence called Phœnice. They studied astronomy, and applied it in practice to navigation. (Kenrick's *Phœnicia*, p. 233, *sq.*)

The art of making glass was known and practised in Sidon at a very early period. The ancients ascribe its discovery to accident; but the probability is, that the Sidonians got it from Egypt, where we find representations of the process in tombs 3500 years old. They obtained their silicious sand from the banks of the River Belus, in the Bay of Acre, and their soda from Egypt. From the words of Pliny it appears, that they knew the use of the blow-pipe, the lathe, and the graver; and they even made mirrors of glass (36. 26). Herodotus describes a pillar of emerald, shining with great brilliancy at night, as one of the most striking ornaments of the temple of Hercules at Tyre (ii. 44). It was probably of coloured glass, hollow, and lighted up by a lamp within. The writer has seen small glass-bottles of a beautiful emerald green, which were taken from Phœnician tombs near Beyrout.

Sidon.

In the Homeric age, the choicest works of art were ascribed to the Sidonians. He tells us that their gems, their chains and ornaments of gold, captivated the hearts of the Greek maidens (*Odys.* 15). The vase of silver which Achilles offered as a prize at the funeral games of Patrocles, was a work of the "skilful Sidonians;" the bowl of silver with edges of gold, presented by Menelaus to Telemachus, was a gift from the king of Sidon; and the gorgeous robe offered by the Trojan matrons to the goddess Minerva, was the work of Sidonian women (*Il.* 23. 743; *Od.* 4. 618; *Il.* 6. 288). The Sidonians were also celebrated for their bronze castings, and their ornaments of brass; and, doubtless, from them the Tyrians obtained the knowledge of an art in which they afterwards excelled.

History.

Of the origin of Sidon nothing is known beyond what is told us by Josephus, that the city was founded by the oldest son of Canaan. It may be fairly ranked among the most ancient cities in the world, and were its historic annals complete, they would embrace a period of full 4000 years. From the direct statement of Herodotus, and the incidental notices in the Bible and Homer, it appears that the inhabitants began, almost immediately after their settlement, to engage in commerce with foreign nations. Sidon was better known to the early Greeks than any other city of Phœnicia. It alone is mentioned by Homer, and his statements regarding it would seem to point back to a period, traditional if not historic, when it was the capital, and in fact the representative, of Phœnicia. Its ships then visited the isles of Greece, and the various ports along the shores of the Mediterranean, carrying the rich manufactures of the city to every market, and plundering and pilfering wherever opportunity offered.

About the twelfth century B.C., Sidon was attacked, and apparently captured by the king of Ascalon; on that occasion a large body of the inhabitants fled in their ships, and took refuge in the secure island of Tyre, where Justin represents them as founding a city (18. 3). Tyre had existed long before that time; but it is probable that after the arrival of the Sidonian refugees it suddenly rose to eminence, and became the capital of Phœnicia, while the power and influence of the more ancient Sidon decreased. From this period till B.C. 880, the history of Sidon is unknown. A recently deciphered Assyrian inscription shows that it was then, with a great part of Phœnicia, subdued by a certain Shalmanu-bar, king of Nineveh (Rawlinson's *Herod.* i. 463). From this time onwards, if we are to believe the self-laudatory records on the monuments of Nineveh, the Assyrian monarchs were the virtual rulers of the Phœnician cities. Josephus states, on the authority of Menander, that Sidon was captured by Shalmaneser about B.C. 728 (*Anti.* 9. 14. 2); but as the historic tablets of Koyunjik describe an expedition of Sennacherib, in which he captured Sidon, banished Luliya, its king, and gave his throne to another, it has been supposed that this is the event referred to by Menander (Rawlinson's *Herodotus*, i. 476). During the rule of the Babylonians and Persians in Western Asia, Sidon had no separate history. In the year B.C. 352, it headed the cities of Phœnicia in a revolt against Persia. Its inhabitants destroyed the residence of the Satrap, murdered many of his officers, and then collecting a large fleet, prepared for a vigorous defence. The valour of the Sidonians and their allies served for a time to keep the Persian forces at bay. At length, however, a large army was collected, and the king of Sidon fearing the result, basely resolved to save himself by betraying his country. One hundred Sidonian nobles were beguiled into the enemy's camp and murdered. Persian soldiers were afterwards admitted into the city. The wretched in-

habitants, having previously burned their fleet, that none might be able to flee from the common danger, now in despair shut up themselves, their wives, their children, and their treasures in their houses, set them on fire, and perished together in the flames (Mela. i. 12). The authors of this tragedy did not escape unpunished. The traitor king died by his own hand; and when, a few years afterwards, Alexander invaded the country, the Sidonians received him with open arms, and thus deprived Persia of the flower of her navy.

During the period which intervened between the death of Alexander and the Roman conquest of Syria (B.C. 323–64), Sidon sometimes owned the sway of the Seleucidæ, sometimes of the Ptolemies, as the fortunes of war favoured one or other; but it still contrived to retain much of its commercial prosperity. Under the Romans this state of affairs was not changed. The city, though subject to a foreign power, was ruled by native princes, and enjoyed great freedom (Joseph. *Anti.* 15. 4. 1). The inhabitants now found both time and ample field in which to prosecute their favourite studies of navigation, astronomy, and geography (Strabo, xvi). Their manufactures of glass, and their works of art, were encouraged by the paternal government of Rome. In the sixth century, when Beyrout was destroyed by an earthquake, the celebrated school of law and philosophy, which had long flourished there, was removed to Sidon.

When the Crusaders invaded Syria, Sidon was still a large and flourishing city. It was invested by the Christian army in A.D. 1108; but the inhabitants purchased a short respite by a large payment of gold. Three years afterwards it was captured by Baldwin. After the fatal battle of Hattin, Sidon fell into the hands of the Saracens, and its fortifications were dismantled; and when, in 1197, the Christians again entered it, they stabled their horses in its splendid saloons, and used their cedar ornaments for fire-wood. The city was finally abandoned by the Christians in 1291. In the fifteenth century it had somewhat revived, though it was not till the seventeenth century that it attained that degree of comparative prosperity it still continues to enjoy. In the beginning of this century, Fakhr ed-Dîn, a warlike and talented Druze prince, having got possession of the towns along the Syrian coast, built a palace at Sidon, encouraged commerce, and contributed greatly to develop the resources of the surrounding country. Unfortunately he was in a state of rebellion against the Sultan of Turkey, and in order to prevent the Ottoman fleet from approaching the city, he filled up the harbour with stones and rubbish. "Professing to be himself descended from French ancestors, he treated the Christians in his dominions with great equity, especially the Franks, granting privileges and immunities to the Latin convents, and encouraging the commerce of the French, which had now extended itself to these shores. In A.D. 1658, on the establishment of a new house at Marseilles for trading to Saida, one of its partners was appointed consul at the latter place, and D'Arvieux, a relative, repaired thither, where he continued chiefly to reside till A.D. 1655. To him we are indebted for a minute account of the city as it then was, and of the state of the French trade. At that period the French were the only nation who took part in the commerce of Sidon and the vicinity. Their trade had become so extensive, and so firmly established as to bring annually 200,000 crowns into the coffers of the Grand Seignor. Sidon was the central point, and traded directly with the Druzes; but the merchants established there had factors in Ramlah, Akka, Beyrout, Tripolis, and sometimes Tyre, who purchased up the products of the country and transmitted them to Sidon, whence they were shipped to Marseilles. The articles purchased and exported by the French were cotton, both raw and spun, silk, rice, nutgalls, ashes from the desert, bird-lime, senna, and a few other drugs. Hitherto these had been paid for in money, but about this time the French began to import various articles in return" (Robinson's *Biblical Researches*, ii. 483).

For more than a century and a half the French continued to monopolize the whole trade of Sidon, which was then the principal port of Damascus. At length in 1791, the notorious Jezzar Pasha drove them from the city, and since that period its trade has continued steadily to decline. At present the tide of commerce has turned to Beyrout, and Sidon is rarely visited by a foreign vessel. The population of the modern town numbers about 5000 souls, of whom 300 are Mohammedans, 600 Jews, and the remainder Catholic and Maronite Christians. (J. L. P.)

SIEDLEC, or SIEDLCE, a town of Polish Russia, capital of a circle in the government of Lublin, 53 miles E.S.E. of Warsaw. It is the seat of a Roman Catholic bishop; and contains a palace with a park, several churches and schools. Siedlec is celebrated for its bakehouses. Pop. (1854) 7830.

SIEGEN, a walled town of Prussia, in the province of Westphalia, government of Arnsberg, and 40 miles S.S.W. of it, on the River Sieg. There are important mines here; and also manufactories of iron, steel, cotton, and woollen cloth. The town has also a school of mining. Pop. 6928.

SIEGEN, LUDWIG VON, the inventor of mezzotinto engraving, was born at Utrecht in 1609, of an old Westphalian family. After receiving his education at the Collegium Mauritianum in the town of Capel, of which his father was superintendent, he was subsequently appointed a page to one of the princes of Hesse. He discovered the method of mezzotinto engraving between the years 1637 and 1641. On the 19th of August 1642 he sent a letter, dated from Amsterdam, to the landgrave, which disclosed his discovery, containing some proofs of a portrait of his mother done in the newly discovered style. Meeting afterwards with Prince Rupert in 1655 or 1656 at Brussels, after he had entered the military service of the Duke of Wolfenbüttel, he communicated to him his new method of engraving. Rupert brought over the discovery to England in 1660, and showing it to Evelyn, he afterwards got the credit of the invention. Evelyn was then engaged on his *Sculptura*, "to which is annexed a new manner of engraving or mezzotinto, invented and communicated by his Highness Prince Rupert," although in the author's paper, prepared for the Royal Society, the invention was ascribed to a "German soldier." Siegen had a paternal estate near Cologne, from which he took the style of Von Sechten. It is not known when he died. He was still living in 1676. (See Laborde's *Historie de la Gravure en Manære Noire*, Paris, 1839.)

SIENA (anc. *Sena Julia*), a town of Tuscany, capital of a province of the same name, in a barren and dreary plain, 31 miles S.E. of Florence. The immediate vicinity, however, is well planted with trees, and thus the town presents a very fine appearance, as it is approached through fine shady avenues. It stands on the declivities of two hills, and its streets are in consequence in many places very steep, so as to be impassable for carriages. They are also narrow and irregular, generally paved with tiles, and the town has so much declined in importance that many of the streets are quite desolate and overgrown with grass. The houses are for the most part built of brick, and frequently bear the imposing appellation of palaces. But the principal buildings are the churches, foremost among which comes the cathedral. This edifice, built in the eleventh, twelfth, and thirteenth centuries, is one of the most characteristic examples of the Italian Gothic architecture; though producing a somewhat disagreeable effect from the incongruity of its different parts, and the profusion of coloured marble with which it is adorned. In the interior are several good paintings and carvings, a curious inlaid pavement, and a beautiful marble pulpit, the work of

Nicolo de Pisá. Several of the other churches contain valuable paintings. The principal public place, the *Piazza del Campo*, is of a semicircular form, about 1000 feet in circuit, and has a general slope towards one end. Here stands the *Loggia di San Paolo*, celebrated in the middle ages as the seat of a commercial tribunal; and the *Palazzo Pubblico*, with a lofty tower. This building was begun in 1295, and completed in 1327; it now contains the public offices, law-courts, and prisons of the town. The other palaces of Siena exhibit fine specimens of mediæval domestic architecture in all varieties of Gothic style. The university, founded in 1203, has greatly declined from its ancient prosperity. It has a library of about 40,000 volumes, and 5000 manuscripts, some of which are of great value. Among the other public buildings of Siena, are an hospital, a citadel with five bastions, several schools, &c. There are several handsome fountains in the town, and some of the gates are very beautiful. Some manufactures are carried on here, the chief productions being woollen cloth, hats, paper, and leather; and there is some trade in corn and marble. The people of Siena boast of the purity of their pronunciation and accent; and they certainly excel in this respect those of Florence, though retaining some of the harshness of the Tuscan dialect. This town was in the middle ages one of the most celebrated and powerful republics of Italy, and played an important part in the history of these times, when it was the rival of Florence. As the latter city belonged to the Guelph party in the contest between the emperor and the pope, while Siena maintained the Ghibeline cause, or that of the emperor, frequent wars took place between the two cities. In 1258, Farinata degli Uberti, who had been expelled from Florence by the Guelphs, took the command of the troops of Siena, and gained a complete victory over his adversaries at Monte Aperto. At a subsequent period Siena extended its dominions as far as the sea; but it never became a naval power of any importance. During the latter half of the fourteenth century, vehement dissensions took place between an aristocratic and a reforming party in the state, which ended in 1384 in the expulsion of several thousands of the latter. Peace, however, was not restored, either by this victory or by the efforts of Pope Pius II., who visited the town in 1460; civil discords continued to rage, and in 1482 a new revolution took place, and the old popular party was recalled. The government now became more democratic, but not less turbulent or factious than it had formerly been. For a time the ambition and ability of Pandolfo Petrucci raised him to be virtually dictator of Siena, and the republican form of government was enabled to survive that of Florence by the protection of Charles V.; but the people subsequently expelled the Spanish garrison. Fnally, in 1555, the town had to succumb to the arms of Spain, by whom it was handed over to Duke Cosmo of Florence. Since that time it has belonged to the Grand Duchy of Tuscany. Its population at the height of its prosperity was 100,000, but in 1855 was only 25,435.

SIERRA in Spanish, and SERRA in Portuguese, names literally signifying a saw, but applied in geography to numerous mountain-ridges, both in the old and new world. (See SPAIN, PORTUGAL, MEXICO, BRAZIL, &c.)

SIERRA-LEONE, a British settlement on the west coast of Africa, consisting of a peninsula terminating in Cape Sierra-Leone, and bounded on the N. by the river of the same name. The cape lies in N. Lat. 8. 30, W. Lon. 13. 18; and the peninsula is 18 miles in length by 12 in breadth, with an area of 300 square miles. The term Sierra-Leone Coast is applied to a more widely extended region, from Cape Verga to Sherboro Island; but the colony itself is confined to the narrow limits above described. The peninsula is rugged and mountainous, its centre being occupied by a group of conical heights, densely wooded, and rising to the height of 2000 or 3000 feet in the Sugarloaf and Leicester Mountains, which are the loftiest points. Between the various hills lie several ravines and small valleys, while in some places there are considerable tracts of level ground. One of these level tracts lies along the Bunce river, which forms the eastern limit of the colony. This plain is 24 miles in length, and varies from half a mile to 3 miles in breadth. Another lies in the S.E. of the peninsula. Numerous streams descend from the hills, which collect into a basin called the Bay of Franca, celebrated as a watering-place. The Sierra-Leone is more of an estuary than a river; it is 20 miles in length, by 10 in breadth at its mouth. It forms the outlet of the Rokelle, a river which rises at some distance in the interior, and affords a considerable water communication. The range of the thermometer at Sierra-Leone is very small, and the average heat throughout the year is 82°. Excessive humidity characterizes the climate; and sometimes the rain that has fallen in two days has exceeded the yearly average in England. The rains continue for six months, and the torrents which descend from the mountains deluge the plains beneath. The climate is very unhealthy, especially for Europeans. A very dry wind from the north-east, called the Harmattan, generally blows during the months of December, January, and February, and the atmosphere then becomes full of minute particles of sand, which prove very injurious. The land breeze also, which blows regularly in the evening over the low and swampy ground to the east, is laden with noxious exhalations; but the sea breeze in the morning is cool and refreshing. Remittent fevers, dysentery, and inflammation of the liver are the most prevalent forms of disease. There are, however, some periods of salubrity; and the climate is believed to have been recently improving from the clearing and drainage of the land. The prevailing geological formation of the country is volcanic; and the most frequently occurring rocks are granite and iron-stone. The soil is far from being naturally fertile, but it has been made by industrious cultivation to yield many crops of various kinds. The total extent of land under cultivation in 1853 was 9414 acres; and in that year there were raised 35,958 bushels of cassada, 2008 of cocoa, 6313 of maize, 12,528 of ginger, 386 of ground-nuts, 548 of Guinea corn, 3303 cwt. of yams, 13,170 bunches of plantains and 11,672 of bananas, 1542 sugar-canes, 528 pine-apples, &c. The edible fruits of Sierra-Leone are numerous and luscious, including pine-apples, the baobab, or monkey bread, a valuable tree; oranges, plantains, bananas, limes, and many others. The animal kingdom is very abundant, comprising many species of antelopes, monkeys, and other denizens of a tropical country. The live stock in the colony in the year 1856 consisted of 9 horses, 710 horned cattle, 229 sheep, and 743 goats.

Free Town, the capital of the colony, is built upon the south side of the Sierra-Leone river, and at the northern extremity of the peninsula. Immediately in front of the town the river forms a bay, where there is good and commodious anchorage for vessels of all classes, and timber ships of considerable size proceed with facility nearly 20 miles higher up the stream, for the purpose of taking in their cargoes. The town is beautifully situated on an inclined plane, at the foot of some hills, on which stand the fort and other public buildings that overlook it and the roads, whence there is a fine prospect of the town rising in the form of an amphitheatre from the water's edge, above which it is elevated 70 feet. It is regularly laid out into broad streets parallel with the river, and intersected by others at right angles. The buildings are commodious, and substantially built of stone, which at once contribute to the beauty of the place, and to the health and comfort of the inhabitants. Numbers of cocoa-nut, orange, lime, and banana trees are dispersed all over the town, imparting

Sierra-Leone.

to it a peculiarly picturesque appearance. The public buildings of the town comprise several substantial places of worship, missionary institutions, schools, a market-house, custom-house, and jail. There are good meat, poultry, and fish markets; and almost every article of housekeeping can be procured at the shops of the British merchants. The population of the capital may be estimated at 16,000.

The colony is divided into five districts and into thirteen parishes, as follows:—

	Parishes.	Acres.	Coloured Pop. (1851).
Free Town District	1	...	17,929
First Eastern District	2	33,600	5,947
Second Eastern District	2	14,600	7,821
Western District	3	...	5,279
Mountain District	5	16,700	7,400
Total	13	...	44,376

To this must be added, for the total population, 125 white people, making in all 44,501 inhabitants.

Throughout the peninsula several villages have been formed, viz., Leicester, founded in 1809; Regent, in 1812; Gloucester, in 1816; Kissey and Leopold, in 1817; Charlotte, Wilberforce, and Bothwell, in 1818; Kent, York, Wellington, and Waterloo, in 1819. These villages are generally situated in different parts of the mountain, but all are connected by good roads with each other and with the capital. The two Banana Islands, situated to the south-west of Free Town, were ceded to the British Government in 1819, by a family who receive an annual payment for them. Many of the colonists, besides the Europeans, possess considerable wealth. Some of the liberated slaves no doubt retain their habits of indolence, but in general the freed African relishes liberty, and is grateful for the boon conferred on him, and several, by their industry and economy, are said to have acquired considerable property. There were, in 1856, 62 schools, attended by 7903 scholars, besides 4 others for liberated blacks and native children. A large portion of the colony are enjoying, and all have access to, the means of moral and religious instruction. Upwards of one-fourth are regular attendants on the public ordinances of religion. They have built for themselves various and expensive places of worship; some of them are employed as spiritual instructors of their sable brethren; and all together, considering its circumstances, this negro colony is composed of an orderly and well-conducted people. In respect of religion the population is divided as follows:—Episcopalians, 13,863; Wesleyan Methodists, 13,946; African Methodists, 5134; Lady Huntingdon's Connection, 2849; Baptists, 462; Presbyterians, 5; Roman Catholics, 46; Jews, 3; Mohammedans, 2001; and Pagans, 6192. There is a bishop of the English Church, with nine clergymen, supported by the Church Missionary Society; and there are places of worship in almost every village. The Wesleyan Mission has four ministers, and several native missionaries, as well as numerous places of worship. Agriculture has not, indeed, been sufficiently prosecuted hitherto, but matters will improve in this respect when population increases and presses upon the means of supply. The trade of the colony has been fluctuating, but on the whole increasing, for a considerable period, as will appear from its extent at different dates—

Year.	Imports.	Exports.	Tonnage Entered.
1825	L.77,974	L.58,965	23,479
1830	87,251	71,076	26,343
1835	69,301	66,903	17,453
1840	73,989	65,888	19,920
1845	114,475	103,384	23,434
1850	97,890	115,139	26,436
1855	114,910	170,547	38,265
1856	152,907	180,385	35,555

The exports and imports for 1856 were divided among different countries, as follows:—

Countries.	Imports.	Exports.
United Kingdom	L.122,801	L.37,208
Gambia Colony	483	6,254
United States	15,926	52,128
France	8,528	57,758
Teneriffe	135	2
Madeira	248	11
Spain	38	...
Africa, Windward Coast	4,067	14,778
„ Leeward Coast	681	12,246
Total	L.152,907	L.180,385

The principal articles imported were cotton goods, chiefly from this country, to the value of L.65,746; while the most considerable exports were palm-oil and kernals, hides and ground nuts. The exports to other parts of Africa consisted chiefly of cotton goods from this country. In the same year there entered 300 vessels with a tonnage of 35,555, and there cleared 324 with a tonnage of 38,672. The public revenue of the colony in 1856 was L.35,601, and the expenditure L.34,457. The supreme power is in the hands of a governor and a legislative council. English law is in force, and is administered by several courts, the highest judicial authority being in the hands of the chief justice.

The colony of Sierra-Leone was originally established with philanthropic designs, which have as yet only partially succeeded. It was intended at once to sow the seeds of civilization and religion in Western Africa, as an antidote to the slave trade; and to provide an asylum for the many destitute negroes who had obtained their freedom by being brought to England, or had been dismissed from the army and navy at the close of the American war. To Granville Sharp and Dr Smeathman belongs the honour of having first suggested the scheme, and of carrying it perseveringly forward in the face of many difficulties and reverses. The first settlement was made in 1787. Soon, however, misfortune came upon it; for in 1789 one of the neighbouring chiefs attacked and burned the settlement, leaving hardly time for the colonists themselves to escape. They were subsequently collected again in a new settlement; and the Sierra-Leone Company was soon after incorporated under the auspices of Sharp, Wilberforce, Clarkson, and others, for the purpose of re-organizing the colony. A fresh detachment of negroes from Nova Scotia was conveyed hither by the Government, and the settlement of Free Town was founded. It was, however, depopulated by a fever; and soon after, in 1794, plundered by a French squadron. Once more the colony was re-established, and this time with more success, though there were afterwards some internal disturbances, which were only quelled by military interference. Meanwhile, these accumulated disasters had so embarrassed the pecuniary affairs of the company, that it was found expedient to transfer their authority to the crown; and thus, in 1808, the settlement of Sierra-Leone became a British colony. The nucleus had been formed amid many difficulties of a free, civilised, and Christian settlement in Africa; and there can be no doubt that a great moral influence is being exerted on the native tribes by the missionaries who labour in this colony. Since passing into the hands of the crown, the territory of Sierra-Leone has been increased at various times by purchases of land from the neighbouring chiefs.

Sievsk.

SIEVSK, or SEVSK, a town of European Russia, capital of a circle, in the government of Orel, and 73 miles S.W. of that town, on the Seva and the Lake Maritza. It has a rich convent, numerous churches, an ecclesiastical seminary, manufactories of pottery and of verdigris, dye-works, and some trade in corn. Pop. 5768.

Sieyès.

SIEYÈS, Emmanuel Joseph, *Count*, better known as the Abbé Sieyès, was born at Fréjus, on the 3d of May 1748. He was educated for the ecclesiastical profession at the University of Paris, where his mind became early imbued with the various schemes of social and political reform then afloat in society. He consequently entertained very liberal views on a great variety of social problems which were then agitating the public mind. This did not impede, however, his upward progress as a churchman. Having first held some subordinate positions, he was subsequently appointed, in the year 1784, canon of the Cathedral of Chartres. From this position he rose rapidly to be vice-general and chancellor of the diocese. He took an active share in the assemblies of the clergy, and spared no pains in disseminating those views which resulted in the Revolution of 1789. Compelled to assemble the States-General, the question occurred to the government as to what manner that body should be convoked. Whether by classes, as hitherto, or by individuals? Sieyès at once rushed into print, and by his *Essai sur les Privilèges*, 1788, attained to a very wide notoriety. Partially satisfied with the amount of success which had attended this pamphlet, he resolved to publish another *brochure*. The second, and by far the most remarkable, pamphlet, had for its title *Qu'est ce que le Tiers Etat?* 1789. The doctrines which the adventurous Abbé set forth were, that the *Tiers Etat* was really the nation, and yet it had possessed hitherto no adequate recognition in the state. Such a recognition the Abbé humbly thought it required; nay, demanded. Hence the appearance of his pamphlet. This bold ecclesiastic resolved to write a third pamphlet, the same year. This one had for its title *Moyens d'Execution dont les Representans de la France pourront disposer*, 1789. He gave all these publications to the French people from behind a very thin gauze of anonymity. When the rude eyes of the Parisians were turned with an impatient curiosity to discover who was the good author who had made bold to speak a word in behalf of the *Tiers Etat*, the thin curtain speedily disseminated like a fog-cloud before the sun. The thin Abbé was descried in the back-ground making his obeisance of affected humility before the French people. The States-General being convoked, Sieyès was chosen deputy for Paris. A majority of the noblesse and clergy refused to unite with the Tiers Etat, when Sieyès, after incredible speechifying, succeeded in inducing the people to form themselves into an independent body, under the name of the *Assemblee Nationale*, June 16, 1789. He it was, also, who proposed the oath taken by all the members at the Jeu de Paume—"Never to separate, but to assemble wherever circumstances required, until the perfect establishment of the constitution." Despite the vehement opposition of Mirabeau, "Mahomet," for so Sieyès was dubbed by the great orator, carried his proposal by an immense majority. Sieyès's vanity was puffed up to an incredible height. The Assembly rose up to receive him, and the meek Abbé was cheered vociferously. On the 23d of June the king declared the proceedings of the Assembly null and void, and ordered them to disperse. "Disperse! we are the same to-day we were yesterday; let us deliberate;" said the fearless Sieyès. The Assembly listened to his words, and the Revolution was the result. It was at Sieyès's instigation the ancient provinces of France were abolished, and the realm was divided into 80 departments. The Abbé's seat was by no means secure, however. When the awe created by the sharp, logical vehemence of his appeals had passed away, there were more than one in the National Assembly prepared to challenge his opinion. His despotic will could brook no contradiction, and he sank into sullen silence, from which even the taunts of Mirabeau could not arouse him. He broke silence once on the question of tithes, and the determined vehemence of his manner was evidently increased by his long quiet. This speech well-nigh cost him his popularity. Its concluding words will long be remembered. He had accused the Assembly of enriching the wealthy proprietors of land by the gratuitous addition of one-tenth of its value, and added, "they wish to be free, and know not how to be just." In his further altercation with the Assembly, Mirabeau remarked to him, "You have unloosed the bull, and you complain that it gores you." In the new Legislative Assembly he was chosen member for Paris, but cautiously declined the honour of being made constitutional bishop. He was deputy for the department of La Sarthe in 1792, but preserved a sullen silence throughout the greater part of their deliberations. Different accounts are given of his conduct on the verdict which sentenced the king to death. The most authentic is that given by Carlyle, among others, in his *French Revolution* (vol. I., p. 113, of 1856). "Then see," says the imaginative historian, "the figure of shrill Sieyès ascend; hardly pausing, passing merely, the figure says, *La mort, sans phrase*, 'death without phrases,'" flinging a sarcasm at Robespierre and company, who had wearied the Assembly by their long-winded addresses. During the succeeding period of the Reign of Terror, the cautious Abbé prudently retired to the country, where he contrived to "live," as he wittily phrased it, during that stormy time.

Sigismund || Signa.

In 1797 he had his hand shattered by a pistol-ball fired at him by the Abbé Poule. He told his servants afterwards, "if Mons. Poule should return, inform him that I am not at home." In 1798 this constitution-builder was sent to Berlin, on a fruitless mission, by the French Government, and on his return to Paris was made member of the Directory. Shortly after he effected the closing of the notorious Jacobin Club, which sealed the unpopularity of the author of *Tiers Etat*. Tired of declamation, what we want, he said, is a "head and a sword." Sieyès got both, sooner, perhaps, than he expected, in Napoleon Bonaparte. The little Corsican looked quite through Abbé Sieyès at the first glance. They feared and hated each other heartily, yet each was meanwhile necessary to the other. On the 9th November 1799, both were chosen Consuls along with Ducos. Sieyès was again busy with his visionary, logical theories of the constitution, when Napoleon watched his opportunity and extinguished this luminary for ever. Sieyès retired in disgust, on a rich allowance of 600,000 francs, and the estate of Crosne, which he subsequently exchanged for a magnificent hotel in Paris, and the valuable lands of Faisanderie. He received the title of Count from Napoleon, and at the Restoration he was exiled. Returning again to Paris in 1830, he lived in obscurity till the 20th of June 1836, when he died. The chief works of this architect of constitutions are, *Preliminaires de la Constitution*, 1789; *Observations sommaires sur les biens Ecclesiastiques*, 1789; *Reconnaissance et Exposition raisonnée des droits de l'homme et du citoyen*, 1789, &c. His life has been carefully traced by Beaulieu and Capefigue, in the *Biographie Universelle*; and notices of him, of more or less merit, will be found in the various histories of the French Revolution. His character has been hit off in a sentence, as usual, by Carlyle. "Behold him, the light, thin man; cold but elastic, wiry; instinct with the pride of logic, passionless, or with but one passion, that of self-conceit." "Polity," said Sieyès to Dumont, "is a science I think I have completed." Alas, no! good Abbé; it is to be feared that science has not yet been completed.

SIGISMUND. See Austria and Poland.

SIGNA, a village of Tuscany, on the right bank of the Arno, 7 miles W. of Florence. It contains a castle, church, and school; and is remarkable for the manufacture of straw-bonnets, which are reputed the best made in Tuscany. Pop. 5500.

SIGNALS, Naval. See Seamanship.

SIGNATURE, in printing, is a letter put at the bottom of the first page at least, in each sheet, as a direction to the binder in folding, gathering, and collating them. The signatures consist of the capital letters of the alphabet, which change in every sheet; and if there be more sheets than letters in the alphabet, a figure is placed before the signature, as 2 A, 2 B, &c., which are repeated as often as necessary.

SIGNET, one of the king's seals, made use of in sealing his private letters, and all grants that pass by bill signed under his Majesty's hand. It is always in the custody of the Secretaries of State.

SIGNORELLI, Luca, a famous Italian painter, was born at Cortona, in 1440. He was nephew to Lazzaro Vasari, and kinsman to the historian of art, Georgio Vasari. He studied art under the care of Piero della Francesca at Arezzo, where he lived with his maternal uncle Lazzaro. Few of his paintings now remain. His most celebrated work was the fresco of the "Last Judgment," in a chapel at Orvietto, which had been begun in 1447 by Fra Giovanni da Fiesole, and was completed by Signorelli probably about 1503. The execution of the naked figure in these elaborate designs has been very much admired; and Vasari says, that Michael Angelo did not refuse to make use of Signorelli's invention in his delineation of the forms of angels and demons in his grand painting of the "Last Judgment" in the Sistine chapel. He retired to his native place, where he spent the evening of his days in honour and tranquillity. He died in 1521, aged eighty-two.

SIGONIO, Carolo, better known under the Latinized form of his name, Carolus Sigonius, an eminent historian and antiquary, was born at Modena in 1520. He was pupil and successor to Franciscus Portus in the chair of Greek literature at Modena. Having subsequently become widely known by his publications on classical antiquity, he had various invitations to occupy the professor's chair at different university seats. He professed belles lettres at Venice in 1552, from which place he removed to Padua to the chair of eloquence in 1560. Here he met his old literary foe Robortello, who disputed with him on the names of the Romans, till the Senate of Venice had to silence the combatants. From Padua Sigonio removed to Bologna, where he received a handsome income, and where he attracted, by the accuracy and thoroughness of his instructions, many students to that university. Having discovered some fragments of Cicero, he undertook surreptitiously to restore the *De Consolatione* of that author. So successfully had he imitated the style and mode of thought of the Roman, that the work long passed for genuine, till his pupil, Riccoboni, exposed the trick. Sigonio retired to the neighbourhood of his native town, where he died in 1584. He left behind him a great reputation as an elegant scholar. To him more recent authors have been more indebted than perhaps they would be willing to own. His numerous writings were collected by Argellati, Milan, 6 vols., 1732–1737, to which is prefixed a life of the author by Muratori. A list of his works will be found in the *Thesaurus* of Graevius and Gronovius, and in the *Biographie Universelle*, vol. xlii.

SIKKIM, a petty state of India, under British protection, bounded on the N. and E. by Thibet, S.E. by Bhotan, S. by Darjeeling, and W. by Nepaul. It lies between N. Lat. 27. 5. and 28. 3.; E. Long. 88. 2. and 89. Length from north to south 66 miles, breadth, 52; area, 1670 square miles. The state is governed by a rajah, who has been in alliance with the British since 1814. The chief productions of the country are cattle and iron. The culture of the tea-plant has been introduced here by the British. Pop. 61,766.

SILESIA (Germ. *Schlesien*), a province of the Prussian monarchy, lying between N. Lat. 49. 40. and 52. 8.; E. Long. 14. 25. and 19. 15.; bounded on the N. by the provinces of Brandenburg and Posen, E. by Polish Russia, S. by Austrian Silesia, S.W. and W. by Bohemia and Saxony. Length from N.W. to S.E. 210 miles, breadth from 70 to 80; area, 15,720 square miles. Along the south-west frontier runs a range of mountains, called the Sudetes, which here divide the Prussian from the Austrian dominions. From these the country descends in a gradual slope towards the north-east; and the Oder divides it lengthwise into two nearly equal parts; that on its left bank, called the German side, being more mountainous; and that to the right, or the Polish side, more flat. The Sudetes present for the most part a very uniform appearance, consisting of long ridges, covered with forests, and having here and there isolated peaks, of a rounded or dome-like appearance. There are many pleasant valleys among these mountains; and several passes across them. The two principal groups of the Sudetes are the Riesen Geberge, near the north-west; and the Glatz Mountains, towards the south-east extremity of the chain. Of the former, the highest point is the Riesen Koppe, 5060 feet high; the latter is divided into several distinct ridges, and reaches the elevation of 4354 feet in the Schneeberg, its highest summit. Besides these there is an isolated mountain called the Zobten, 2246 feet high, at the foot of the latter group. There are no hills of any size on the other side of the Oder; but the land, though flatter, is not by any means so fertile as that which lies among the mountains on the south-west, and the land which slopes down from them to the river. The Oder, the only great stream in Silesia, enters the province from Moravia, in the south-east, and is navigable for small boats as far as Ratibor. Its banks are in general low and uniform; but in the upper part of its course it is bordered by mountains and oak-forests; while at various points lower there are hills covered with vines. The principal affluents of the Oder in Silesia are, on the right, the Klodnitz, Malapame, Stober, Weida, and Bartsch; and on the left, the Silesian Neisse, Ohlau, Weistritz, Katzbach, and Bober. A small portion in the extreme south-east of the province sends its waters to the Vistula; but with this exception, the whole waters of the province flow by the Oder into the Baltic. There are few lakes, and these not of any great size. Silesia is not, on the whole, so well cultivated as some other parts of Prussia, and does not produce a sufficiency of corn for the domestic consumption. The extent of arable land in the province, in 1852, was 4,418,522 acres; of gardens and vineyards, 133,028 acres; of meadows and pasture land, 785,531 acres; of forests, 2,313,402 acres; and of waste land, 2,976,383 acres. Wheat is extensively grown here, especially on the land to the east of the Oder. This crop is more cultivated in this than in any other province of Prussia. Oats, barley, rye, pulse, and potatoes, are also raised. Flax, hemp, rape, and madder, are produced here more largely than in any other province. Vines are cultivated only in a few places. Considerable attention is paid to pastoral pursuits; and large numbers of live stock are reared. In the year 1855, there were in Silesia 190,647 horses, 7586 mules and asses, 965,643 horned cattle, 2,431,687 sheep, 48,867 goats, and 127,058 pigs. The mineral productions of Silesia are of considerable importance. Gold and silver are found here to a small extent; but the principal wealth of the land consists of the more useful, though less valuable, metals. Iron is found in considerable abundance; zinc comes next in point of amount, while smaller quantities of copper, lead, &c., are also obtained. The province contains mines of coal, quarries of marble, granite, and sandstone. The minerals of the country are found chiefly in the upper portion; while it is in its middle and lower parts that manufacturing industry is most actively carried on. In 1852 there were in the province 10 establishments for spinning flax and hemp, 51

linen manufactories, 8 cotton factories, 170 woollen factories, 56 paper mills, 40 tanneries, 58 tobacco factories, 49 sugar-houses, 1501 breweries, 1517 distilleries, 227 iron-works, 21 machine factories, 27 glass-houses, and 39 manufactories of earthenware and porcelain. The inhabitants are very industrious, especially those of German origin (for a large number of the people are of Polish extraction), and most of the men are employed in weaving, and the women in spinning. Besides the river, there are additional means of communication furnished by many good roads, and by several railways; the chief of which are the Lower Silesian Railway, from Berlin to Breslau, and the Upper Silesian Railway, from Breslau to the Austrian frontier, with other smaller lines and branches. In respect of religion, the population belongs, in nearly equal numbers, to the Roman Catholic and Protestant faiths; the latter numbering, in 1855, 1,617,943, and the former 1,528,300 adherents. Besides these, there were in the same year 36,217 Jews, and a small number of Greeks and Mennonites. The provision made for popular education is considerable, and the proportion of the inhabitants sufficiently educated is somewhat above the average of the provinces of the kingdom. There is a university at Breslau, with 49 professors, and 842 students, in 1852. The province has also 21 gymnasiums and 1 progymnasium, 6 normal seminaries, 46 middle schools, and 3847 public elementary schools, with 497,697 scholars. The history of Silesia contains no events of any interest until we come down to the middle of the last century. In the tenth century it came under the dominion of the Polish sovereigns; and in 1163 was divided into three parts, under three independent dukes or princes. Subsequently the country was split into many smaller portions, and thus reduced to such a state of weakness that the several princes were by degrees induced to put themselves under the protection of the king of Bohemia. Thus, in 1526, Silesia became a part of the inheritance of the house of Austria, and remained such till the time of Maria Theresa. By the treaties of 1742, 1745, and 1763, Silesia was ceded to Prussia, having been conquered by Frederick the Great in the Seven Years' War. It is at present divided into the three governments of Oppeln, Breslau, and Liegnitz, nearly corresponding to the divisions of Upper, Middle, and Lower Silesia. Its population, in 1855, was the following:—

	Pop.
Oppeln	1,014,383
Breslau	1,227,009
Liegnitz	941,104
Total	3,182,496

Silesia, Austrian. See Austria.

SILHET, a district of British India, in the presidency of Bengal, lying between N. Lat. 24. 3. and 25. 12.; E. Long. 91. and 92. 38: bounded on the N. by the land of the Garrows and the district of Jynteah; E. by the district of Cachar; S. by Independent Tipperah; and W. by the districts of Mymensing and Tipperah. Length from E. to W. 102 miles; breadth, 80; area, 3532 square miles. It forms a vast basin, enclosed on three sides, the north, east, and south, by mountains, and only open towards the Brahmapootra, which receives the rivers of the district. The largest of these is the Soormah, which is navigable, except during the dry season, as far as Silhet, the capital of the district. The low country between the mountain-ranges is undulating, and contains many alluvial tracts; but it is for the most part very marshy. Even in the loftier portions there are some marshes, though of less extent. A great part of the country is occupied by forest and jungle. The climate is moist, and not very healthy, and the soil is not suited for many kinds of crops, though there are extensive pastures, on which large numbers of live stock are reared. Butter, cheese, and hides, along with grain, form the chief articles of export. The only manufactures are a few coarse cotton cloths, mats, and baskets. The population is 380,000, of which about three-fifths are Brahminists, and the rest Mohammedans, there being very few Christians. The only place of importance in the district is Silhet, the capital, which is rather a large straggling village, 120 miles N.E. of Calcutta.

SILISTRIA, a town of European Turkey, Bulgaria, capital of an eyalet of the same name, one of the strongest fortified places on the Danube, stands in the angle formed between that river and its confluent the Dristra, 66 miles N. by E. of Shumla. It is semicircular in form, and for the most part meanly built, consisting of narrow, crooked, and dirty streets, lined with low and gloomy houses. The public buildings are—numerous mosques, a large Greek church and convent, public baths, barracks, a custom-house, and bonded warehouses. The inhabitants are principally employed in weaving, tanning, and gardening. Some trade is carried on in cattle, wool, and timber. The fortifications are strong and solid; and the place is defended by several admirably constructed detached forts. Silistria was taken by the Russians in 1829, after a siege of nine months, and it remained in their hands for some time, but was afterwards restored to Turkey. Again, in 1854, the town was attacked by the Russians; but the Turkish garrison, aided and directed by two British officers, made such a brave defence, that the assailants were obliged to raise the siege. Pop. 23,000. (See Russia, § History.)

SILIUS ITALICUS, Caius, a celebrated Roman poet, and author of the *Punica*, an epic poem in seventeen books, which contains a history of the second Punic war, was born in the reign of Tiberius, probably about A.D. 25, and is supposed to have derived the name of *Italicus* from the place of his birth; but whether he was born at Italica in Spain, or at Corfinium in Italy, which, according to Strabo, had the name of Italica given it during the Social War, is a point which is unascertained. When he came to Rome, he applied himself to the bar; and, by a close imitation of Cicero, succeeded so well, that he became a celebrated advocate, and a most accomplished orator. His merit and character recommended him to the highest offices in the republic, even to the consulship, of which he was possessed when Nero died. He is said to have lent his assistance in accusing persons of high rank and fortune, whom that wicked emperor had devoted to destruction; but he retrieved his character afterwards by a long and uniform course of virtuous behaviour. Vespasian sent him as proconsul into Asia, where he behaved with great purity and unblemished reputation. After having thus spent the best part of his life in the service of his country, he resolved to consecrate the remainder to retirement and the muses. He had several fine villas in the country; one at Tusculum, celebrated for having been Cicero's, and a farm near Naples, said to have been Virgil's, at which was his tomb, which Silius often visited.

He has imitated Virgil; and though he falls greatly short of him, yet he has displayed a very great amount of talent, which would have enabled him to succeed in some degree in whatever he undertook. Having been for some time afflicted with an imposthume, which was deemed incurable, he grew weary of life, to which, in the language of Pliny, he put an end with determined courage, by slowly starving himself. This occurred about A.D. 100. There have been many editions of Silius Italicus. A neat and correct one was published at Leipsic in 1696, in 8vo, with short and useful notes by Cellarius; but the best are those of Drakenborch, 1717; of Mitau, 1775; of Ernesti, 1791; and of Ruperti, 1795–98. The *Punica* has been translated into English by T. Ross, 1661; and into French by Le Febvre de Villebrune, 1781.

SILK. Under the head SILK-WORM, will be found an account of the first introduction of the insect, and the commencement of the manufacture in the western empire. From thence it spread into Sicily and Italy; and during the time that the French occupied Milan (1521), artizans were conveyed by Francis I. to Lyons, and under his protection the manufacture of silk made great progress.

When the Duke of Parma took and plundered the city of Antwerp in 1585, a great proportion of the merchants and artizans took refuge in England; these introduced the silk manufucture into this country, which was fostered and encouraged by the English government. Before this period the produce of the silk-worm had been little seen in England.

The climate of England has not been found favourable for the rearing of silk-worms: repeated attempts have been made to cultivate the breed with profit, but they have always failed. It was supposed that the British settlements in America would prove more favourable for this purpose, and in several of them the experiment was made; but though a large quantity of excellent silk was produced, the business of planting mulberry-trees and rearing worms in the northern United States having been made the basis of a monstrous stock exchange speculation, and consequent ruin to many, the whole effort has become nearly abortive, for the present at least.

The manufacture of silk goods has been the object of solicitous care to the British government, and various enactments were made by successive monarchs, with the view of encouraging it in this country. It received a great stimulus in 1685, when the revocation of the edict of Nantes banished from France multitudes of her most industrious and skilful artificers, which greatly benefited the countries that sheltered the injured emigrants. About 70,000 took refuge in England and Ireland, and transplanted various branches of the useful arts to different districts of this country. A large body of silk-weavers settled in Spittalfields, where descendants of many of them may still be found.

England was, however, entirely dependent on foreigners for organzine silk thread, till Mr Lombe of Derby, in the year 1718, having gone to Italy in the disguise of a common workman, took drawings of the silk-throwing machinery in Piedmont, and, on his return, erected a large mill on the river Derwent at Derby. The extensive and powerful machinery of this mill contained 26,586 wheels, and 97,746 movements, which worked 73,726 yards of organzine silk thread, by every revolution of the water-wheel, which revolved three times in the minute, and thus produced 318,504,960 yards of organzine per day. The same amount of motive-power employed upon the beautiful, compact, and simplified throwing machinery now at work at Derby and elsewhere, would bring out far greater results both in quantity and quality.

The silk manufacture continued to increase in England, though the workmen were constantly clamouring against the importation of foreign goods. With a view to encourage the manufacture, an act was passed (3 Geo. I. cap. 15) for granting bounties on the exportation of silk fabrics; this was, however, no more than a drawback of part of the duties paid on the importation of the raw silk. In 1741, permission was given to the Russian Company to import the raw silk of Persia at the same rate of duty as from the Levant; and, in 1749, the same reduction was made on the duties on raw silk imported by the East India Company from China. In 1764, the fashion of the times running in favour of French silks, and the wages of the English weavers being low, and work scarce, the operatives assembled in great multitudes, and in a tumultuous manner presented petitions to Parliament, praying for the total prohibition of foreign wrought silks. By the representation which the operatives made of their sufferings, Parliament was induced to reduce the duties on raw and thrown silk, and entirely to prohibit the importation of certain articles of manufactured silk goods. The operative weavers did not, however, derive those benefits from the prohibitions against importation which they expected, and they had frequently recourse to combinations to force their masters to raise their wages. These disputes between the masters and workmen having led to violence and riot, an act was passed in 1773, and confirmed by two subsequent acts, empowering the aldermen of London, and the magistrates of Middlesex, to fix the wages of the Spittalfields weavers. But it is unnecessary to recapitulate the applications of the operatives and manufactures for protection against foreign competition, and the attempts of the legislature to encourage the manufacture by restrictive and prohibitory enactments from 1773 to 1824; the silk trade in England, from the futile attempts to bolster it up, was kept in an artificial and languishing state. The manufacturer, depending upon the protection of parliamentary restrictions on foreign competition, rather than on his own skill and exertions, was not anxious to discover and introduce improvements into the manufacture. Since the change of system, the imports of the raw material, and the exports of the manufactured article have rapidly increased. In 1825 there

Table of Imports and Exports of Silk to and from the United Kingdom in 1856, 1857, *and* 1858.

Imports—Year ending 31st Dec., as per landing accounts.	Within these years respectively.			Being of real value computed.		
	1856.	1857.	1858.	1856.	1857.	1858.
	lb.	lb.	lb.	L.	L.	L.
Silk, Raw—						
From China	3,723,693	6,664,532	2,011,186	3,198,190	5,571,149	1,672,128
„ British East Indies and Egypt	3,124,778	4,678,415	3,652,617	2,625,611	4,860,554	3,324,269
„ Other Countries	535,201	734,984	613,773	571,385	1,170,633	794,819
Total	7,383,672	12,077,931	6,277,576	6,395,186	11,602,336	5,791,216
	lb.	lb.	lb.	L.	L.	L.
Silk, Waste—Knubs & Husks	2,015,211	2,316,160	1,877,680			
	lb.	lb.	lb.			
Silk, Thrown—						
From France	331,048	289,800	124,129	541,454	594,498	207,031
„ China	428,553	262,494	185,990	330,150	287,377	170,346
„ Other Countries	93,414	88,642	48,150	167,937	188,090	80,489
Total	853,015	640,936	358,269	1,039,541	1,069,965	457,866
	lb.	lb.	lb.	Entered, Home Consumption.		
Silk Manufactured Goods—						
Of Europe—				lb.	lb.	lb.
Broad Stuffs, Silks or Satins	230,568	204,297	277,163	229,288	197,550	270,914
Broad Stuffs, Gauze, Crape, and Velvet	39,529	27,598	32,762	38,294	26,282	31,681
Ribbons, all kinds	463,780	375,890	383,619	[441,421	363,159	376,562
Plush for Hats	170,936	118,368	134,106	170,818	118,717	133,738
Total	904.813	726,154	827,650	879,821	705,708	812,895
	Pieces.	Pieces.	Pieces.	Pieces.	Pieces.	Pieces.
Of India—						
Bandannas, Corahs, Choppas, Tussore, Remals, and Taffeties	601,461	370,295	207,081	108,193	93,014	83,012
The silk in 1858 paid in customs duties, L.270,536.						

were at most 24,000 English silk looms employed. In 1855 at least 110,000, using 5,400,000 lb. of thrown silk, and producing goods valued at L.8,800,000, besides spun-silk and mixed goods of uncertain amount. The English consumed in 1855 of her own silk goods, L.7,200,000; and imported L.4,000,000. In 1856 the probable returns of the English silk manufactures were L.11,000,000. In 1857 L.19,000,000. In 1858 (a year of panic) L.10,000,000. 1859 will be about L.14,000,000.

Nothing more fully demonstrates the folly of attempting to encourage manufacturers by prohibiting importation than the history of the silk trade. The greatest importation of raw and thrown silk which took place in any one year, previous to the repeal of the prohibitory system, was in 1833, when the quantity imported was 2,432,286 lb.; while, by the foregoing table, it appears that 11,266,820 lb. were imported, on an average of the years 1856, 1857, 1858, at the same time that the official value of our silk manufactures exported during the same period was L.140,520 during 1823, and L.1,622,270 on the three years average, together with L.1,027,220, the average annual value in 1856, 1857, 1858, of English thrown silk and spun-silk exported. The larger proportion of both classes was to France. Total of silk manufactured goods exported from England in 1844, L.736,455; in 1858, L.2,391,506.

Table of Exports and Imports of Silk—continued.

Exports—Year ending 31st Dec.	1856.	1857.	1858.	Declared Value. 1856.	1857.	1858.
	lb.	lb.	lb.	L.	L.	L.
Silk—						
Raw	1,438,598	1,706,625	2,314,519			
Waste Knubs, Husks	62,944	105,168	272,048			
Thrown (foreign)	282,705	238,529	364,680			
	lb.	lb.	lb.			
Silk Manufactures—						
Europe	21,966	21,682	18,092			
	Pieces.	Pieces.	Pieces.			
India	396,316	324,664	227,139			
	lb.	lb.	lb.			
Silk Manufactures, English—						
Stuffs, Handkerchiefs, and Ribbons	665,218	624,894	489,709	773,389	803,502	603,699
Other articles, Silk only (entered at value)	...	...	...	557,362	479,115	328,710
Do. mixed with Silk	...	...	...	427,906	520,593	372,536
Total	...	...	...	1,758,657	1,803,210	1,304,945
	lb.	lb.	lb.	L.	L.	L.
Silk—						
Thrown (English)	841,553	641,204	551,281	907,480	769,897	563,002
Twist and Yarn (do.)	602,859	577,116	442,641	295,919	316,722	228,644
Total	1,444,412	1,218,320	993,922	1,203,399	1,086,619	791,646

All silks are now imported *free of duty*.
Manufactures of silk pay *an average* of 15 per cent. duty on importation.

It is an inquiry of great interest, what may be considered a fair approximation to the amount of silk produced in various countries of the world, and from which English manufacturers must seek their supplies. We shall endeavour to give reliable figures, so far as enabled to collect them, confining ourselves to weights rather than the excessively fluctuating values. The inferences which must be drawn by a due comparison and estimate of them, are exceedingly important in regard to the future extent and profitable employment of labour and capital in European silk business, especially that of the United Kingdom.

There are few of the four hundred millions of its population, except the lowest classes in China, but what are clad in silk garments. The weight or value of the silk thus produced for home consumption is unknown. The exportation to England from 1795 to 1810, averaged in sixteen years 85,810 lb. per annum; from 1810 to 1822 inclusive, twelve years, 164,166 lb.; 1830 to 1841, eleven years, average was 808,000 lb. The export from China in 1858 was 78,154 bales, equal to about 9,376,000 lb. weight of silk. The average of English imports of China silk for 1856, 1857, 1858, was 4,133,100 lb. No doubt, inasmuch as in all China proper, except the northernmost districts, silk is grown, its power of extended export is indefinite. The price has as yet gradually increased with the surprisingly enlarged demand. The China silk production and reeling is almost entirely a peasant one.

The production of "filature" silk under the management of the East India Company, was from 15,723 reeling basins, in 12 principal silk factories; the cocoons being produced by "ryots" (peasants), and paid for at prices fixed by the company's agents. Private traders at length were permitted to enter into this business. At present it is altogether an ordinary commercial operation, except that the company lay a double tax on land used for the growth of mulberries. In 1750 England imported 80,000 lb. Bengal raw silk; 1795 to 1809, an average of 401,600 lb. a year; 1810 to 1820, 814,600 lb. The average import of the years 1856, 1857, 1858, from Bengal (including a small amount from Egypt) into England was 3,818,666 lb., of the annual value of L.3,603,000. How the intrinsic value per lb. might be raised is shown elsewhere in this article. The supply might certainly be made an unlimited one with great advantage both to India and England.

How much raw silk of commerce is consumed in India is not known, probably not much. Tussah and other wild silks are used immensely. In Cochin-China and Siam, there is a considerable production of silk. Of the amount we have no reliable statement. The like may be said of Japan; from which country, however, at the time of writing, we learn that a shipment of 1000 bales of strong coarse silk is on its way to this country. It is said, on fair authority, that the price amongst natives of these countries is from 5s. to 6s. English per pound weight. In the Island of Madagascar silk-worms of great size are fed in open fields on pigeon-pea (ambiravatry) and give very large cocoons.

Persia grows silk for home use largely, and exports considerably. The imports into England from 1830 to 1840, was, on average, 125,000 lb. a year. This amount is now increased. The quality is low, being ill reeled and irregular. From Asia-Minor a silk is exported to England and France in large quantity, because of its rapidly improved manipulation of the cocoons (which are of unsurpassed excellence, and largely importing now into France), in reeling into skeins of small instead of large circumference. Of Brutia "old long reel" we imported 251,850 lb.; and of "new short reel," 319,000 lb.; making a total of 570,850 lb. annually, on an average of ten years ending 1840. The actual production is about 1,200,000 lb. per annum, of which England uses 500,000 lb. It is computed that in 1836 Syria produced 856,800 lb., and Asia 132,000 lb.; Cyprus and Crete about 50,000 lb. Tripoli produced in 1842 45,000 oques, or 126,000 lb. English of silk, worth 20s. per oque. Of the produce of Turkey in Europe no exact account can be given. The government levies 20 per cent. or more on silk exported, and prohibits export of

cocoons. The Morea produced, in 1824, 71,000 oques, or 200,000 lb. English of silk, inferior in quality. The average amount of silk raised in Hungary was lately estimated at more than 200,000 lb. yearly, produced in 40 localities, and from a million and a half of mulberry-trees. In Poland, and even in Russia, silk is produced, but at present in small quanties. Spain produced in 1842 about 2,000,000 lb. weight of silk, three-fifths of which was obtained in Valencia, and one-fifth each in Murcia and Granada. The Catalonians used 400,000 lb., and there were exported 1,400,000 lb. The cocoons are excellent, and may be exported free. Peasant reeling is very irregular; and raw silk resulting from it, not of even and clean quality. The growth of silk might be greatly extended; for the otherwise barren soil of many tracts in Spain could be made, with little trouble and expense, to grow mulberry-trees, and to vast advantage. As the Valencia silks, where reeled skilfully, are of magnificent quality, and the stuffs manufactured from them command high prices and ready sale, there only needs capital and internal tranquillity to make Spain a far greater silk-producing country than at present.

The Milanese has long been a large field for the cultivation of silk. In 1825, we took an account of the basins reeling silk (averaging 1½ lbs. per day, for about 100 days, included in the reeling season, if by proprietors of filatures, and 1 lb. by smaller producers), and were enabled to enumerate 20,395 basins, which, in that year, gave 2,652,000 lb. raw silk, value L.2,387,000; probably, 4000 or 5000 basins were not seen. In 1800, 1,800,000 lb. of raw silk was said to have been collected. But, in 1858, the quantity was believed, by Italian silk dealers, to have been increased threefold at least—say 5,400,000 lb.; and the money value certainly would be fivefold in amount to that paid for this article to the Lombard growers in 1800. Nearly all was exported in 1825; 2400 looms only being at work in Milanese. At present, a larger proportion is consumed in the territory where grown. In 1825, Piedmont produced 1,440,000 lb., of a superior quality, all things considered, to any other silk, except that of the Cevennes, France. The greater part is thrown now, as then, and exported to Germany, France, and England. The present weight of Piedmontese silk grown is not known to us. A very large amount is of white colour (*Novi*), and a larger worm is bred, and produces cocoons so large as only to require 100 to 120 to the pound. Tuscany, the Romagna, Naples, and Calabria, produced, in 1825, 1,500,000 lb. of raw silk, from very excellent cocoons; but reeled with various degrees of care and success. Amongst them, Fossombrone is a celebrated quality. The Royal Neapolitan Filature produces superior silk. Calabrian stands low in the scale of quality. The "*Annuario Statistico Italiano*," of 1858, estimates the total Italian production to be of the annual value of L.8,000,000 sterling to L.10,000,000 sterling. But this must be much below the real amount. The selling price of all raw silk has been for several years 50 per cent. higher than in 1825, when, undoubtedly, the value of the Italian production was at least L.6,000,000 sterling. The increased quantity grown in Lombardy alone would therefore raise the total annual value of Italian silk beyond L.10,000,000 sterling. From an official source we learn, that, in 1851, the Austrian dominions produced L.4,340,000 sterling, in raw silk, and L.2,840,000 sterling, in manufactured silks, making a total of L.7,200,000 sterling. This total had been raised, in 1855, to L.12,000,000. The increase must have included a large proportion of Milanese raw silk. This advance in quantity is to be attributed to the great excellence attained by reelers in the north of Italy. Prussian silk manufacture has rapidly increased. In 1831, the number of looms was 8956; in 1837, 14,111; in 1855, there were nearly 25,000.

It may here be stated, that, in the Swiss cantons, Basle and Zurich, the looms, chiefly alimented with silk from Northern Italy and Bengal, and which, in 1851, were under 30,000, had increased, in 1855, to 40,000, and produced about L.4,000,000 sterling of manufactured goods; importing the raw materials, and exporting nearly all the stuffs produced (which are amongst the best in the world), without intervention, or protection, premiums, or custom-houses. The Zollverein exports ribbons and broad silks largely to France. In 1854, in those states, 1,600,000 lb. weight of raw silk, worth L.1,760,000 sterling, was worked up, on 40,000 looms, into L.3,055,000 sterling of articles of silk entirely, and 1,050,000 lb. weight of mixed materials. The silk business of France is one of its most important sources of agricultural wealth, in the growth of the mulberry, of domestic employment in tending the caterpillars, and of factory capital, skill, and labour, in breeding worms, on the larger scale; as also in reeling and throwing raw silk. Subsequent processes in weaving, dyeing, &c., are alike extensive and valuable.

The report of French jury, in 1855, makes the following remarks:—"Every day shows more and more the advantage to *the health of silk-worms*, of breaking up the large establishments for breeding silk-worms (*Magnaneries*); *i. e.*, returning to peasant or small "*recolts;*" and, on the other hand, of improving the reeling of cocoons and throwing of silk, by increasing the size of establishments for those purposes. It is now incontestible, that small separate growths of cocoons produce more cocoons, and of superior quality, while the excellence of the silk from them is greatly promoted by cessation of domestic reeling. In both these respects, Piedmont and France are making great progress, followed very closely by Lombardy. In each, the growth of the mulberry, species of worms and their management, together with the arts and mechanism for reeling and throwing silk, are receiving successful attention." In 1789, France produced 1,000,000 lb. of raw silk. In 1812, 590,750 lb. raw, and 342,000 lb. organzine; total, 932,750 lb., worth L.1,000,000 sterling; and imported 900,000 lb., valued at L.1,350,000; in 1825, 1,600,000 lb., worth L.1,750,000. From henceforth, about half was produced by peasants. The French consumed, this year, L.3,000,000 lb. Looms, which had been in seven of the principal towns, 27,432 (in Lyons, 10,720) in 1812, had become in Lyons alone, in 1824, 24,000. These increased, so as that, in 1839, Lyons employed 40,000 looms, and 80,000 workmen. The whole of France, 84,648 looms, and 169,280 workmen, and the same number of assistants. The produce was a return that year of L.4,000,000 sterling at Lyons; that of the whole of France being L.9,260,000 sterling. Of this sum the silk cost L.5,600,000 sterling, and wages and profits were L.3,660,000 sterling. The value of the silk grown in France, in 1850, was L.6,000,000 sterling. Silk goods were produced there that year of L.15,000,000 sterling value; of which about L.5,000,000 sterling was for home consumption, and L.10,000,000 sterling for export. The home consumption of France had increased in 1855, 47 per cent., the home consumption 33 per cent.; so that the whole production of French goods, pure and mixed, in 1855, was about L.21,300,000 sterling. This consisted of materials two-thirds, and one-third labour and profit; *i. e.*, of imported silk 5,000,000 lb. costing L.5,300,000 sterling; French raw silk, 6,100,000 lb., costing L.7,600,000 sterling. Other materials, as cotton, wool, linen, silver, &c., of the value of L.1,300,000 sterling. Total materials, L.14,200,000; workmanship and profits, L.7,100,000 sterling. Entire home consumption of silk goods of French origin L.7,000,000, and exported L.14,000,000 sterling. The annual production of a French silk-loom is rather below L.100 sterling. The number of looms was, in 1855, about 220,000. The importation of raw and thrown silk into France rose from L.3,346,000 sterling, in 1851, to L.5,280,000 sterling, in 1855. The exports rose from L.654,360 sterling, in

1851, to L1,560,000 sterling in 1855. There were about 500,000 people employed; which is about one in eighty of the entire population. The excellence of materials used, solidity of workmanship, unsurpassed taste in colour and design, and plan pursued by best manufacturers only to work to order, render the continued increase of the silk production and manufacture of France certain. It is but justice to French public spirit and enterprise to state, that in all the eight principal silk growing departments, as well as, particularly, in Lyons and Paris, unexampled efforts are putting forth, in regard to the great and vital questions—breeding and cross-breeding of silk-worms, causes of epidemics which have been sweeping over silk growing countries of late years, and the true economy in management, in all other respects, both of trees, worms, and their produce. Results have been arrived at by experiments on a small scale, which, if verified by a lengthened experience, will certainly tend to considerable decrease of cost, and, of course, increase in demand both at home and abroad. The annexed table shows that the average weight of raw and thrown silks imported into England in 1856, 1857, and 1858, was 11,266,918 lb., and we have already seen that the English silk trade returns this year about L.14,000,000 sterling. To this sum being added for France, L.21,300,000 sterling; Zollverein, L.4,105,000 sterling; Switzerland, L.4,000,000 sterling; Austrian States, L.7,200,000 sterling; and L.5,000,000 sterling for Spain, Italy, Turkey, Greece, &c. the total of silk manufactures produced in Europe would amount to L.55,605,000 per annum.

Silk *Manufacture.* The processes of silk manufacture fall under two great divisions. The one, comprehending all those operations undergone by the silk in its preparation for textile or other purposes; and the other, those by which the prepared silk is formed into the various beautiful creations of the loom. The operations comprehended in the first division being for the most part peculiar to this manufacture, are those which will here occupy our attention; while those of the second division, being common to the various textile substances, will be found described under the general head Weaving.

In other textile substances, the manufacturer operates upon bundles of short fibres, which, by drawing out and twisting together, he forms into continuous threads; but in the case of silk, a very different treatment is for the most part required. Here the silk-worm is the spinner, and art is called in, not to join short filaments, but so to strengthen the delicate threads of the worm by combination as to fit them to endure the manipulations to which they are afterwards subjected. We have said for the most part, for this reason, that, from the manner in which the worm labours, there arises a necessity for two modes of operating, one of the nature already described, the other analogous to that of the cotton-spinner; and that the reader may be prepared to understand the reason for this, and many other peculiarities arising from the same cause, we shall here present him with a sketch of the manner in which the worm produces the material to be operated upon; and this sketch needs to be but brief, as in the article Silk-Worm, immediately sequent, the fullest imformation will be found. When the silk-worm has arrived at that stage of its existence at which it begins to spin, it ceases to feed, grows restless, and moves about, seeking a place wherein to commence its labours. When it has found a corner or hollow fit for its purpose (bunches of dried heather are most properly placed for this purpose), it attaches a long thread from side to side, to form a support for its work; this it does not dispose in any regular manner, but crosses and recrosses it in such a way as to make its work as strong as the situation will admit of. In plying its labours, the little creature by degrees narrows its sphere, and when it has enclosed a space of about the size of a pigeon's egg, its work assumes a more regular character, and shortly presents the appearance of a loose silken ball of an oval shape, with the worm labouring inside of it. In a little while, the increasing compactness of the ball renders the labours of the worm no longer evident to the eye, and that it continues to work can only be known by the noise within. When all sound has ceased, the formation of silk has also ceased. Although from the compactness of the ball, the worm labours unseen, we can yet tell by after dissection, and by the unwinding of the thread, that it does not lay its thread regularly round the inside of the ball, but to and fro from one spot to another, for many times, gradually shifting its position, until it has gone over the whole surface, and so gradually, that a great many yards of thread may be unwound without once turning the ball. The thread of the silk-worm is secreted by the animal in the form of a fine yellow transparent substance, and exuded by two minute orifices beneath its jaw; hence the thread is a twin one, formed of two threads proceeding from these orifices, cemented together by a gummy varnish, and when the worm has finished its labour of spinning, it smears over the whole interior surface of its work with the same gum and albumen, doubtless for the purpose of protecting it in its chrysalis state from rain. If we examine the finished work of the worm, we shall find it to consist first of a filament used as that irregularly placed support, and next of a ball of a loose texture and irregularly constructed, serving as an envelope for another ball, compact in its nature, and regular in its formation, within which the worm lies enshrouded. This compact ball is called a *cocoon*, and its soft envelope *floss silk*. The thread of the cocoon, from the continuity of its deposition, can be unwound to the end, and the operations to which it is afterwards subjected are those of doubling, twisting, twining, and their accessories, classed under the name of silk throwing. The floss silk, with the additions afterwards to be noticed, is not unwound, but, under the name of waste, has its filaments hackled, combed, and reduced to short lengths, and then carded and spun in a manner analogous to those of cotton.

When the spinning of the cocoons is accomplished, a selection of those that are to be kept for breeding is made, and the remainder are assorted according to their qualities. These are generally reckoned nine, and are as follows:—

1*st*, Good cocoons; these are strong, firm, and nearly equally round at both ends, not very large, but free from spots.

2*d*, Calcined cocoons, in which the worm has died, and been reduced to powder by a disease which sometimes attacks them after having completed their work.

3*d*, Cocalons, larger and less compact than the good cocoons.

4*th*, Choquettes, cocoons in which the worm had died before it had finished spinning; the silk is fine, but apt to furze in winding.

5*th*, Dupion, or double cocoons, containing two or more larvæ; these are difficult to unwind, and are often kept for seed by ignorant breeders, but the best formed by single worms are selected by experienced growers of silk.

6*th*, Soufflon, cocoons of so loose and soft a texture as to be almost transparent; these cannot be unwound.

7*th*, Pointed cocoons. In these one end rises in a point, which breaks off after a little silk has been unwound, and so spoils the thread.

8*th*, Perforated cocoons, from which the moth has made its way out.

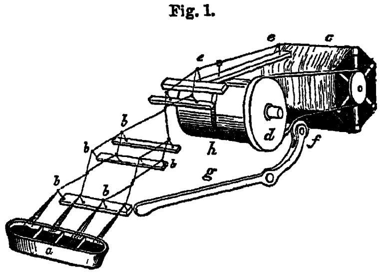
9*th*, Bad choquettes, in which the silk is spotted, rotten, and blackish in colour.

The first operation to be performed, preparatory to the unwinding of the silk from the cocoon, is to destroy the vitality of the contained worm. The means used for this is heat, either natural or artificial; sometimes simple exposure

to the solar rays will effect this object; but in climates where these have not power, some artificial heat must be employed, such as the heat of steam or of an oven, but more generally that of the latter, though steam-baths are greatly to be preferred. The heat should not be greater than what is used in the oven after the bread has been withdrawn. Long shallow baskets are taken and filled nearly to their tops with cocoons, and are covered over, first with paper, and then with cloth. In these baskets, the cocoons are exposed to the heat of the oven for nearly an hour, and on being withdrawn, several cocoons are chosen from the part of the basket least exposed to the heat, and the chrysalides in them stripped and pricked with a needle. If upon being pricked, they give no sign of animation, it may be fairly presumed that the destruction of the creatures has been accomplished. Before the silk of the cocoons can be reeled off, it is necessary to separate them from the floss in which they are enveloped; this is effected by opening the floss covering at one end, and protruding the cocoon. It is of the greatest importance in the reeling process, that all the cocoons reeled together be of one class.

The apparatus for reeling is sketched in fig. 1, and to avoid confusion, the working parts only are shown: *a a* is a bath or vessel of water, which, when of the best construction, is heated by steam. Into this the cocoons are put, that the gum which retains the thread in its place may be so much softened as to permit the thread to be unwound; the bath is usually divided by three partitions into four divisions, each of which may contain about five cocoons; *bbb* are wires with eyelets at their ends, through which the filaments from the cocoons are put. In their upward progress towards the reel, the groups of filaments are twisted round each other, before their final combination at the last eyelet, and by the friction thus produced, they are freed from an adhering portion of the gum; *c* is the reel driven by a belt from the pulley *d*, which is itself driven by the prime mover, whatever that may be; *f* is a tumbler, whose end carries a pulley, which presses on the belt that drives the reel; by lifting up the long end of the tumbler, the belt is slackened, and the reel stops. The filaments when combined at the upper eyelet, pass along the guide *ee*, and through eyelets at its ends; this guide has a pin projecting from its under side, working in a spiral groove cut round the barrel *h*; by this it receives a reciprocating motion, and so spreads the filaments equally over the reel.

Fig. 1.



The filaments, in their passage from the bath to the reel, must necessarily traverse a considerable space, to allow their softened gum to be again hardened by the air, that they may not afterwards adhere together. In China a fire is placed mid-way between the reel and the basin with some advantage.

In the place where the reeling of silk is performed, many of these machines are arranged along the building, and driven by the moving power through a shaft extending the whole length, carrying on it pullies, at the proper intervals. In working the apparatus, the reeler, who is generally a woman, sits at the bath, and having taken a number of cocoons, immerses them in the water. When their gum is sufficiently softened to permit the thread to come off, the reeler takes a whisk formed of fine twigs bound together, and cut off evenly at the ends at about six inches long, and with it she gently presses and stirs the cocoons, and entangles their loose threads on its points; she then raises her whisk with the thread of each attached to it, disengages them from it, and draws their ends through her fingers, to remove the outside floss or impurity; this process is called *battue*. Having thus freed the ends of such a number of the filaments as she means to use, she passes them through the various eyelets in the manner previously mentioned, and attaches them to the reel; when this is accomplished, the reel is put in motion by dropping the end of the tumbler, and the filaments are drawn from the cocoons. It is the province of the reeler so to regulate the motion of the reel, and the heat of the water, that the silk may come off the cocoons regularly, not in lumps, which shows that the water is too hot; nor in such a manner as that the cocoon shall be tossed out of the bath, which shows that the silk is yielded with difficulty, from the water being too cold sufficiently to soften the gum.

From the threads of the cocoons being finer near their termination than at their commencement, it becomes necessary for the reeler to add other cocoons before the first set is quite exhausted; and it is her care to do so in such a manner as that the requisite thickness of the compound thread may be kept up throughout. It is generally considered that the filaments of three fresh cocoons added to two half-wound ones, make a thread equal to that from four fresh cocoons.

The cocoons may not entirely wind off, but the husk, or *bairré*, in which the worm lies, if left, is used along with the floss silk, under the name of waste.

Ordinarily, in China and throughout Europe, 11 or 12 lb. of cocoons yield 1 lb. of reeled silk; and as it takes from 240 to 250 cocoons to weigh 1 lb., the number of cocoons necessary to produce 1 lb. of silk may be reckoned to be 2800; cocoons may yield about 600 yards of silk, consequently the pound of silk filament, as produced by the worm, would, if stretched out, reach the amazing length of 500 to 1000 miles.

When a sufficient quantity of silk is reeled off, it is folded into a hank for use or sale; and it is in this state that it generally comes to be operated upon by our manufacturers,—the hanks by the silk throwster, the waste by the silk spinner.

It is of the utmost importance in the succeeding manufacture, that this reeling process should be well performed. Sometimes from the temperature of the water used to soften the gum being too high during the reeling, the parts of the hank of silk that lie on the spokes of the reel become very hard, and occasion the breaking of the thread in the after processes. Sometimes, too, when in the reeling process the threads happen to break, the ends are again only laid upon one another, and not connected by tying; the threads consequently come off the hanks in short lengths, and much trouble and loss of time is experienced in searching for the other end; and sometimes the reelers, either from inattention or design, reel off the whole of the thread of the cocoons without a regular supply of fresh ones, by which an exceedingly foul silk is produced. Thus coarse and fine silks are reeled together in the same hank; and, what is of common occurrence, the hanks when reeled are twisted up so tight, that the untwisting of them greatly damages the silk. But the greatest injury to the manufacturer arises from dishonesty on the part of those who produce the reeled silk; and this remark applies especially to the coarser descriptions. To get rid of their waste, some producers of raw silk roll up the refuse of the cocoon into what are here technically called *dollies*, and insert these into the hanks in such a manner that they cannot be discerned by the purchaser; they also have a method of mixing their waste with the good silk while it is being reeled, and as it cannot again be separated from it without great injury, this mode of vitiating the silk is more

objectionable than the other. But dishonest practices are unfortunately not confined to the description of silk above mentioned; it is too common to find in hanks some coarse inferior quality of silk artfully prepared with a covering of a much finer kind, to enhance its value.

The loss of capital, which careless reeling, and the base practices we have alluded to, entail on the manufacturer, is immense; for if an establishment be formed, with machinery and workers sufficient to throw a given quantity of good silk; take, for example, the Italian silk, called *Fossombrone*, which, of all the raw silks, is the easiest manufactured, and if, in place of some of the *Fossombrone*, the machines and workers come to be employed on some silks vitiated as we have described, or reeled in a careless manner, then, from the foulness and unevenness of the thread, the number of workers will, in all probability, not be sufficient to attend to above one-third of the machines, one winder being able in a given time to wind five times as much of the *Fossombrone* as of some of the *Bengalese* silks.

From what we have said it may be inferred, that it is a matter of great difficulty for the manufacturer to determine the number of machines and workers in the various processes; and that, from the ever varying nature of the silk, he will seldom have the whole of his machinery employed.

If the preparation of the raw silk, as reeled silk is termed, were conducted by persons conversant with the processes of the silk filature, who would adapt their mode of working to suit the various purposes to which the article prepared by them was to be applied; or, if the whole of the operations were under the conduct of an instructed agent of the manufacturers, the evils on which we have animadverted would be removed, and a better and a cheaper article would be furnished to the consumer.

The operations which succeed the reeling are those of silk throwing, and are as follows:

1st, *Winding* the silk from the hanks upon bobbins, to fit it for the further processes.

2d, *Cleaning*, consisting in the silk being unwound from the bobbins of the winding machine, and wound upon another set of bobbins; and, in its passage between, made to pass through an opening between two metal plates, by which any inequality, caused by knots or adhering substances, is removed.

3d, *Spinning*, consisting in twisting the cleaned thread.

4th, *Doubling*, consisting in laying together on one bobbin the threads of several bobbins, so that they may be afterwards combined by being twisted together.

5th, *Throwing*, the name by which the operation of twisting the doubled silk is known, and also the name by which the whole class of operations is distinguished.

It has been conjectured, that the name *throwing* is derived from the swinging and tossing of the threads and cocoons while reeling, but we need not travel out of the way for its derivation, as the operation of twisting is in many other arts called throwing. The ropemaker *throws* twist into his ropes; and the little instrument used in the farmyard for twisting straw ropes, is called a *throw-crook*.

6th, *Reeling*, consisting in forming into hanks suited for undergoing the processes of scouring, dyeing, and bleaching the silk which has undergone some or all of the previous operations.

7th, After the scouring, bleaching, or dyeing processes have been performed on the hanks, these have again to be wound on bobbins, for the use of the warper or weaver.

It is not to be understood, that silk in every case undergoes all the operations we have mentioned, but that, when it does so, these succeed each other in the order described.

It is sometimes merely wound and cleaned, and is in this state under the name of dumb *singles*, used for Bandana handkerchiefs, and, when bleached, for gauze, and similar fabrics.

It may be wound, cleaned, and thrown, and is then called *thrown singles*, and used for ribbons and common silks.

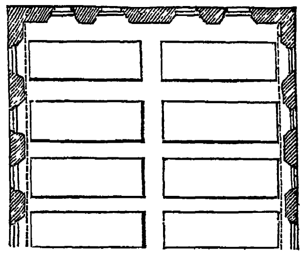
If wound, cleaned, doubled, and thrown, which twists it into one direction, it is called *tram*, and is used for the woof or shute of Gros de Naples, velvets, and flowered silks.

If wound, cleaned, spun, doubled, and then thrown, so as to be of the nature of twine, or the strand of a rope, it is called *organzine*, which, from its strength, is used for warp.

Silk, in any of these states, before being subjected to the operation of scouring, is termed *hard*, but after it is by scouring deprived of its stiffening-gum, it is called *soft*.

The operations of the throwster are generally carried on in a building which admits of an apartment being allotted to each description of machines, and these apartments are generally in stories. All the machines used in the processes are each made up of a repetition of the same parts, each part being a distinct and separate apparatus, capable of performing its work independent of its fellows; and these are arranged in juxtaposition in the *machine*, in order that the moving power may be conveniently applied to a long series of them. The length of the machines is regulated by the extent of the building, and the manner of their arrangement. A manner of arranging them is here sketched (fig. 2.) The apartment is supposed to be about thirty-eight feet wide, and the machines are placed athwart the room, so as to afford a passage four feet in width along the centre, and at such a distance lengthways, as to give room for the workers to attend to their charge. Two shafts traverse each apartment in the direction of the dotted lines, and carry on them pullies, or toothed wheels, opposite to each machine; a belt from each pulley is carried over a corresponding pulley on the end of the main shaft of each machine, or the toothed wheels are connected by proper gearing with the shafts of the machines, and so motion is given to the whole.

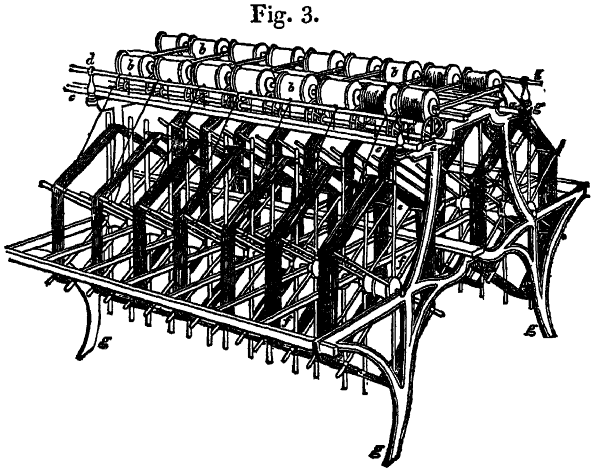
Fig. 2.



The rooms are generally heated by steam, and the temperature of the apartments, when above the minimum of 50°, is regulated more by a regard to the health of the workers, than from any necessity for a particular temperature in the operations; but these cannot be performed with advantage when the temperature is allowed to fall below 50°.

The first machine or apparatus used is the winding-machine, or that by which the reeled hanks are wound on bobbins, to prepare them for the subsequent processes. A perspective sketch of this machine is shewn in fig. 3. Along

Fig. 3.



each side of the machine, at *a a*, directly under the line of bobbins *b b*, run two shafts, called frame shafts, or frame friction-shafts; on these shafts at each bobbin are fixed two friction pullies, of about $4\frac{1}{2}$ inches diameter; and on the axis of each bobbin are fixed two corresponding pullies, about $1\frac{1}{8}$ inch diameter. The friction-pullies of the bobbins rest upon those of the shaft, and receive motion from them. Opposite to each bobbin is a wire, with an eyelet at its end, fixed to a bar of wood *c c*, called the traverse bar. This bar, with the eyelets attached, has an alternating motion, right and left, through a space equal to the length of that part of a bobbin on which the silk is to be wound. In front of these eyelets are fixed the guide-rods, or friction rods, *d d d d*, over which the threads glide in their passage from the reel to the bobbins, and which are formed of polished iron, and in front of these the reels *e e e e*, are placed on their bearers *f f*. At every seventh bobbin or so is placed a main frame, like *g g*, and between these stretch bars of wood, for the support of the bobbin and reel bearers. Motion is given to the bobbins, we have said, by the lying shafts bearing friction - pullies, and the threads being passed from the reels, over the friction-bars *d d*, through the eyelets, and attached to the bobbins, are, by the motion of the latter, wound up, and drag round the reel on which the hank is fixed. The bobbins are, with their friction-pullies, represented in figs. 4, 5, and 6. Fig. 4, a section; fig. 5, a front view, and fig. 6, a plan: *a* is the lying-shaft, with one of its friction-pullies *b b*, and on this rests the friction-pulley *c*, of one of the bobbins *d;* the axis of the bobbin is confined laterally by working in the groove *e* of the bearer, but has perfect freedom of motion up and down, so that its friction-pulley may remain in contact with that of the shaft. If, during the process, a thread happens to break, the bobbin is lifted out of its working-groove and placed in the higher groove *f*, by which its friction-pulley is kept from touching the friction-pulley of the shaft, and it consequently remains at rest; but when, after the damage has been repaired, it is lifted into its former position, its motion is immediately resumed. In front of the bobbin is seen the traverse bar *g*, carrying the wire *h*, with its eyelet for the thread; this traverse bar is moved by an eccentric in such a manner, as not to spread the thread equally over the bobbins, but to heap it up more in the middle than at the ends.

Fig. 4. Fig. 5.

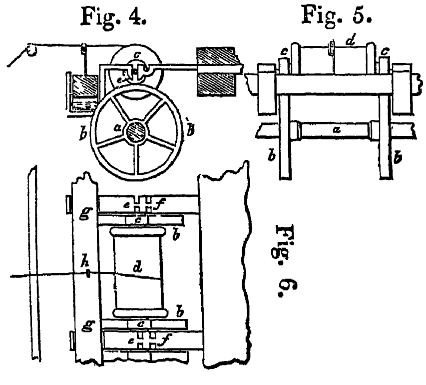
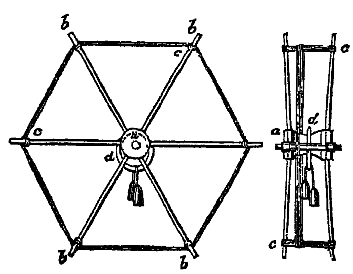


Fig. 6.

The reels are called swifts, and are formed of twelve light spokes, about $16\frac{1}{2}$ inches long, inserted into a wooden nave in pairs, so as to form a six-sided reel; the nave has an iron axle, which turns freely on its bearings. The hanks not being all of one size, makes it necessary to have a reel, the diameter of which may be varied. Various means of adapting the reel to the size of the hank have been and still are used. Amongst others, one deserves notice; it is, where each spoke of the reel is made in two parts, the one fixed to the nave, formed of tube containing a spiral spring, the other formed of a light rod, nicely fitting the tube, the opposite pairs of rods being joined together by a cross bar, forming the periphery of the reel. When it is wished to put a hank on a reel of this kind, one of the pairs of spokes is pushed into the tubes, and the hank slipped on; the spiral springs now exert their force, and throw out the pressed-in spokes with such a force, as to keep the reel in a proper state of tension. But the method generally adopted, if not so elegant, is more simple. The spokes in this case are formed of lance-wood, and the outer extremity of each pair are rather farther asunder than the ends which are inserted into the nave, and are connected together by a band of small cord passed several times round them; on these bands the hank or skein of silk rests, and, by slipping the bands along the spokes nearer to or further from the centre, the diameter of the reel can be adapted to the size of the hank; and when the hank is stretched the bands can be moved in any way, so as to balance the hank, which, as will be afterwards seen, is a matter of considerable importance. Each pair of spokes, it has been mentioned, slightly diverge as they proceed from the nave; and, as they are again slightly drawn towards each other by the bands, the tendency to return to their natural position effectually retains the band in any place to which it may be slipped. It has been said, that the reels turn freely on their supports, but it is necessary to create such a friction as will prevent them giving off the silk faster than it can be taken up by the bobbins; this is sometimes done by a spring being made to press upon the nave of the reel, but more commonly by hanging on its centre a wooden ring, to which weights may be hung, so as to create such a degree of friction on the reel, and, consequently, of tension upon the thread, between the reel and the bobbin, as may be desired. The subjoined sketch (figs. 7 and 8.) shews the reel as it has been described: *a* is the nave, *b b* the lance-wood spokes, *c c* the bands of cords forming the periphery of the reel, *d* the friction-ring, with the weight hanging on it.

Fig. 7. Fig. 8.



Referring again to fig. 3, it will be seen, that in front of the swifts are bars of wood, extending along both sides of the machine; their use is to support the bars which carry the swifts, and to prevent the persons of those who work the machines from coming in contact with the reels; from this last use they are termed knee-rails.

Previous to the hanks being put upon the swifts, they are washed in a solution of soap and water, which cleans the silk without depriving it of its gum. In putting the hanks on the reel care is taken to balance them, as, were one side heavier than another, it would be apt to fall suddenly, after having passed the highest point, in turning, and thereby injure the thread.

The winding-machines, under the general superintendence of a man called a steward, are tended by girls, who are termed *denters* and *winders;* the denters put the hanks on the reel, and the winders, or piecers as they are also called, tie the ends of the threads and exchange the bobbins. When the bobbins are filled with thread they are conveyed from the winding-machine room to the warehouse, to be assorted or separated into finer or coarser qualities, which are kept apart throughout the remaining processes. To carry the bobbins, a board, called a *doffing-board*, is made use of; this consists of a piece of deal, about a foot wide, and rather more than two feet long, having a number of wires corresponding to the number of bobbins in one side of a frame, and about four inches long, inserted into its surface; on these wires the bobbins are put. When the separation of the qualities has been made,

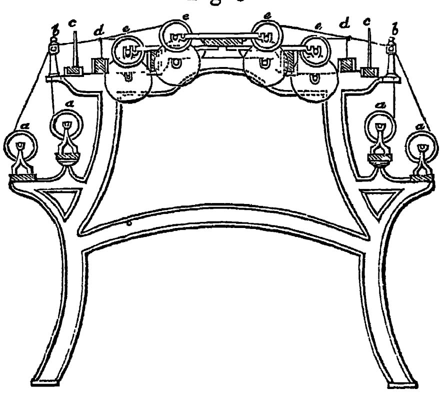
Silk Manufacture.

the bobbins are carried to another machine-room, where the thread undergoes the operation of cleaning.[1]

Cleaning.

The *cleaning*, *drawing*, or *picking-machine*, as it is variously called, is represented in fig. 9. In this, as in the last machine, motion is communicated to the bobbins by a friction shaft. The bobbins, *a a*, from the winding-frame are fixed on plain spindles, and placed in a horizontal position between their supports. The threads are carried from the bobbins over the iron or glass rod, *b b*, and each thread is passed through an adjustable opening, between the two iron blades of an instrument called the *cleaner*, *c c*, which is fixed to a bar of wood running along the machine, immediately behind the friction-rods. The *cleaner* is here represented on a

Fig. 9.



larger scale, (figs. 10, 11); *a* is the bar of wood to which the instrument is fastened; *b*, *b*, are the blades, which are held together at the bottom by the screw *c*; *d* is the opening through which the thread is made to pass, the width of this opening being adjusted by means of a screw *e*. the key of which is kept by the steward of the room. The tops of the blades are curved outwards, so as readily to guide the thread into the slit. The threads, after having been passed through the opening of the cleaner, are put through the eyelet *d*, of the traverse bar, which is, in every respect, like that of the former machine, and then attached to the bobbins *e e*. When the machine is put in motion, the bobbins *e e* drag the thread from the bobbins through the cleaner; and, as the cleaner is adjusted to a certain size, all impurities and irregularities are removed, and the thread thus rendered equal.

Fig. 10.

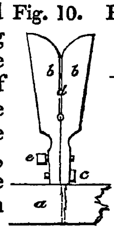
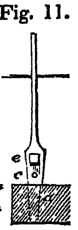


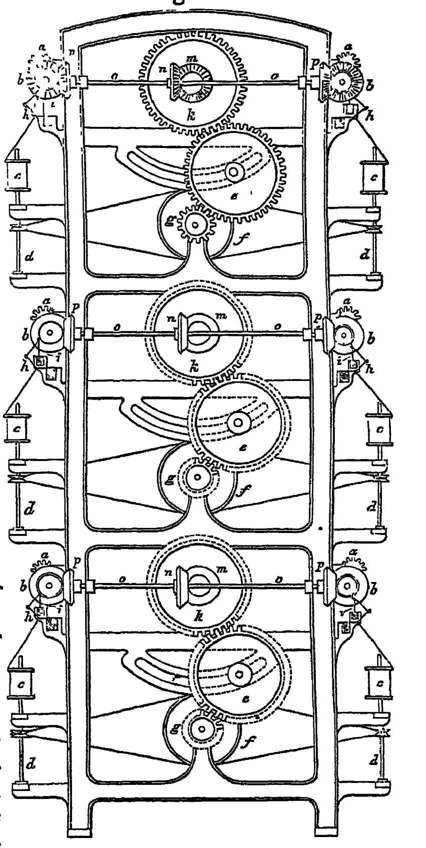
Fig. 11.



Spinning.

The process which succeeds that of cleaning is called spinning, although, as we have already observed, it is only twisting. The spinning-machine is represented in fig. 12. This, like the two former machines, consists of a series of frames placed at wide intervals, and connected by bars of wood, which serve as supports for the different parts of the machinery. The spinning machine contains sometimes two but generally three tiers of working apparatus in height. The bobbins on which the twisted silk is to be wound, are seen in the figure at *a a a*, placed horizontally along the machine; in this case they are not driven by friction-rollers, but by toothed wheels, fixed on the extremity of the axis of each bobbin, and corresponding ones on the shafts *b*, *b*, *b*. The bobbins are, as before, suspended by their axis in little grooves; each bobbin-bearer contains two such grooves, one higher than the other, so that, on the bobbin being lifted from the lower to the higher groove, its toothed wheel is thrown out of gear with the wheel of the shaft *b*, *b*, and it remains at rest. Under each bobbin is seen the twisting-apparatus. This consists of a bobbin *c*, fixed on an upright spindle *d*, to which motion is communicated by a belt from the drum *f*, fixed on a horizontal shaft *g*, passing over a pulley on the bobbin spindle. The silk threads from these vertical bobbins are wound three or four times round a bent wire *h*, fixed to a bar, extending along the machine, passed through an eye in the end of each of these wires, carried through the eyes of the traverse-guides, and attached to the horizontal bobbins. On motion being given to the machinery, the vertical bobbins are made to revolve with a greater or less velocity, and the horizontal ones with a velocity so proportioned to the others, that they may only draw away the thread as it is twisted in the due degree.

Fig. 12.



Silk Manufacture.

In figs. 13 and 14, we have represented, on a larger scale, a section and front view of these working parts: *a*, *a* is the bobbin from the cleaning-machine, *b* the fixed wire-guide round which the thread is carried, *c* the traverse-guide for spreading the thread over the bobbin, *d* the bobbin for receiving the twisted thread.

Fig. 13.

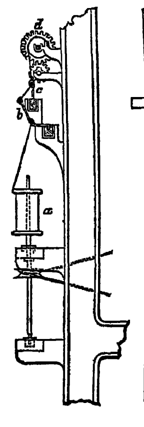
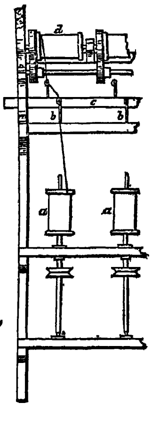


Fig. 14.



Motion is communicated to the different parts thus: On one end of the drum-shaft *g*, (fig. 12,) is fixed a fast and loose pulley, not seen in the drawing, driven by a belt from the main shaft which traverses the apartment; belts from the drum on the drum-shaft pass over the pullies of the vertical spindles *d*, and so give motion to the bobbins *c*; on the hither end of the drum-shaft is fixed the pinion *g*, which, through the intermediate wheel *e*, drives the spur-wheel *k*; on the axis of this last wheel is fixed the bevel-wheel *m*, giving motion to the

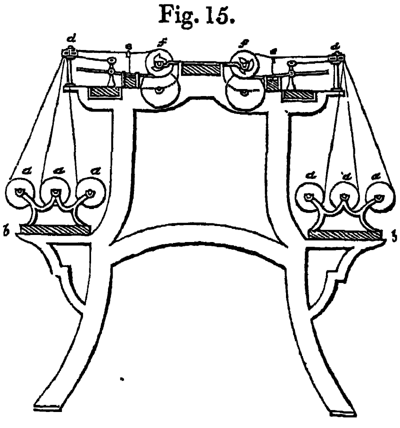
[1] The doffing board is an adoption from the cotton manufacture, and its use, as described above, is, we believe, peculiar to Scotland. Its chief advantage is, the check it affords against pilfering. When carried to the machine-room, the wires of the empty board are filled with empty bobbins, and, as the bobbins of the machine become charged with silk, they are exchanged for the empty ones of the board, which is again carried to the warehouse, that the bobbins may be assorted according to the quality of the silk. The filled bobbins are exchanged for empty ones, to be carried on the board to the winding machine room, and the same system is followed out in all the different stages of the operation.

bevel-wheel n, and thereby to the shaft o, which crosses the end of the machine; each end of this shaft carries a bevel-wheel p, which drives a bevel-wheel h, fixed on the end of the shaft, on which the little spur-wheels that drive the spur-wheels of the bobbins are fixed. On this last shaft is also fixed a pinion, to work the traverse guide-bar; this it effects by giving motion to a small wheel, round which another pinion revolves, in the manner of the sun and planet-wheels, and, being connected by a short rod with the traverse-bar, the latter is consequently moved through a space equal to the added diameters of the wheels. In the usual mode of constructing this machine, there is a want of a mean of lessening the velocity of the drawing-bobbin, as its diameter increases by the accumulation of silk. In consequence of this want, the thread is very unequally twisted; for although at the commencement of the process the drawing or upper bobbin may, by appropriate toothed-wheels, be made to turn with the velocity requisite to allow of the thread receiving, say twelve twists in the inch, yet, after a very short time, the silk will have accumulated on it, and increased its diameter so much, that for every revolution which it now makes, it will take up and draw away a much greater length of thread from the revolving bobbin, whose speed remains constant, so that the number of twists are constantly on the decrease, and, at the end of the operation, may be no more than eight in the inch. A very ingenious mode of equalizing the draw of the bobbin has been put in practice In place of driving the drawing-bobbins by toothed-wheels, they are here driven by friction-rollers; the part of the bobbin on which the silk is wound rests on the roller, and receives motion from it; and, as the diameter of this part increases by the accumulation of silk, its velocity, of course, diminishes in precisely the same ratio; thus, the surface on which the silk is wound has a uniform rate of motion from the beginning to the end of the process, insuring, what has ever been a desideratum, perfect equality in the twist of the thread.

Doubling.

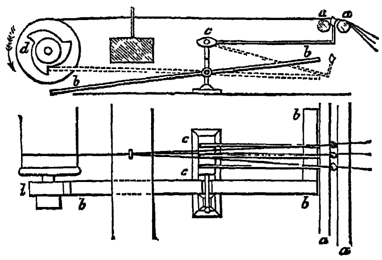
The next operation is doubling. Fig. 15 is an end view of the doubling-machine. In this machine the bobbins $a\ a\ a$, containing the spun silk, are arranged along the lower platform b, in little brackets capable of each containing three bobbins; from these the threads are carried over the guide-rods d, of which there are two on each side of the machine, and, after being passed through the eyes of an apparatus called the falling-wires, and the traverse-guides $e\ e$, are then attached to the bobbins $f\,f$, to which motion is given by friction-pullies, as in the first machines, and on them the threads are thus wound up in combination.

Fig. 15.



In all formerly described machines the breaking of the thread causes no injury, but, in the doubling process, were one of the three threads to break, and the upper bobbin to continue to revolve, the other two threads would be wound up separately, and so spoil the work; to prevent this is the use of the falling-wires described above, which, on the breaking of the thread, stop the bobbin until the damage is repaired. The subjoined sketch (figs. 16, 17), shews a side view and plan of this apparatus: $a\ a$ are the two guide-rods, with the threads passing over them; between the rods are seen the eyelets of three bent wires, whose other extremities are hinged to a piece of brass at c. The threads are passed through these eyelets, and support the wires in the horizontal position shewn in the sketch. Hinged to the same supports as the wires is a brass lever, $b\,b$, bent at right angles horizontally under the wires; the straight end or tail of the lever is a little heavier than the bent end, and it consequently lies in the oblique position of our drawing. On the end of the bobbin is fixed a little ratchet-wheel, moving as indicated by the arrow. Now, when one of the threads sustaining the bent wires happens to break, the wire falls down on the bent part of the lever, which, by this additional weight, is depressed, and its opposite end consequently rises into the position shewn by the dotted line, and acts as a paul to the ratchet-wheel, effectually stopping the bobbin until the attendant has leisure to lift it out of its working-groove, repair the damaged thread, and again set it in motion.

Figs. 16, 17.



When the lighter kinds of silk have to be doubled, they would be injured by being made to drag round the heavy bobbins; therefore, for such kinds a modification of the apparatus is required. In place of the bobbins being placed horizontally in bearers, they are placed vertically on spindles, as shewn in figs. 12, 13, 14; the spindles project beyond the upper end of the bobbins, and carry a little wheel of hard wood, which is made to turn freely; this wheel has two flyers with eyelets at their extremities; the thread being put through these, and drawn by the upper bobbins, causes the light flyers to revolve round the vertical bobbin, and unwind the thread without straining it.

The next is the throwing machine. As this machine closely resembles the spinning-machine shewn in fig. 12, we here only sketch such a portion of it as will shew wherein they do not agree. Fig. 18 is an end view, and fig. 19 is a side view of one of the working parts: $a\,a$ is a vertical bobbin with its loose flyer $b\,b$; the bobbin being driven by a band acting on the spindle pulley as in the spinning-machine; c is a traverse guide wire, through the eye of which the thread is passed; d a reel on which, in this case, the thread is wound into hanks as it is twisted by the revolution of the vertical bobbins. The traverse guide bars have, in this machine, a very short range of lateral motion, so as to confine each hank within a very narrow limit on the reel's surface. The motion of the reel can be so regulated in relation to that of the twisting bobbin, as in any way to modify the amount of twisting received by the thread.

Fig. 18.

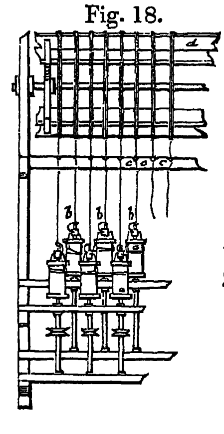
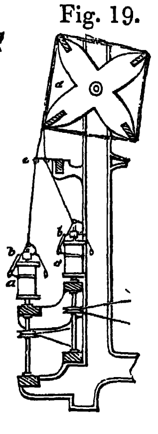


Fig. 19.



In the case of the heavier silk threads used for sewing, fringing, and the like, the doubling and throwing processes are both performed by one machine, called a throstle frame, which is similar to the machine of the same name used in the cotton and linen thread manufacture. The

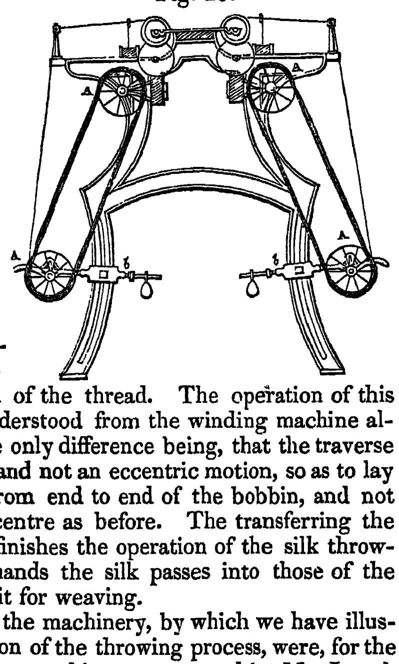
throstle, however, does not contain apparatus for reeling the silk, so, for this purpose, a subsidiary reel has to be used. This machine is automatic, in respect of stopping when a predetermined quantity of silk has been wound. One end of the axis of the reel is supported by a lever, whose fulcrum is at the centre of the machine; the other end of the axis has a fixed bearing. Motion is given to the reels by a pinion fixed on the end of its axis, being driven by a spur wheel on the main shaft; by raising the lever, which carries one end of the axis, the pinion would be withdrawn from the spur wheel, and the reel would necessarily cease to revolve. The machine is rendered automatic from the raising of the lever being effected by proper machinery at the very instant that the reel shall have wound up the length of silk predetermined, and by a detent locking it out of gear until the attendant shall have time to shift the apparatus which guides the silk to a new space on the reel.

We are sorry that we cannot present our readers with a more minute description of this machine, from the number of drawings which would be required to illustrate it.

Whether the hanks of silk have been reeled in the throwing-machine or on the automatic reel, they are afterwards treated in precisely the same manner. When the reels are filled with hanks, they are placed in a steam box, and subjected for a time to the action of the steam, to give the twisting of the thread a *set*, as it is termed; each skein or hank is then tied up separately in two places while yet on the reel, which is then carried to the proper apartment, and the hanks removed from it and bundled up.

The silk may be used without being deprived of its gum, and is termed *hard*, or it may be acted on by soap and water to deprive it of its gum, and reduce it to the *soft* state. In either of these states it may be put into the hands of the dyer, whose operations succeed those we have described. When the hanks come from the dyer they are again transferred to bobbins; the hard silk by a winding machine, similar to the one already described, the soft silk by the machine represented in fig. 20.[1] In this machine, in place of the swifts are substituted the small reels A A, the upper one fixed in position but turning freely on its axis, the lower one also turning freely on its axis, which is attached to a lever *b*, whose short end carries an adjustable weight, by means of which the hank of silk can be kept between the reels with the degree of tension suited to the strength of the thread. The operation of this machine will be understood from the winding machine already described, the only difference being, that the traverse guide has an equal and not an eccentric motion, so as to lay the silk regularly from end to end of the bobbin, and not heaped up in the centre as before. The transferring the silk to the bobbins finishes the operation of the silk throwster, from whose hands the silk passes into those of the warper, to prepare it for weaving.

Fig. 20.



The drawings of the machinery, by which we have illustrated our description of the throwing process, were, for the most part, made from machines constructed by Mr. Joseph Lomas of Glasgow, an engineer who has devoted much of his attention to the machinery used in this particular branch of manufacture.

Having thus traced the silk of the cocoons from its developement to the perfection of the filature, and its adaptation for the loom, we will briefly describe the means used for preparing the waste silk for the weaver, in so far as they are peculiar to the silk manufacture.

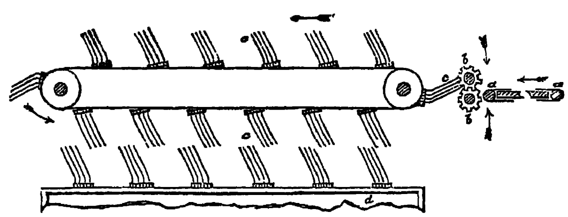
Silk Spinning.

Under this term are included those operations by which floss silk, and the refuse of the throwing process, are, under the name of waste, worked into yarns for coarser uses, such as the manufacture of shawls, Bandana handkerchiefs, and similar textures.

When received by the silk spinner, the waste is in the form of small balls of entangled filaments. These, as a preparatory step, he assorts in parcels according to their quality, and these different qualities are of course kept separate throughout the processes; after being assorted, the waste is hackled on a hand hackle, to disentangle the filaments, the instrument and manner of operating being the same as in flax-dressing. When, by the hackling process, the filaments of a quantity of the waste have, to a certain extent, been disentangled, they are ready for the *filling engine*, which is a kind of hackling machine, whose effect is, in a greater degree, to disentangle the filaments, and in some measure to lay them parallel.

The essential parts of this machine are sketched in fig. 21: *a a* is a feeding board, over the surface of which a tra-

Fig. 21.



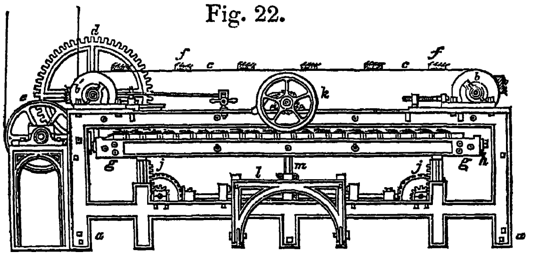
velling belt moves in the direction of the arrows, and carries forward to the feeding rollers *b b*, the hackled waste, which is laid on it. These rollers are fluted and move very slowly; between them the filaments from the feeding board enter, and are held fast, and at the same time drawn forward into the machine As the ends of the filaments come to the other side of the rollers, they are acted upon by a series of iron teeth *c c*, fixed to an endless belt which revolves with a very quick motion in the direction of the arrows, and the teeth are consequently made to pass many times through the same portion of the filaments, clearing and disentangling them as they are slowly yielded by the feeding rollers; and as the ends of the successive portions of filaments cease to be held by the rollers, they are caught up by the teeth and carried round with them. Beneath the combs, as the travelling teeth are termed, a board *d* is fixed, having at intervals, along its surface, sets of teeth similar to the combs. When the filaments carried round by the travelling combs happen to fall off, they are caught on the fixed combs of the boards, and the regularity of their arrangement is not disturbed. When the combs, by repeated gleanings from the rollers, have become filled, the workman, with a pair of boards called *clutches*, removes from them, and from the teeth of the horizontal boards, their accumulation of filaments; these he carries to the next machine, called the *dressing frame*, which, like the filling engine, operates on the principle of combing. In this, however, the filaments are not gradually brought for-

[1] In England, throwsters rarely if ever wind the soft silk, this duty devolving upon the manufacturer; but in Scotland, manufacturers being seldom provided with the requisite machinery, soft-silk winding is usually a part of the business of the throwster.

Silk Manufacture.

ward by rollers and yielded to the comb, but they are held firmly in their place by one end, while the combs travel over their surface, dragging away all impurities and all fibres which are shorter than the average length of the mass. Fig. 22 is a side view of the machine: *a a* is a fixed framing, at

Fig. 22.



each end of the frame is a roller *b b'*; over these rollers the endless web *c c* moves. Motion is communicated to the roller *b'* by the spur wheel *d*, on its axle being driven by a pinion on the axle of the pulley *e*, to which motion is given by a belt from a pulley of the main power shaft. The distance between the rollers *b b'* can be increased or diminished by a screw connected with *b*, so as to tighten or relax the endless web which travels round them. The endless web carries the combs *f f*, which, in this machine, are composed of a great number of short inclined teeth. Immediately below the top bar of the machine is seen the side of an iron frame *g g*, in which the silk to be operated on is fastened. Along the frame is seen the ends of a series of boards, whose lower edges are hinged together; between these boards, when opened like a book, the ends of the silk filaments from the filling engine are inserted, and the boards closed and put into their place in the iron frame, and between every pair of these boards is put a piece of solid wood. The pinching screws *h h*, at the ends of the iron frames, are now turned, and the silk is thus held tightly between the boards. The iron frame, it will be seen, rests upon two supports *j j*, which, by means of a rack and pinion worked by the wheel *k*, can be moved up or down, and thus the frame can be raised or lowered; when lowered to its utmost extent it rests on the wheeled carriage *l*, which runs on the floor on a railroad placed at right angles to the machine. The operation of the machine is as follows: The frame which contains the silk is lowered until it rests on the carriage, which is then drawn out at the side of the machine. The boards containing the silk are then put into their places and firmly compressed by the pinching screws; the carriage is now returned to its place under the combs, and by means of the wheel, the frame is adjusted so that the combs may act on the silk. The machine is then put in motion, and the combs, by repeatedly passing over the silk, disentangle and lay parallel the filaments and remove impurities. When the combing of one side of the filaments has been effected, the frame is again lowered, and the carriage withdrawn. The workman with a skewer turns over the silk so as to expose the uncombed side, wheels round the frame on its centre pivot *m*, and again runs the carriage into its place; again he raises the frame until within the scope of the combs, which constantly move in the same direction; and thus both sides of the material come to be thoroughly operated upon. The gleanings of the silk gathered by the combs, when accumulated, are screwed between the boards, and again subjected to the action of the machine; what is carried away by the combs in this operation is unfit for spinning, and is used, like the refuse of flax, for stuffing cushions and similar purposes.

When the filaments are by the dressing machine cleaned and laid parallel to each other, they are cut into lengths of about an inch and a quarter by the *cutting engine*, which operates upon the principle of chopping, and resembles the agricultural chaff machine. It is then operated upon by the scutcher, which is a modification of a similar machine used in the cotton manufacture. When it leaves the scutcher it resembles fine down, and is put into bags of a convenient size, and boiled for an hour and a half or so in soap and water, to deprive it of its gum; it is afterwards washed in pure soft water and again boiled, but not now for so long a period, this boiling being merely for the purpose of getting rid of impurities. It is then subjected to the action of a Bramah press, and when taken from the press, dried by means of a stove, after which it is cooled, and a second time passed through the scutching machine to fit it for carding. The carding is followed, as in the cotton manufacture, by the drawing and fly frames, to produce a rove, and these, by the spinning mill and the throstle, after which reeling and bunding complete the operations and fit the thread for the market.

Silk-worm.

The art of silk-waste-spinning, we may observe, is still in its infancy, but is advancing rapidly to greater maturity. In 1814, the quantity of waste imported by Great Britain amounted to 28,996 lb., and in 1836 it had reached to the amount of 1,509,334 lb. In the years 1856, 1857, 1858, it averaged 2,069,684 lb.

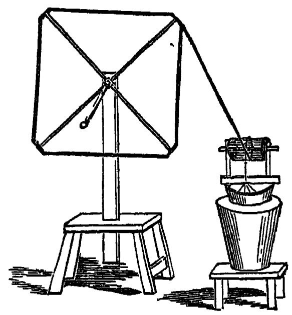
Silk-Worm. Although the article now known to ourselves under the name of silk is "familiar as household words," yet its nature and origin were but obscurely, if at all ascertained in ancient times. Pliny, whose judgment and discrimination as a compiler are not greatly to be relied upon, reports that the *bombyx* (or silk-worm) is a native of Kos, an island of the Mediterranean archipelago. It is known that silk was manufactured there at a very eary period, but Aristotle had previously explained that *bombykia*, or the stuff produced from from the bombyx, was respun and rewoven by the women of that island. The inventress of this process was Pamphilia. "She unwove the precious material to recompose it in her loom into fabrics of a more extended texture; thus converting the substantial silks of the Seres into thin transparent gauze, obtaining in measure what was lost in substance. Attempts have been made to rob the inventress of all the merit belonging to this process, by identifying the bombykia with the raw material, which it is said Pamphilia and her nymphs procured from Seres, and spun or wove into sericum or silk. But the fact of the re-weaving rests upon too good authority to be doubted."[1]

Had Pliny been right in supposing that silk was a natural product of the island in question, it is by no means probable that so laborious a process as that of converting foreign wrought articles into threads for reweaving, would have been resorted to. Indeed, the Byzantine historians inform us, that prior to silk-worms being imported into Constantinople in the sixth century, no one in that capital knew that silk was the produce of a caterpillar. Although Aristotle gives an account of the silk-worm, which he describes as a horned caterpillar, he does not indicate its native country. Assyria is named by Pliny as the original region of the bombyx, and he adds the extraordinary statement, that the stuff which the women of Rome unraveled and wove anew, was made from a *woollen* substance combed by the Seres from the leaves of trees, and that draperies formed from it were imported from the country of the Seres. These ancient people, we need scarcely remark, are generally believed to be the same with those we now name Chinese. Silk, in their language, is called *se* or *ser*, the latter term corresponding with that used by the Greeks, who, we cannot doubt, derived both the material itself, and the name by which it was designated, from the Chinese nation. According to Latreille, the city of Turfan, in Little Bucharia, was for a long time the rendezvous of the western caravans, and the chief entrepôt of the Chinese silks. It was the metropolis of the Seres of Upper Asia, or of the Serica of Ptolemy, situate, according to that au-

[1] Cabinet Cyclopædia, xxii. 5.

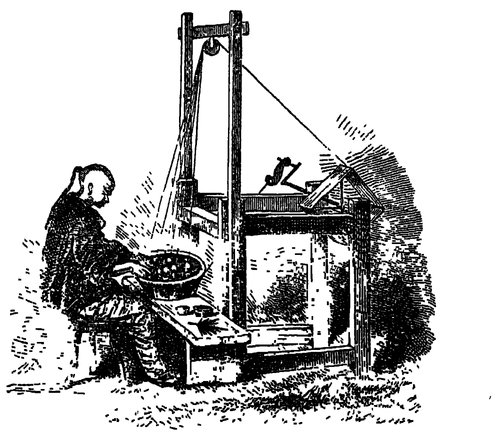
Silk-worm. thor, between the Ganges and the Eastern Ocean. Hence the *Serica vestis* of the Romans, and the word *Sericum*, their name for silk. The most ancient languages in India have names for "silk-worms," and for "wrought-silk." Ancient Hindu books mention, as separate classes, "silk-worm-feeders," and "reelers of silk." Heavy silks from China, India, and Persia, were unraveled and rewoven, of slighter texture, at Gaza: thence called "La Gaze"—gauze. Fig. 23 represents an ancient Indian reel.

Fig. 23.



The growth of silk has been considered by the Chinese for 4000 years next in extent and importance to that of rice; and the annual initiatory processes of the hatching eggs of silk-worms, and gathering mulberry-leaves, by the empress, as of the emperor's holding the plough for preparation of the ground in the cultivation of rice, are ordered in the book of rites, printed by Chinese authority, and composed by Confucius 2300 years ago, giving religious ceremonial authority to them. One of their kings was deified because he encouraged the cultivation of the mulberry, and one of their queens on account of her improvements in the art of weaving silks. It is not generally known to European silk-growers, that works have been composed, many ages ago, by the Chinese, describing minutely (and with many particulars not noticed by any one of the nearly fifty French and Italian writers on the subject usually consulted) each process, from sowing the mulberry-seed and hatching the silk-worm's eggs, to the winding of the silk from the cocoon, the doubling and dyeing the filaments, weaving these materials into their truly gorgeous stuffs, and fashioning the latter into garments. Such a volume is now lying before us, published at an astonishingly low price, and illustrated by wood-cuts facing every page. Fig. 24

Fig. 24.



is an ancient Chinese reel. M. Julien published, about twenty-five years ago, a translation, made by himself, of a valuable work found by him in the Imperial Library at Paris, accurately describing the Chinese method of managing their *annual* silk-worms, and in producing their best raw silk. This treatise insists much upon the necessity of pure air and wholesome food for the worm, and suggests many important points for improvement on the part of European unprejudiced silk-growers.[1] Nevertheless, while the strength and colour of China silks are in the main still unrivalled, the unevenness arising from the defects in their reeling is no small deterioration of their value, in comparison with the best silks of France and Italy. It is probable that, for a long time to come, we shall have to resort to China for fresh supplies of silk-worms' eggs, when, from epidemic disease, those hatched from acclimated worms cannot be depended upon. About fifty years ago, the eggs of the Chinese white species were successfully introduced into the department du Gard, France, and from them silk of double value in the market has been ever since obtained. Silk-worm.

This substance was but slightly known in Europe before the time of Augustus, and in the days of Aurelian was valued at its weight in gold. This was probably owing to the mode in which it was procured by the merchants of Alexandria, who had no direct intercourse with China, the chief country in which the silk-worm was then reared. Though so highly lauded both by Greek and Roman writers, it was in frequent use for many centuries before any certain knowledge was obtained either of the country from which the material was derived, or of the means by which it was produced. By some it was supposed to be a fine down adhering to the leaves of trees and flowers; by others it was regarded as a delicate kind of wool or cotton,[2] and even those who had some idea of its insect origin, were incorrectly informed of the mode of its formation.[3] The court of the Greek emperors, which surpassed even that of the Asiatic sovereigns in splendour and magnificence, became profuse in its display of this lustrous ornament; but as the Persians, from the advantages which their local situation gave them over the merchants from the Arabian Gulf, were enabled to supplant them in all those marts of India to which silk was brought by sea from the East, and had it in their power to cut off the caravans which travelled over land to China through their northern provinces, Constantinople thus became dependent on a rival power for an article now deemed essential to the enjoyment of civilized life. The Persians, with the rapacity inseparable from the power of monopolists, exorbitantly raised its price. Procopius says the price per ounce for silk of common colours was equal to L.2, 12s., and of royal purple, L.9, 8s. English money; and many attempts were made by Justinian to free his subjects from their exactions. An accidental circumstance is said to have accomplished what the wisdom of the great legislator was unable to achieve. Two Persian monks, who had been employed as missionaries in one of the Christian churches established in India, had penetrated to the country of the Seres, that is, to China, where they observed the operations of the silk-worm, and acquired a knowledge of the art of working up its produce into so many rich and costly fabrics. The love of lucre, mingled, it is said, with a feeling of indignation that so valuable a branch of commerce should be enjoyed by unbelieving nations, induced them to repair to Constantinople, where they explained to the emperor the true origin of silk, and the various modes by which it was prepared and manufactured. Encouraged by the most liberal promises, they undertook to transport a sufficient supply of these extraordinary worms to Constantinople, which they effected by conveying the eggs of the parent moth in the interior of a hollow cane. They were hatched, it is alleged, by the heat of a dunghill, and the larvæ were fed with the leaves of wild mulberry. They worked, underwent their accustomed metamorphoses, multiplied their kind,

[1] See also translation, recently published at Shanghae, and reprinted at Madras in 1858, of a *Dissertation on the Silk Manufacture, and Cultivation of the Mulberry*, by Tseu-kwang-K'he, a Chinese minister of state, in which are historical references to silk-growing ranging in Chinese annals from B.C. 2356 to A.D. 960, with many interesting details of the cultivation of the trees, care of worms, and manufacture of silks generally.

[2] See Robertson's *Historical Description concerning Ancient India.*

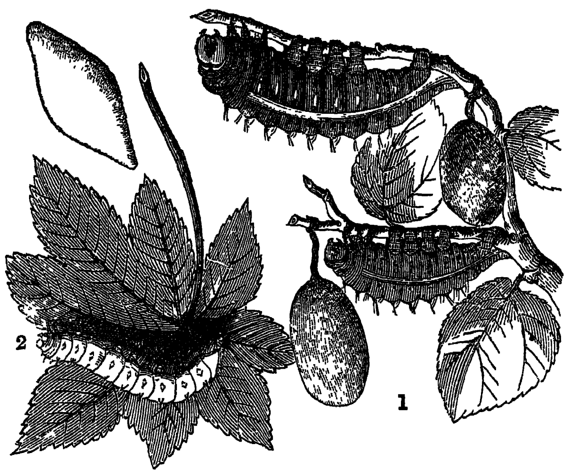
[3] *Edin. Cabinet Library*, viii. 152.

Silk-worm. and in the course of time have become almost universally cultivated throughout the southern countries of Europe, thus effecting an important change in the commercial relations which had so long existed between our continent and the east.[1]

The cultivation of the silk-worm spread, at the period of the first crusades, from the Morea into Sicily, the kingdom of Naples, and several centuries afterwards, more especially under the administration of Sully, into France, to which kingdom it is now a source of great wealth. It is indeed curious to consider how the breeding of a few millions of small caterpillars should occasion such a disparity in the circumstances, or at least in the outward show, of different tribes of the human race. When the wife and empress of Aurelian was refused a garment of silk on account of its extreme costliness, the most ordinary classes of the Chinese were, we doubt not, clad in that material from top to toe; and although, among ourselves, weekday and holiday, we see the great mass of our female population clothed externally in silk attire, yet our James the Sixth was forced to borrow a pair of silken hose from the Earl of Mar, that his state and bearing might be more effective in the presence of the ambassador of England, "for ye would not," said the uncouth pedant, "that your king should appear as a scrub before strangers." Queen Elizabeth, in the third year of her reign (1560), was highly gratified by receiving from her silk-woman, Mrs Montague, a pair of knit black-silk stockings, with which she is said to have been so delighted as never afterwards to have worn those of cloth. Even Henry the Eighth, notwithstanding his expensive magnificence, could not indulge himself as did his daughter, but wore cloth hose, except on gala days, for which he sometimes contrived to obtain a pair or two of silken ones from Spain.

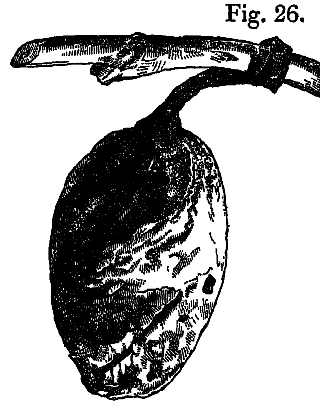
It was long supposed that the cultivation of the white mulberry required a high temperature, but the contrary is proved by the fact of its thriving well in so many northern provinces of Germany. Even in Russia it is reared with considerable success. In France, however, it is not raised in large quantities with a view to the feeding of silk-worms, except in the central and southern provinces, as far north as the environs of Lyons. It might be easily grown throughout France, as also silk produced. A double crop might be obtained in the south, as in Naples. The white mulberry is by no means nice in regard to the constituent character of its soil, and it is known to flourish in a great variety of situations. At the same time, the nature both of soil and situation seems to exercise considerable influence over the produce of the caterpillars which feed upon its leaves; the silk being cleaner, ampler, and more resistant, in proportion as the plant is successfully cultivated in a dry and rather elevated position. In the south of France it is customary to cut off all the medium-sized branches every year, with a view to facilitate the production of a greater number of young shoots, these bearing the largest and most numerous leaves. The leaves of the black mulberry (*Morus nigra*), and in general those of all the other species of the genus, are adapted to the nourishment of the silk-worm cultivated in Europe, which is the same as that which produces the greater proportion of the Chinese manufacture. But in Bengal and other parts of India, and to a very large amount in China, valuable silk is procured from the cocoons of other species of moth. The first of these is described by Dr Roxburgh under the title of *Phalæna paphia*, and occurs in such abundance over many parts of Bengal, and the adjoining provinces, as to have afforded to the natives, from time immemorial, an abundant supply of a very durable and dark-coloured silk, called *Tusseh*, much used by the Brahmins and other sects of Hindoos. The thread is too fine to be reeled off; the cocoon is softened, carded, and spun. Fig. 25 represents Tussah worms and Silk-worm.

Fig. 25.



cocoons. This species, however, cannot be domesticated; so the hill people go into the jungles, and when they perceive the dung of the caterpillars under a tree, they immediately search for them among the branches, and carry off what they require. These they distribute on the Asseen trees (*Terminalia alata glabra* of Roxb.), and as long as they continue in the caterpillar state, the Pariahs guard them from birds by day and from bats by night. The natural food of this species is the *Byer* tree of the Hindoos, called *Rhamnus jujuba* by botanists. The Jaroo cocoons are produced from a rare variety of the kind just mentioned. The tussah silk-worm moth appears to be synonymous with *Bombyx mylitta* of Fabricius, and is figured by Drury.[2] The curious silk band, hard as leather, by which this worm secures its cocoon on the tree, is seen in fig. 26. Fig. 25, 2, is the Arrindy worm and cocoon. The

Fig. 26.



Arrindy silk-worms, however, belong to an entirely different species, *Phalæna cynthia* of the last named author.[3] It seems to be peculiar to two districts in the interior of Bengal, viz., Runpore and Dinagepore, where it is reared in a domestic state. The food of this kind of silk-worm consists entirely of the leaves of the common *Ricinus*, or Palma Christi, which the natives call *Arrindy*, and hence the name by which the insect is itself distinguished. The cocoons in general are about a couple of inches in length, three inches in circumference, and pointed at both ends. They are of a white or yellowish colour, and their texture is extremely soft and delicate. The filament, indeed, is so extremely

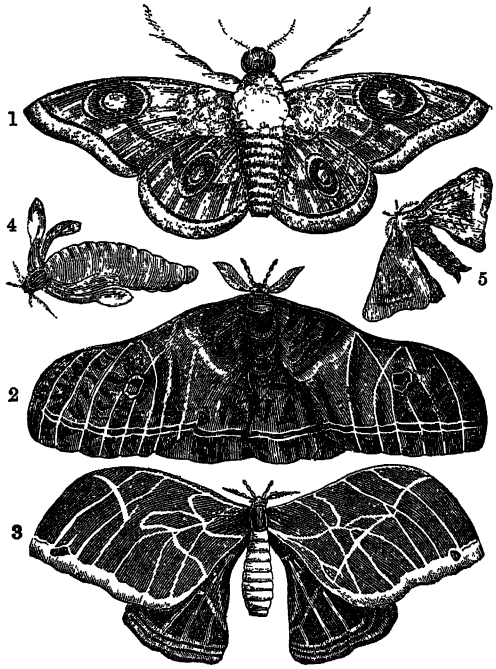
[1] See Procopius, *De Bello Gothico;* Gibbon's *Decline and Fall* (Reign of Justinian); *Edin. Cabinet Library,* already cited; and this *Encyclopædia*, art. ENTOMOLOGY, ix.

[2] *Illustrations of Natural History,* ii., tab. 5.

[3] Ibid., tab. 6.

fine, that the silk cannot be wound off, but must be spun like cotton. The yarn is wove into a kind of coarse white cloth, of a seemingly loose texture, but of such extreme durability, that the life of one person seldom suffices to wear out a garment of it, so that the same piece frequently descends from parent to child. It must always be washed in cold water.[1] Fig. 27 shows the four principal wild silk

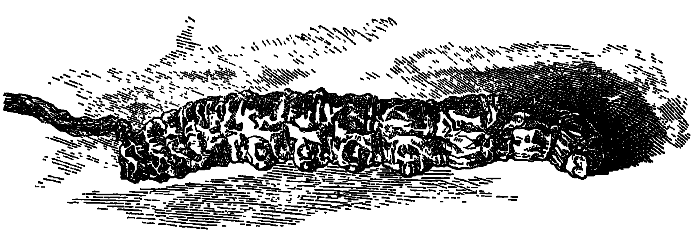
Fig. 27.



moths of India: 1. Tusseh; 2. Arrindy male; 3. Female; 4. Religiosa; 5. Moogha. All these are so easily reared in India, and at so low a cost, as to be used there in immense quantities, and might be imported into Europe with great advantage. The Chinese have wild worms, feeding on the oak, the ash, the pepper tree, and probably other kinds; one produces cocoons monthly, others three-monthly, others one crop a-year.

The silk-worm represented in fig. 28 is found at the roots

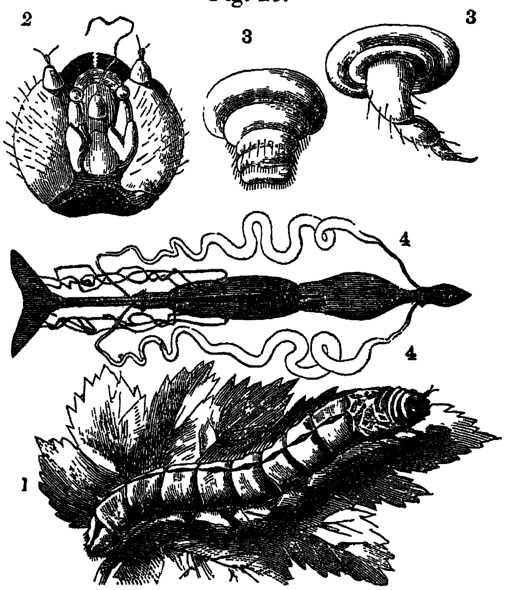
Fig. 28.



of trees in Australia. These caterpillars often become (as those received are) entirely lignified, and from the mouth of each proceeds a root (apparently) of 6 or 8 inches in length.

The practice of rearing silk-worms in this country is usually followed rather as an amusing occupation than for purposes of gain. Abroad, it is pursued with skill and energy as one of the most profitable businesses of life. The female moth is induced to lay her eggs, about 300 in number, upon sheets of paper, to which they adhere by a natural viscosity. The period of hatching may be hastened or retarded by a higher or lower temperature, and the chief point for the breeder to bear in mind is, that the worms should not make their appearance till an abundance of natural food is near at hand. The eggs are at first of a very pale hue, but such as are to produce worms speedily become of a bluish grey colour; the unproductive ones continuing of a pale yellow. As there are tricks in all trades, the foreign dealers often favour their old useless eggs with a wash in dark-coloured muddy wine, which gives them for a time a deceptive healthy aspect. A stove-room, or other apartment, with a temperature of 64° will suffice for the hatching of eggs, and the heat may afterwards be raised with advantage a few degrees every other day, for about ten days, but not so as to exceed about 80°. They will, however, thrive well enough in summer in any comfortably kept apartment, though a continuous warmth by night as well as by day is of great advantage. Whatever parts of a brood are hatched at the same period should be kept together; and those of

Fig. 29.



same age, or which shed their skins at sametime, ought to be kept and fed together, so that they may pass through the changes of their course with proper care and safety.

The best and simplest apparatus for keeping silk-worms is that used in France and Italy. It consists of small tables to be used from hatching to the time when, by reason of increasing size of the worm, more extensive accommodation is necessary. To meet this, wooden stages about 6 feet wide, and the length which will allow of passing round them, are placed, the lowest one, 3 feet from the ground, then another and another, &c., above it at intervals of 12 or 15 inches. The insects are gradually spread over these till their full size is attained, when, for each ounce of eggs hatched, 300 square feet of boarding superficies must be allowed. When cleansed, it is by turning up the leaves and sweeping off the offal. The worms having six claw-feet and eight that stick by pressure, will not easily fall off the boards. The worm, 1; its head, 2; feet, 3 3; and silk-bags, 4 4, are shown in fig. 29.

[1] See "Account of the Tusseh and Arrindy Silk-worms of Bengal," by William Roxburgh, M.D., *Linn. Trans.*, viii. 33; and "British India" (in *Edin. Cab. Library*), iii. 154. Also an elaborate and interesting paper in part ii. pp. 237–270, of *Proceedings of Zoological Society, London*, 1859, being "Synopsis of Asiatic Silk-producing Moths," by F. Moore, assistant, Museum, India House, comprising 30 species, minutely described, of *wild* silk moths, their caterpillars, and food.

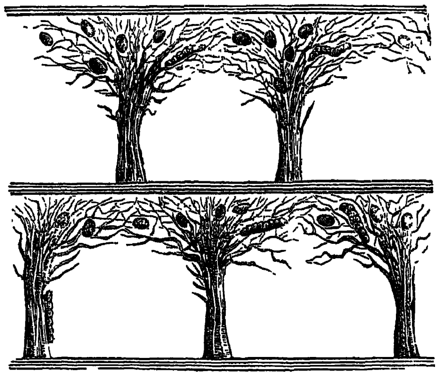
Silk-worms ought to be fed with regularity at least four times a day; additional or intermediate meals being given when their extraordinary appetite is manifested. The duration of the lives of these animals depends, to a certain extent, upon temperature and locality; warmth, well kept quarters, and abundance of food, being found to hasten the spinning process. All these things should be very sedulously attended to by those who rear silk-worms in large quantities with a view to profit, time being so imporant an element in all commercial undertakings.

In the south of France 40 days is the average time elapsing from hatching to beginning to spin the cocoon. Dandolo got the time reduced in his experiments to 30 days; Bronski to 22, 23, and 24 days. The Chinese get to the commencement of cocoon spinning in 24 days. In the United States the best kind of cocoons feed 20 days, the worst 50 days. In England worms hatched frôm foreign eggs were 56 days before spinning. Others have been 45 days in one case, 70 days in another. Experience can alone decide how far food and warmth may be safely supplied so as to lessen the time.

When the silk-worm makes its first appearance, it is of a dark colour, and measures only one or two lines in length; after the lapse of eight days, it is attacked by a lethargic sickness. The creature is about to cast its skin, and for about three days it remains motionless, refusing food. On the termination of this period the old skin opens at the anterior end, the fore-legs are disengaged, and the new and delicately attired worm escapes forth, to enjoy itself once more on pastures green. It had previously exuded a peculiar fluid, and had also, by means of its silken string (how provident is benign nature!) fastened down its old and useless coat, that it might not be dragged after it when the hour of delivery has arrived. This coating is so complete, that even the skin which covers the eyes, and the teeth are thrown away. Immediately after this renewal, the body of the worm appears grey and somewhat wrinkled, the new coat being made full size to admit of future growth; but the latter attribute speedily disappears. It feeds freely for five additional days, during which it grows to about half an inch in length, and is then seized by its second sickness, and again casts its skin. Then succeed other five days of feasting, in the course of which it increases to three quarters of an inch, when it sickens a third time, and acquires in a similar manner a third suit. Again five days of feeding; again a removal of the outer garment, or a fourth casting of the skin. The caterpillar now measures from an inch and a half to two inches long, and for a continuous period of about ten days it eats voraciously, and increases greatly both in length and thickness. On the expiry of this last-mentioned period, it has attained the full size of a silk-worm, being from two and a half to three inches long. Its desire for food abates, it nibbles and wastes its leaves, then ceases to eat, and becomes restless and uneasy, moving circularly from side to side, owing to some instinctive feeling of desire to secure a quiet haven in which to spin its silken shroud. Its colour is now of a palish-green, with a mingling of a deeper hue. In the course of about twenty-four hours from the time of its having ceased to feed, the silky fluid becomes abundantly supplied to its interior reservoirs; the green colour disappears; the body becomes of a soft yellow, and somewhat transparent towards the neck. Previous to spinning, the general dimensions rather decrease than otherwise, but greater firmness of substance is acquired.

When the desire to spin is thus unequivocally manifested, art must come in aid of nature. In China, netting is extended on frames. In India, paper tubes are placed; into these caterpillars will creep and weave their golden woof incessantly till the work is done. Those who rear extensively in Europe, supply their caterpillars with small twigs or branches of broom, heath, or any other brush-wood, which happens to unite suppleness and tenacity. These are placed carefully so as to form arches across the tables, leaving in the arcades room for the worms to adjust themselves comfortably to spin (fig. 30).

Fig. 30.



Great attention must now be paid in regard to keeping up a moderately warm temperature. The observations of a writer in the fifth volume of the Society for the Encouragement of Arts, amply illustrate this important point. He had successfully reared 30,000 silk-worms, when in the beginning of July, just as they were about to spin, there came a chilly north-east wind, and many assumed the chrysalis state, without making any attempt to form a protecting covering. On examining these individuals, it was apparent that their silken reservoirs had been congealed by cold, so that the insects were unable to draw out the filaments in their usual slender state, their own capacity of movment and exertion being no doubt at the same time chilled. Even when they have commenced to spin, or have made some progress in their labours, they will cease if exposed to damp and cold, and if the surrounding web is still of sufficient transparency, they may be seen lying idle and inactive in the interior of their cocoons. But if the temperature is raised, they will immediately resume their work. A heat from 65° to 70° is thought advisable at this time. The opposite extreme of oppressive heat or close temperature must be equally avoided.

These beautiful silken coverings, or cocoons as they are called, are generally completed in three or four days. They are commenced by the formation of a loose decomposed structure of an oval form, made of what is denominated *floss* silk. Within this, in the course of the ensuing days, the firmer cocoons are completed. These are rounded somewhat oval balls, varying in tint, but some species give cocoons of a golden hue, some others of a straw-colour, and some white. Those of a bright yellow yield the greater weight of reeled silk, but as the finer colouring substance is contained chiefly in the gum which is boiled out before weaving, less advantage is reaped by the grower. Raw silk, of a pale colour, is moreover preferred, on account of its better reception of certain dyes. Whether the insect sleeps or not during spinning, it rests. Its daily work may, by cutting the cocoon lengthwise, be separated, and the different layers found indicate the rests, and are also distinguished by great difference in the proportions of gum, albumen, and colouring matter found in each. The included worm, having finished its labour, casts its skin once more, but never appears again as a caterpiller, as it now assumes that rounded shapeless form termed *chrysalis.* The cocoons may be selected for reeling in about a week, and then comes the ungrateful and ungracious task of destroying the peaceful tenants of the tomb. This is variously accomplished, either by exposure (in sunny climates) for some hours to unclouded solar light and heat; by

Silk-worm.

steam; or by placing the cocoons in a temperature corresponding to that of an oven from which loaves have just been withdrawn after being baked.

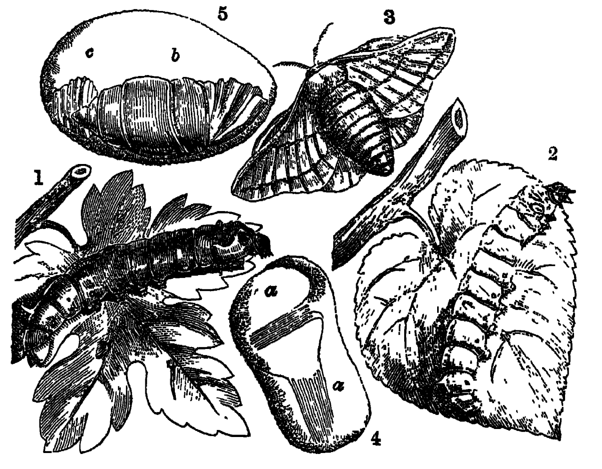
If not killed, the chrysalis remains in its natural dormant state for a longer or shorter time, in accordance with the clime in which it has had its birth. In eastern countries this is not more than eleven days; in the most southern parts of Europe from eighteen to twenty; in France about three weeks; in England, if unaided by artificial means, about a month. After these respective periods, according to climate, whether natural or acquired, the perfect moth emerges, and the reason for destroying the chrysalis is this, that, in emerging, the moth makes an opening by softening the gum and putting aside the silk thread, and so by letting in the water prevents the cocoon being reeled. A few, however, are of course spared for the sake of a future progeny, sound cocoons being selected, and in equal numbers as to sex. The worms break out of the egg in due season, go up to spin, and eventually emerge from the cocoon, for the most part, from two to three hours after the morning light reaches them.

Such as have been killed for reeling are, before the commencement of that process, placed in warm water, so that their gummy nature may be partly softened, but not dissolved. The length of silken thread which may be unwound from a single cocoon, is in truth astonishing. Count Dandolo found it occasionally to exceed 600 yards. The French commissioners, examining Count Bronski's cocoons, saw one reeled which they certify to have been 982 metres in length. The length must, to some extent, be indicated by the weight of the cocoon, an Indian one of 1½ grains, and an American one of 8 grains, may well be supposed to differ greatly in length of thread; more facts are needed to decide on any true average. The only English filature of any magnitude for reeling silk was put into operation at Tiverton in 1825, by J. Heathcoat, Esq., who caused 35,000 lb. of Florentine cocoons to be reeled there. The quality and quantity of raw silk (about 3300 lb.) were satisfactory, and this produce was wrought into lace. There was no profit over silk grown abroad.

The following statements are intended to explain those points which are necessary to the production of the raw silk of commerce of the *best quality*, and at the *least cost*. The silk-worm cultivated on the continent of Europe is of the same family as that which produces the white silk we import from China. So far as is at present known, the Chinese cultivate the production of that domesticated *annual* worm, which gives the *pure white* silk only, when they wish to use the raw silk reeled from them in the manufacture of their woven, plain, or flowered broad fabrics, crapes, &c. They have, however, other species, some monthly, or rather reproducing eight times; and some three-monthly, or producing four successive hatchings and four crops of cocoons, in the year. Like those of India (with which they are probably identical in origin), these cocoons are all inferior in weight, and, from the greater fineness of filament, much more difficult to reel in an even size of thread; therefore are much less valuable in commerce. These silks, as also those from their wild silk-worms (of which an immense quantity are gathered every year), are spun and woven into the heavy silk cloths with which the Chinese cover themselves in cold weather, and are cheap enough for every common purpose. Those which were brought into Europe originally produce chiefly yellow silk; but about one-tenth of the worms in each yellow hatching give cocoons of a spurious, inferior white colour. This domesticated silk-worm of China, Bengal, or Europe, is the larva of the ***Bombyx mori***, a pale coloured moth, with two or three obscure and transverse streaks, and a lunate spot on the superior wings. This caterpillar feeds on the leaves of the mulberry; and before assuming the chrysalis form, it spins a protective covering. This cocoon is oval in shape, if by a female; but if by a male, the cocoon is round at each end, but of less circumference in the middle part. The engraving (fig. 31) shows two species, 1 2, of

Silk-worm.

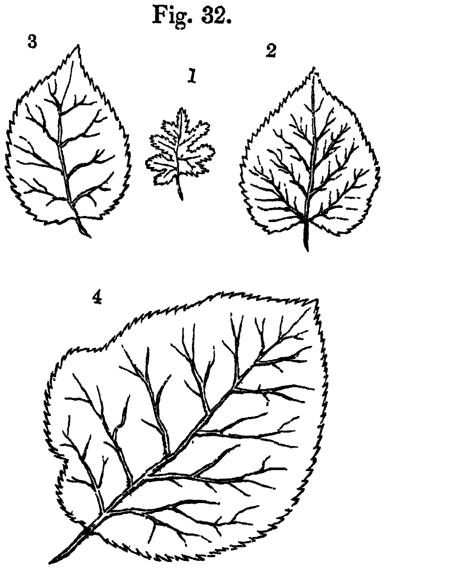
Fig. 31.



Italian worm; the moth, 3; the cocoon of a male, 4; that of a female, 5; and the chrysalis *b*, with the last skin of the worm, *c* in the latter. On the cocoon of the male is shown, *a a*, the zig-zag mode in which the thread of silk is laid in patches by the worm when forming its temporary abode. The finest of each sex in size, weight, colour, and compactness of make, are carefully selected and secured for next year's eggs; any discoloured, or ill-made, are reeled off without killing the chrysalis; the remaining good ones are, in China, killed by being placed in hot dung; in India, under the heat of the sun, or dung, or by baking; in Europe, by baking (or which is best), by placing the cocoons in a steam bath.

Domesticated silk-worms will live, and even a small portion of a hatching may spin cocoons, if fed upon lettuce; but their existence is a weak and languid, because an unnatural one. A healthy, full-grown worm shows, along each ring on its back, from tail to head, an expansion and contraction, indicating pulsation of 40 to 45 beats in a minute. If fed on lettuce, this is reduced to 20 or 25, and often lessens till the insect ceases to live. The mulberry-

Fig. 32.

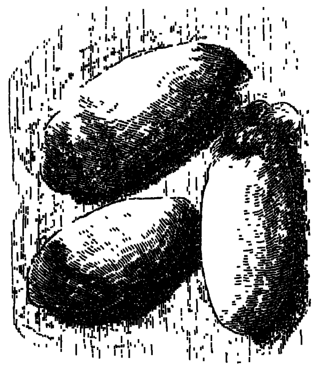


leaf, therefore, furnishes its only natural aliment. This in Italy and France is for the most part the produce of the

Silk-worm.

white variety (*Morus alba*). The wild leaf, 1; grafted, 2; black, 3; and large *Multicaulis*, 4, are shown in fig. 32. The worm is always most safely and easily fed upon the white kind until it has completed its last sloughing of the skin; by that time the black mulberry (*Morus nigra*) will usually have come into leaf; and will, if the silk to

Fig. 33.



be produced be of the yellow colour, furnish superior brilliancy in dyeing the darker hues. For white silks, and the lighter shades of dyed colours, no doubt the white, or rose variety of mulberry, should furnish exclusively food for the worms. Valentia silk is, to a large extent, produced by worms fed on black mulberry-leaves. An experiment, by the hatching of about 10,000 worms at Nottingham, in 1839, showed a loss of seven-eighths of the worms which were partly fed on lettuce. Of those fed (by necessity in this case, from the absence of any white mulberry-trees) upon the leaves of the black mulberry, the loss, before spinning of the worms hatched, was between 30 and 40 per cent. The loss in Europe, under peasant manage-

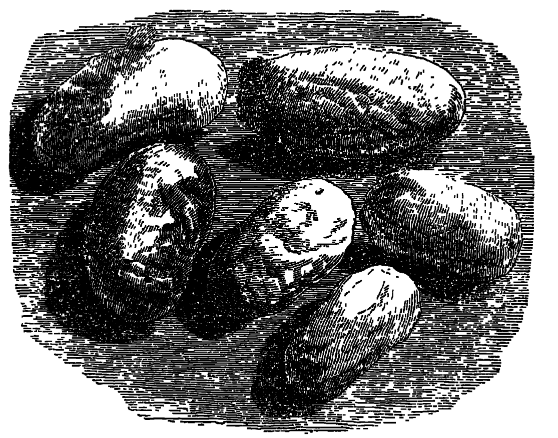
Fig. 34.

ment (which includes half the production of ordinary years), is generally 40 to 60 per cent., fed upon white mulberry. Larger proprietors suffer less loss from ordinary diseases, often rearing 70 per cent. of the worms hatched. Epidemics are, however, very fatal, when large numbers of worms are bred together.

The mulberry-tree is well described, from its important uses, by a French writer, Olivier des Serrès, as "full of the blessing of God." It is found growing in most temperate climates in the Old World, and several varieties in the New. Long before the time of Justinian it had been brought from China or India into Persia and Asia Minor; and, at length, was spread around the Bosphorus, and throughout Greece, probably giving the name *Morea* to the Peloponesus. In 1130, Roger King of Sicily transported the tree, together with silk-worms, and persons used to their cultivation, into his own country. It became well known in Naples; from whence, in 1493, certain nobles, who had followed Charles VIII. to Italy, on their return from that unfortunate expedition, brought the mulberry, and planted it at Montelimart; where, a few years since, these trees, the source of so rich a branch of commercial industry to France, were still the objects of almost religious veneration. Our James I., desirous of emulating the successful efforts put forth on the continent to establish the growth of silk, caused black mulberry-trees to be planted in nearly every parish in England, where thousands of them are still flourishing in a fruitful old age. Experiments have frequently been made for raising silk-worms in this country. The few in which French or Italian eggs, and the black mulberry, have been employed, proved successful. Bertezen thus took the medal of the Society of Arts seventy years ago, by producing good cocoons and raw silk, no doubt hatching French eggs, and using the black mulberry-leaf. The attempt, before mentioned, made at Nottingham, was perfectly successful. Specimens of the cocoons are placed in the Adelphi, London, and in museums in Birmingham, Glasgow, Manchester. &c. Three hundred of these cocoons weighed a pound. In France and Italy two hundred and fifty are usually required. The time from hatching to spinning was prolonged about fourteen days by the humidity of our climate. Cocoons spun by the common English silk-worm average, when dry, each 1 to $1\frac{1}{2}$ grains (fig. 33); Bengal

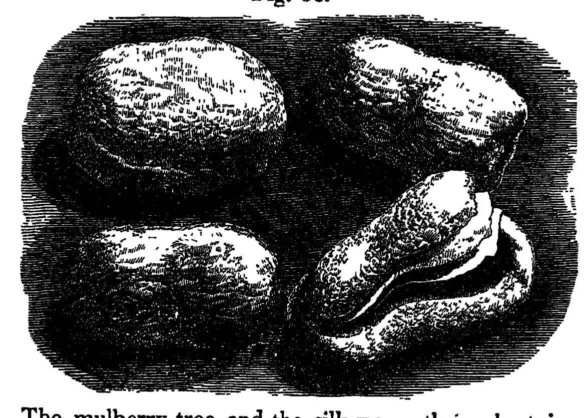
Silk-worm.

Fig. 35.



rainy crop (November), $1\frac{1}{2}$ to 2 grains (fig. 34); Italian vary from 3 to 6 grains (fig. 35); Nottingham experiments from foreign eggs, $2\frac{1}{2}$ to 5 grains (fig. 36). In New Jersey, U.S., by two hatchings a-year, cocoons have been obtained from one kind of silk-worm averaging about 5 grains (fig. 37); and from another, an annual worm (Mammoth), weighing, when dry, 6 to 8 grains (fig. 38). Though silk of good quality may be produced in England, yet its cost, as compared with that of drier climates, would render it unprofitable.

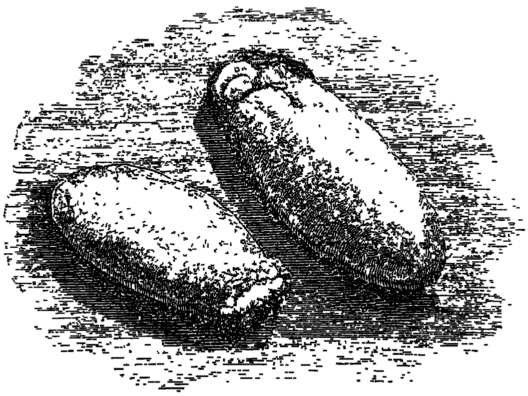
Fig. 36.



The mulberry-tree and the silk-worm thrive best in a pure, dry air, in the neighbourhood of mountains, and in illy districts, upon a dry soil. The tree should be trained

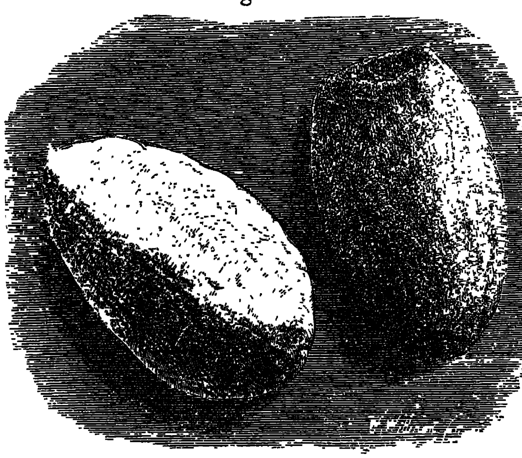
Silk-worm. to a standard form, and an open head, being annually pruned, and the stem and principal branches freed from insects. Thus treated, the trees will bear being stripped of the leaves each year, for ages. At thirty years of age an average tree will supply 50 lb. weight of leaves annually, and 250 lb. weight of leaves will feed 2500 worms, equal to the

Fig. 37.



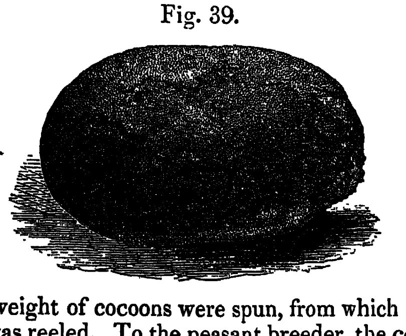
production of 12 oz. weight of raw silk. The following short particulars of a certain French "recolt" (crop) will show consumption of food, and results:—The manager hatched 11 oz. of eggs; *i.e.*, about 33,000 per oz., or 363,000, reduced gradually before spinning to 241,000. He supplied, during 32 days, up to 30th May, and before

Fig. 38.



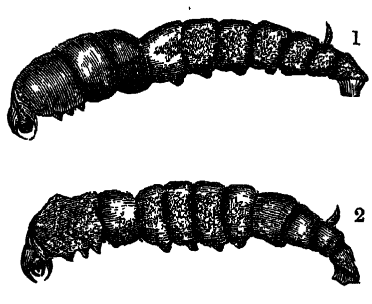
last change of skin, 10,600 lb. weight of leaves. On 31st May, 1000 lb.; June 1, 1500 lb.; 2d, 2500 lb.; 3d, 2500 lb.; 4th, 2500 lb.; 5th, 2000 lb.; 6th, 500 lb.; *i.e.*, during these seven days of their great appetite, and filling silk bags for future cocoons, these insects ate 12,500 lb. weight of leaves; in all, they consumed 23,100 lb. weight of leaves;

Fig. 39.



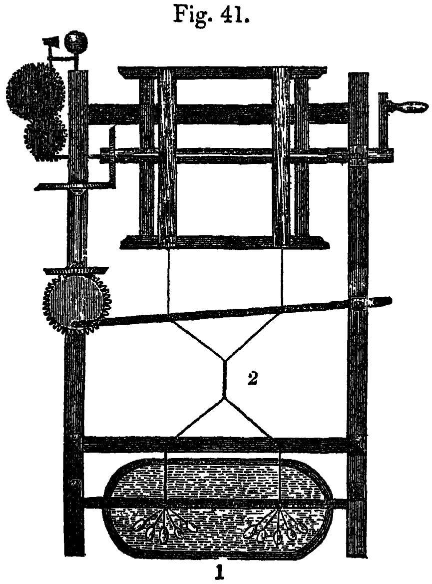
1050 lb. weight of cocoons were spun, from which 87½ lb. of raw silk was reeled. To the peasant breeder, the cost of this process is the labour of his family and himself, in planting, pruning, hatching, gathering leaves, and feeding; and the proceeds paid to him for his cocoons in hard cash is usually entirely additional to his ordinary income. The average of many years' cost and prices, computed by a French grower of high character, is, that the proprietor of large crops gains 12½ per cent.; and the purchaser and reeler of cocoons for the market makes about 12½ per cent. upon his outlay in capital, risk, and skill. A rough calculation is thus made in France:—An ounce of eggs requires 20 quintals of leaves, and will bring 1 quintal of cocoons, to be reeled into 120 ounces of silk. The temperature of the air in which silk-worms are bred should be at hatching about 85 deg. Fahr., and gradually lowered to 75 during great appetite, and 65 at spinning, and with adequate means provided for its frequent change. As the insect progresses in age and size, the air without renewal soon becomes vitiated. Cleanliness is imperatively necessary to its health; therefore vegetable refuse and excrementitious matter must be withdrawn; at first weekly, then half-weekly, daily, and during the great appetite, constantly. The leaves must be given to it free from moisture, not heated, or even damp, however wet when gathered. If there have been diseases amongst the worms in the previous year, the walls, boards, and tools for cutting off branches, and spreading out leaves, must be most carefully scraped, washed, and purified. We have known disease continue in a building, the wood-work and even walls becoming leprous, and necessitating destruction, or disuse for this purpose, of the place altogether. Late experience for several years of the loss of half or two-thirds of the crop in Europe, by epidemics amongst silk-worms, renders this a most interesting and important point in management. Foreign writers have enumerated as the diseases of silk-worms "Calcinès" and "Lusettes," "Gras" and "Tripes," and "Muscadine;"—the two former produced by electrical and atmospherical causes; the next two by improper state or quality of food; the last as an ineradicable plague or leprosy—the cause unknown. Each of the first-named four diseases, if it invades a breed of worms within the last ten days of their eating course, or when going up the twigs for the purpose of spinning their cocoons, is dangerous and difficult to remedy. Lessened supplies of very carefully selected leaves, and plenty of fresh air, into which are introduced the fumes of burned aromatics acting as stimulants, have been, in China and Europe, found most useful. A hatching has been saved, when supposed to be beyond restoration to vigour, and thrown out upon a straw-yard, by the clear cold air of night, and almost every worm has formed its sound cocoon, the crop being, four days after, gathered from the straw. Increased dry temperature, together with vinegar burned in large quantities for an hour or two, has sent up to spin nearly every worm which had, from the first effort to mount, fallen, in consequence of a sudden north-east cold blast, or of a violent storm, and discharges of electricity. We have observed two diseases not described in works on this subject (fig. 40). One (1), probably the effect of lightning, rendering the head and two front rings of a coal-black colour, and showing a tight ligature beyond; the other (2) swelling out the four middle rings with tight ligatures at each end of these rings. Both were fatal and incurable, as far as could be ascertained. This whole subject of disease amongst silk-worms deserves more minute

Fig. 40.



inquiry throughout their whole course on the part of scientific observers. This will necessitate a close analysis of the proportions of fibre, resin, albumen, saccharine, and colouring matter and water, which enter into the composition of the most healthy leaves, and from which the insect obtains nutriment, and ultimately eliminates the silky materials for its cocoon in largest abundance. All these silk-spinning caterpillars can throw out, on the approach of danger, their silk thread from the opening of the tube under their mouth, attaching it at once to anything near; and this they do at any time from the moment of hatching, even before having eaten. The thread is double, supplied from long silk bags, which open into the tube or duct where they are brought together, and are there covered with gum and other matters, which varnish hardens immediately on exposure to the air. This filament of the cocoon is continuous through its whole length; its size is according to the species of caterpillar, and also depends on the health and strength of each worm. It decreases gradually as drawn out within the cocoon, till it becomes at the last end only about two-thirds the size it was at the outside commencement. The eventual thread of raw silk is rendered of even size by its being composed in reeling of two-thirds of the filament drawn from those cocoons which are partially reeled off, and one-third from those newly begun to be drawn off. Though the form of this silk ball is somewhat rounded or oval, yet the insect does not lay its thread in rings round its circumference, but in zig-zag patches here and there; which, nevertheless, when the cocoons are wound off in warm, or even cold water, if the produce of healthy worms, will draw out in a perfectly straight line; and the whole covering of the chrysalis within will be wound off, from end to end (in length usually of 600 to 1000 yards) frequently without breaking. But if the insects have been weak or unhealthy; and if therefore ill supplied with the varnishing, adhesive substances which should make all parts of the entire length of the thread equally compact as laid in the cocoon, and thus equally softened by the warmth of the water, then one or more of these zig-zag patches will often separate in a mass from the remainder of cocoon, and come off, passing towards the reel in a "burr" or *knott.* This is not all the mischief, which the following explanation shows:—As the raw silk threads are winding off, they bring with them 25 or 30 per cent. of their entire weight in gum. To

Fig. 41.



bind the four, six, or more filaments from as many cocoons together in one thread, a certain proportion of this gum must be left with the thread; the remainder is forced out. To accomplish this with ease and exactitude, the silk is generally wound from the basin (fig. 41, at 1) from two sets of cocoons into two separate skeins on the reel; but the thread of one skein is carried ten, fifteen, or twenty turns round the other (at 2), and then again separately carried forwards. This torsion forces out, according to the size of the thread, and number of turns round each other, the surplus quantity of gum. But if one of the burrs, above spoken of, arrives at this entwining junction, it inevitably breaks one of the threads, and then the whole of both pass together, *in one thread*, upon the skein, which there becomes, for so many scores of yards as the reel may draw off before its exceedingly swift revolutions can be stopped, a thread of double size—twelve cocoons instead of (say) the intended six cocoon silk ("un marriage"). This, however careful the reeling, reduces the value of raw silk ten to fifty per cent., and must result where there is an unhealthy state of the worms. The best cocoons may be, from want of skill or carelessness, reeled into uneven silk. Brutia silk sold in 1825 at 10s. per lb.; care and skill have raised its value to 30s., and even 40s. per lb. in recent years. The pure white three-cocoon silk of the Cevennes is worth 60s. to 70s. per lb., this price being paid chiefly on account of the perfect evenness of so fine a thread. To avoid the evils and loss resulting from double threads in reeling, the thread of each skein may, when the other is broken, be cut by sharp blades (fig. 42), or it may receive the necessary torsion round itself (fig. 43, 1), then the burr breaks it, and no more goes on the reel till tied up afresh. Raw silks may be reeled into threads of heavy weights, say 20 or 40 cocoons each, by a system of division into small numbers, say of four or five cocoons each, at the basin, so as to admit of constant accuracy in keeping up supply to replace broken filaments, and then giving the whole a subsequent union before torsion (*croissée*) (fig. 43, 2; and fig. 44). The

Fig. 42.

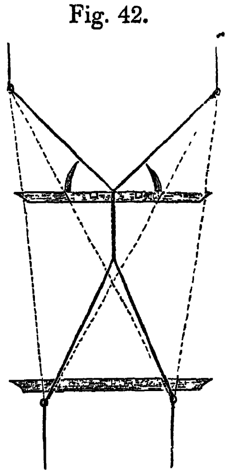
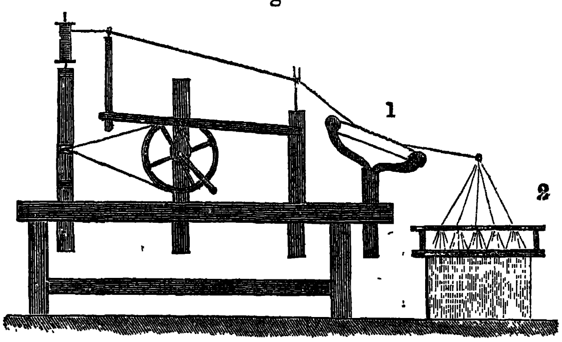


Fig. 43.

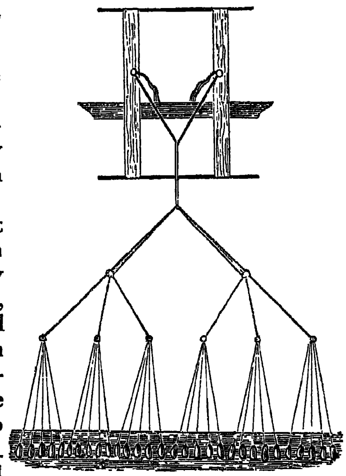


result will be perfect evenness of thread; and for most useful purposes a saving of all the expense of labour and waste in winding from the fine raw, and doubling to make the thread heavy enough for the loom. This method (discovered by us, and patented in France and Italy in 1825) has become almost universal where the raw silk is used, unboiled, or where heavy "trames" are desired of an even, good quality. Raw silk may be reeled, and receive an actual twist at the same time, while passing upon the bobbin (fig. 45). This also was the subject of a patent in 1825–26; but in practice nothing is gained by it in time or labour, and certain inconveniences appear to be an unavoidable result.—For peasants to reel their own cocoons is an unwise system;

Silk-worm.

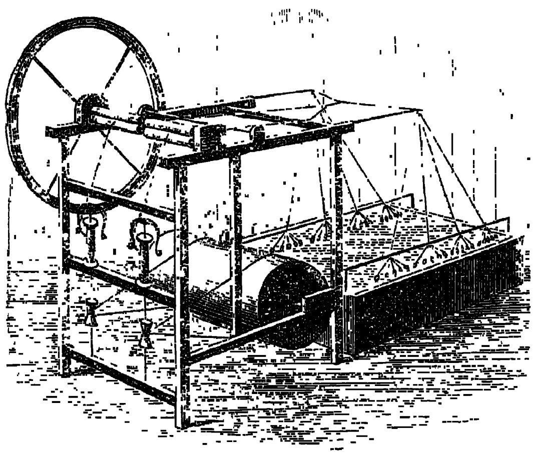
their cocoons, wound off by professed silk-reelers, always produce a much more valuable result in quantity and price. The peasant *reeled* raw silk of China, India, and every other silk-growing country, mixing, as it more or less does, with "filature" (factory reeled) raw silk, tends to depreciate the character of really first-class productions. Peasant reeling is rapidly going out of use in France and Italy.

Fig. 44.



It follows, from what has been stated, that, in order to obtain good raw silk, there must be good, well made cocoons, reeled with care and skill. In order to get such cocoons there must be healthy worms; and to secure these, pure air, dry, wholesome food, and vigilant superintendence, and this not in low and marshy, but in hilly parts, where the mulberry-leaf will, instead of gross watery substance and large size and weight (which may suit the planter but kill the worm), possess a warm and somewhat exciting flavour and scent. The more worms spin out of a given number hatched, the more silk will be reeled from their cocoons, and the more valuable the product in sale and use.

Fig. 45.



The silk-worm does not eat a quantity of food proportionate to the size and weight of its cocoon, as compared with others. The worm acclimated in England eats as much as the French, yet the cocoon of the former yields only one-fifth of the weight of silk. The growth of the Bengal silk of commerce supplies a most important example of neglecting this fact. This Indian silk is produced partly by a worm rehatching four times a-year, viz., two three-monthly, fine weather "bunds" (crops), and two rainy "bunds," and partly by one annual worm; both kinds are fed on mulberry, the *Morus Indicus*. Three thousand cocoons produce, from French or Italian worms, 16 oz. of raw silk. It requires 14,000 of Indian annual crop, and often 20,000 to 22,000 cocoons of three-monthly crop, to reel into the like weight, and that of far inferior quality and value. The thread of the Bengal silk-worm is so attenuated, that a very large proportion of the cocoons breaks off in reeling, and there may be twenty to thirty required to obtain the required size—a number which any one accustomed to silk-reeling will know cannot be counted. Six or ten are therefore supplied at once, which render an even thread, and consequent average value in the market, impossible. The remedy at once seems to suggest itself. Resort to China, to America, or to the continent of Europe, for other and better eggs. This was proposed to the East India Directors in 1832. The memorial was forwarded to the council in Bengal, and by Lord W. Bentinck to every filature. A few pounds sterling would have secured eggs for the supply of every silk-growing district in the peninsula; but they were not obtained, and things remained much as before—a fivefold prime cost, and an article of two-thirds the value. The lamented death of the late Dr Royle has alone prevented the special points insisted upon in this paper (as in the memorial referred to) from again reaching India, and strengthened by his scientific researches, so as to give them effect in improving this truly important and wide-spread product of Indian labour. It is a fact not so well known as it ought to be, that there are more people on the face of the globe clad in silk fabrics than in any other textile material whatever. To what extent India might, by this substitution of superior breed of worms, with other improvements, supply Europe and the world with silk, it is difficult to say. The real cost of the silk supplied in 1800 was but 10s. per lb.; all the testimony of experienced civilians, together with that of the Company itself, say it need only cost 7s. per lb. In 1827 it had risen to 13s. per lb., all expenses paid on board. If the annual worm of China or Europe were taken to the hitherto useless millions of mulberry-trees now growing amongst the lower ranges of the Himalayas, the annual crop of cocoons would doubtless surpass in valuable results, by this three months' labour only, all the five crops added together at present obtained, and leave the peasants nine months for other profitable employment. Mr Bashford, of Surdah, East Indies, an eminent silk-grower of long experience, in a paper read to the Society of Arts, February 1857, states that, having imported French and Chinese eggs, he proceeded, through very careful and well-arranged experiments, to obtain cocoons equal to those of either country. But his main object was to improve the native breeds of worms by crossing them with the Chinese and French, and so continue a three-monthly crop. There is no instance known where any other than an annual crop yields good silk. This plan did not succeed. Under the circumstances of excessive heat, and mulberry-trees growing in marshes, deep in water, hatching-houses filthy and without ventilation, and obstructive attendants, the best foreign worms would, and did slowly, but effectually, become extinct. The facts given by Mr Bashford confirm the principle that an *annual* silk crop should be first obtained of cocoons from foreign eggs; and that the whole system, and even the localities for carrying it on, should be, if needful, changed. The initiatory proceedings and expenses, which need be, for all really useful purposes, of very moderate amount, should be by public authority and at the public charge. Judging from the spirit and talent evidenced in his paper, no man would be more suitable for carrying them out with firmness, skill, and prudence, than Mr Bashford himself.

An effort was made, 1840–1845, to grow mulberry-trees, and produce raw silk, in Jamaica. The hilly parts of the island were found sufficiently temperate for both trees and worms. American eggs were hatched under the care of an experienced grower from the United States, and several small annual crops of excellent cocoons were the result. Silk, of good quality, reeled from them, together with letters from Lord Metcalf, the then public-spirited governor, under whose auspices this attempt was originated, and others, which give details of management, are now lying under our eye. But the affair was in the hands of a public company, who laid out at once too much capital, incurred heavy, yet needless, expenses, and, growing impatient of slow returns, the spe-

culation collapsed, and, it is presumed, a promising and perfectly feasible plan was abandoned. Yet one hundred pounds weight of mulberry-seed, delivered to five hundred negro peasants, having cottages and families amongst the hills, followed three years after by one hundred ounces of good silk-worms' eggs, distributed, in like manner, would have almost certainly resulted in crops of good cocoons. Fifty or sixty basins and reels would have been required to give the raw-silk. The total outlay would not have exceeded L.500 sterling. The proverb is true of every effort made successfully to grow this important raw material: "Patience and perseverance turn mulberry-leaves into the silken robes of a queen."

The following books will be found of use on the study of silk :—

Le Tellier sur l'Education des Vers à Soie, &c., 1744. *L'Art de Cultiver les Muriers blancs, d'elever les Vers à Soie ; et de tirer les Cocons*, Paris, 1757. *Culture des Muriers blancs, et Education des Vers à Soie* Pommier, Orleans, 1763. *Mémoires sur l'Education des Vers à Soie et le Culture des Muriers blancs*, L'Abbé des Sauvages, 2 vols., Nismes, 1763. *Mémoires sur la maniere d'elever Vers à Soie et la Culture des Muriers blancs*, M. Thome, Lyon, 1767. *Recherches sur les Maladies des Vers à Soie*, &c., P. H. Nysten, 1808. *Recherches et experiences sur la Culture des Muriers blancs*, Calvel, Paris, 1812. *Mémoire sur la greffe du Murier*, Duvaure, 1818. In volume seventieth of first series, and volumes second and seventh of second series of *Annales d'Agriculture Française*, interesting papers may be found. Malphigi and Lewenhoek have written upon the anatomy and habits of the silk-worm. Vincent St Laurent has given an analysis of Dandolo's celebrated work on the silk-worm. *Trattato sopra la Cultura del Gelso*, &c., Naples, Velmont di Bolmano, 1796. Under similar titles are works written in French by Bourgeous, Constant Castellat, Isnard, Regnard, de St Jean du Gard, Duhamel, and the Abbé Nollet. In Italian—by Vida, Le Guidoboni, Le Gallo, Le Corsuccio, Garzoni, and Pol Francesco Pol Franceshi. The following French works on Dyeing Silk may be consulted with advantage :—*L'Art de la Teinture Soye*, Macquer, 1763. *Sur les Teintures Solides, ou receuil des Experiences*, par Daubourney, Paris, 1778. *Elemens de l'Art de la Teinture*, Berthollet, 2 vols., 1791. Also the Journals of Arts and Manufactures, published by order of the French Minister of the Interior. (W. F—N.)

SILVER. See Precious Metals.

SIMBIRSK, a government of European Russia, lying between N. Lat. 52. 40., and 55. 40., E. Long. 45. 30. and 50.; bounded on the N. by the government of Kazan, E. by that of Samara, S. by that of Saratov, and W. by those of Nijni Novgorod and Penza. Area, 17,760 square miles. Along the bank of the Volga, which forms the eastern frontier of the government, runs a range of hills about 400 feet high. The rest of the country consists of a gently undulating plain, watered by affluents of the Volga, the chief of which is the Sura, itself the recipient of several smaller streams. The lakes are very numerous, but almost all of small size. The climate is extreme both in heat and cold, the Volga being often frozen over for five months in the year. It is, however, generally salubrious. The soil is fertile, and well cultivated; producing rye, wheat, oats, barley, and other grain, in quantities more than sufficient for the domestic consumption. Hemp, flax, and tobacco, are also raised. The largest proportion of the area consists of arable land, which, in 1849, occupied 6,566,193 acres; the meadow land covered 2,494,488 acres; and the forests 5,478,286 acres. These last chiefly occur in the north of the government, and consist of birch, alder, and oak trees. The number of horses in the country in 1849 was 531,582; of horned cattle, 363,330; of sheep, 1,084,684; of swine, 152,386; and of goats 7886. All, however, are of inferior breeds; and the rearing of cattle is not much attended to, except among the Kalmucks. Although the country is not destitute of mineral resources, no important mining operations are carried on. Several branches of industry, however, are in vigorous exercise. In the year 1849 the government contained 113 manufactories, employing 5684 hands. Among the former there were 28 tanneries, 18 manufactories of cloth, 16 of tallow and candles, and 13 of potash. A considerable trade is carried on by the Volga; corn, hemp, cattle, hides (raw and prepared), fish, and soap, being the chief articles exported. The inhabitants for the most part belong to the Greek Church; but there are also 133 Roman Catholics, 128 Protestants, 76,441 Mohammedans, and 1291 Pagans. Simbirsk is divided into 8 circles, as follows :—

	Pop. (1851).		Pop. (1851.)
Simbirsk	143,243	Alatyr	111,216
Sysran	146,332	Buinsk	108,100
Ardatov	142,680	Kurmysch	98,737
Karssun	162,368	Sengibej	111,566
Total pop. (1851)	1,024,242		

But in 1856 the total population amounted to 1,118,605.

The capital of the government is Simbirsk, which stands on the Volga, about 100 miles S. of Kazan. Its houses are chiefly of wood, and its streets narrow and irregular. There are numerous churches and two convents; and these, as well as an elegant market-house, are built of stone. Simbirsk has also a monument to the historian Karamsin, who was a native of the government. There are here some tanneries, and manufactories of soap and candles. Many of the inhabitants are also employed in gardening and fishing. The trade of the place is considerable, and there is an active navigation on the Volga. A large market is held here annually. Pop. 35,474.

SIMEON *of Durham*, the contemporary of William of Malmesbury, must have been born late in the tenth century. He took great pains in collecting historical information, especially in the north of England, after the country had been ravaged by the Danes. From these he composed a history of the kings of England, from A.D. 616 to 1130, with some smaller historical pieces. Simeon both studied and taught the sciences, and particularly mathematics, at Oxford; and he became precentor of the church at Durham, where he died, probably soon after the conclusion of his history, which was continued by John, prior of Hexham, to the year 1156. Simeon is supposed to have died shortly after 1130. His *History* is included in Twysden's work, and his *History of Durham Cathedral* was published in 1732.

Simeon, *Charles*, an eminently pious divine of the Church of England, was born at Reading in 1759. He was educated at Eton, and at King's College, Cambridge, where he received those deep impressions of religious truth which formed so marked a feature of his character throughout his whole life. The theological studies of the place formed for him the chief attraction. He was presented to the living of Trinity Church, Cambridge, in 1783, and continued to labour with an astonishing amount of assiduity among both poor and rich, learned and ignorant, for the next 53 years. In 1832, his sermons were published, forming 21 volumes, with upwards of 2000 skeleton sermons, which have had a large degree of popularity among the common run of preachers of Great Britain since his time. He was on terms of intimate friendship with nearly all the pious ministers of his day. None was more esteemed than the godly missionary Henry Martyn. Simeon died on the 13th November 1836, leaving behind him a name for piety and worth not likely soon to be forgotten. (See *Memoirs of the Rev. Charles Simeon*, by the Rev. W. Carus, 1847.)

SIMFEROPOL, called formerly *Akhmetschet*, a town of European Russia, capital of the government of Taurida, on the Salghir, 192 miles S.E. of Odessa, and 40 N.E. of Sebastopol. It consists of an old or Tartar town, and a new portion, which has been built by the Russians. The

former is irregularly and wretchedly built, while the latter contains wide straight streets, and a spacious square. The Greek cathedral here is one of the finest churches in Russia. Among the other places of worship are a Roman Catholic, an Armenian, and a Lutheran church, several mosques, and a synagogue. The town contains also several schools, a botanic garden, a large bazaar, an hospital, law-courts, and public offices. Simferopol is the chief centre of all the trade of the Crimea, and is inhabited by Russians, Tartars, Greeks, Armenians, and Germans. Pop. 26,481.

SIMILE. See Comparison.

SIMLA, a British station in India, in the lower portion of the Himalayas, between the rivers Sutlej and Giree, 22 miles N.E. of Soobathoo. It is celebrated for its salubrity, and is much resorted to by invalids for the restoration of their health. It consists of a number of houses irregularly scattered over a narrow mountain-ridge, terminated on the east by the densely wooded peak of Jako, which rises to the height of 400 feet, and on the west by a bare hill of somewhat less height. The scenery of the place is very fine, the valleys and ravines in the vicinity being covered with pine-forests; while the eye may range towards the south over the vast plain of the Sutlej, and towards the north as far as the snowy crest of the Himalayas. The population is very fluctuating. During the winters, which are very severe, it is not more than 2000; but in the milder seasons it is sometimes almost ten times that number.

SIMON MACCABEUS. See Jews and Jerusalem.

Simon, *Richard*, a learned Hebraist, was born at Dieppe on the 15th May 1638. He began his studies in the Oratory of that city, but in a short time quitted the place. From Dieppe he went to Paris, where he made great progress in the study of the oriental languages. Some time afterwards he joined the society of the Oratory again, and became a priest of it in 1660. In 1670 he published some pieces of a smaller kind; and in 1678 his *Critical History of the Old Testament* appeared, but was immediately suppressed by the influence of the gentlemen of Port-Royal. It was reprinted the year after, and its excellence soon drew the attention of foreigners; an edition of it was accordingly published at Amsterdam in Latin, and in London, in English, in 1682. He died at Dieppe in 1712, at the age of seventy-four.

Simon certainly possessed a vast deal of learning. His criticism is exact, but not always moderate; and there reigns in his writings a spirit of novelty and singularity which raised him a great many adversaries. The most celebrated of these were Le Clerc, Vossius, Jurieu, Dupin, and Bossuet. Simon wrote an answer to most of the books that were published against him, and displays a pride and obstinacy in his controversial writings which do him little honour. He was the author of a great many books. The following are the principal, viz.:—*The Ceremonies of the Jews*, 1674, translated from the Italian of Leo of Modena, with a supplement concerning the sects of the Caraites and Samaritans; *The Critical History of the Old Testament*, 1678; *Critical History of the Text of the New Testament*, 1685; *Critical History of the Versions of the New Testament*, 1690; *Critical History of the Principal Commentators on the New Testament*, 1693; *Inspiration of the Sacred Books*, 1687; *A French Translation of the New Testament*, 1702, which was censured by Cardinal Noailles and by Bossuet; *The History of the Rise and Progress of Ecclesiastical Revenues*, 1684, which is commended by Voltaire, as is his *Critical History of the Old Testament; A New Select Library*, 1714, pointing out the good books in the various departments of literature, and the use to be made of them; *Critical History of the Belief and Customs of the Nations on the Levant*, 1711; and *Critical Letters*, 1730. The works of Simon have nearly all been translated into English.

SIMONIDES, a celebrated lyric poet of Greece, and one of the greatest masters of the elegy and the epigram which the world has yet known, was born at Julis, in the island of Ceos, about 566 B.C. He belonged to a family of lyric poets. His paternal grandfather had been a poet; his nephew Bacchylides was a poet; and his grandson, Simonides the younger, was a poet. His attention accordingly was early directed to impassioned verse as a vehicle for communicating his thoughts, and time fully ripened those powers which he had bestowed on lyrics from his earliest years. Simonides was originally chorus-teacher in the town of Carthæa in Ceos, and lived, while he held that office, at the chorus-house, near the temple of Apollo. He restrained early the lively genius of his island race by the cultivation of philosophy, and the practice of moderation. So much was this the case, that the moderation (Ἡ Σιμωνίδου σωφροσύνη) of the poet became proverbial. Many apothegms and wise sayings are likewise attributed to him, which show that he must have been a man much given to reflection. The evasive answer ascribed to him, when King Hiero of Syracuse asked, "What is God?" he must share with the philosopher Thales, as it has been recorded of both of them. He has been accused of avarice by nearly all his biographers, founded partly on the very insecure evidence of tradition, and partly on the alleged enormity which he committed in selling the products of the divine gift within him for a few pieces of base gold. All our writers at the present day do likewise, but then the sin of Simonides consisted in anticipating the present generation in the matter of literary bargain-making by upwards of twenty centuries. One would think he might be excused, at this date, for having got so far ahead of his cotemporaries. Simonides, no doubt, committed an unheard-of act in asking moneyed remuneration for his effusions. But it is one of the prerogatives of genius to be guilty more or less of some outrage upon the current practices of men. From all accounts left of the poet Simonides, he must have been a keen, far-seeing man, with no great amount of what is called character, with a very noble disposition, and a delicacy that sometimes bordered upon weakness. He was in the highest sense a wise, and in some instances a very politic man. He seems likewise to have possessed the rare gift, granted but to few, of being capable of looking to the present life and its wants, while he sang, as very few have ever sung, the glories of victories and the sad wail of dirges, the honours of heroes and the lustre which hung upon an Olympic crown. To possess this eminently practical faculty, in combination with such high poetic powers, is granted only to such poets as Shakspeare, Molière, and Goethe.

The greater portion of the later years of the poet was passed in Sicily, at the court of Hiero of Syracuse. He was in friendly intercourse with this monarch, and what astonishes us more, with his professed opponent, Thero of Agrigentum. The poet was the friend of Themistocles, and of the Spartan general, Pausanias. He gained a high reputation among the Greeks during the time of the Persian war. He wrote a splendid lyric on the heroes who had fallen at Thermopylæ, two grand odes on the sea-fight of Artemisium, and the triumphant naval engagement of Salamis, and he poured out all his sublime pathos on those who had fallen at Marathon. A Thermopylæan epigram from his pen has been preserved. "Stranger, tell the Lacedemonians that we lie here in obedience to their laws." He was, on the whole, perhaps the most prolific lyrist which Greece has known. He wrote hymns and prayers, pæans and hyporchemes, dithyrambs and parthenia for public festivals. He composed matchless dirges and noble songs of victory for private individuals. It was in the dirge that Simonides excelled most. If Pindar could outsoar him in a lofty flight, he could not equal him in grace where less wing

was required. Simonides yielded himself to the genuine feelings of human nature, while Pindar, mounted grandly upon the pinions of his imagination, could outsing the tempest in wild grandeur, or lend a plaintive grace to the sighing of the hollow evening wind. Simonides polished his verses with infinite care, while Pindar flung them from him in a somewhat careless style, but completely saturated with his genius. Pindar was the lyrist of majesty, Simonides of pathos. The one could chant a triumph to the armies of the world; the other could sing a threnode which would make the nations weep. Simonides died in his ninetieth year, B.C. 468. Very little of his poetry now remains, if we except the *Lament of Danaë*. To Simonides has been ascribed the invention of certain of the Greek characters; but this is not well authenticated. His fragments will be found collected by Schneidewin in his *Simonidis Cei Carminis Reliquiæ*, 1835, 8vo.

SIMPLICIUS, a celebrated commentator on Aristotle and Epictetus, and one of the last representatives of the Neo-platonic school, was born in Cilicia, probably between A.D. 500 and A.D. 510, and flourished during the reign of the Emperor Justinian. He was a disciple of Ammonius and of Damascius, the last president of the Alexandrian school. An edict was issued by Justinian in A.D. 528, that the heathen philosophy should no longer be taught in Athens, when Simplicius, along with six other philosophers, resolved to seek protection from Chosroes, the famous King of Persia. On reaching that distant court, they found matters not quite so hopeful as they had been led to anticipate. They resolved to return again to Greece, but not before Chosroes, who had just concluded a treaty with Justinian in A.D. 533, had inserted a clause in the contract, stipulating the safe return of the seven philosophers, and the liberty of practising the rites of their ancient faith on their regaining their destination. On reaching Athens, Simplicius and the rest of his brethren went into voluntary retirement, where they probably spent the remainder of their days in the quiet study of their favourite science.

Simplicius has left us four of the best commentaries on Aristotle extant, viz., on the *Categories; On the Soul; Concerning Heaven;* and on *Physics;* besides an interpretation of the *Enchiridion* of Epictetus. In these commentaries he has left to posterity rich notices of his contemporaries, and of the writers or thinkers who preceded him. A student of ancient philosophy must frequently have recourse to Simplicius, as to the only authority for fragments of the Eleatics, the Mathematicians, and other sects of the ancient schools of philosophy in Greece. Besides giving many extracts from the lost books of the Stagirite, he likewise gives numerous ancient readings now no longer in possession of scholars. Among the lost writings of Simplicius are an abridgment of the *Physics* of Theophrastus, and a work upon the Syllogism. There have been various editions of his works on the books of Aristotle, both Greek and Latin. They will be found contained in the *Scholia Aristotelem*, by Ch. A. Brandis, Berlin, 1836. The best edition of his comment on the *Enchiridion* of Epictetus is that of Schweighäuser, Greek and Latin, 2 vols., Leipzig, 1800. This work has been translated into German by Schulthess, Zürich, 1778; into French by Dacier, Paris, 1715; and into English by Dr George Stanhope, London, 1704.

SIMPLON, a pass of the Alps, between Switzerland and Italy, in the east of the canton of Valais, celebrated for the road which was constructed over it by order of Napoleon I. This is one of the greatest works of engineering in modern times. It is 38 miles long, from Brieg in Valais to Domo d'Ossola in Piedmont; its height is 6592 feet above the sea; its breadth from 25 to 30 feet; and in its course it is carried over 611 bridges, and through many tunnels.

SIMPSON, THOMAS, professor of mathematics at the Royal Academy at Woolwich, fellow of the Royal Society, and member of the Royal Academy at Stockholm, was born at Market-Bosworth in Leicestershire in 1710. His father, a stuff-weaver, taught him only to read English, and brought him up to his own business; but meeting with a scientific pedlar, who likewise practised fortune-telling, young Simpson by his assistance and advice left off weaving, and professed astrology. As he improved in knowledge, however, he grew disgusted with this pretended art; and renouncing it, was driven to such difficulties for the subsistence of his family, that he came up to London, where he worked as a weaver, and taught mathematics at his spare hours. As his scholars increased, his abilities became better known, and he published his *Treatise of Fluxions*, by subscription, in 1737; in 1740, he published his *Treatise on the Nature and Laws of Chance*, and *Essays in Speculative and Mixed Mathematics*. After these, appeared his *Doctrine of Annuities and Reversions* in 1742; *Mathematical Dissertations*, 1743; *Treatise on Algebra*, 1746; *Elements of Geometry*, 1747; *Trigonometry, Plane and Spherical*, 1748; *Select Exercises*, 1752; and his *Doctrine and Application of Fluxions*, 1750, which he professes to be rather a new work, than a second edition of his former publication on Fluxions. In 1743 he obtained the mathematical professorship at Woolwich academy; and soon afterwards was chosen a member of the Royal Society, when the president and council, in consideration of his moderate circumstances, were pleased to excuse his admission-fees, and his giving bonds for the settled future payments. At the academy he exerted all his abilities in instructing the pupils who were the immediate objects of his duty, as well as others whom the superior officers of the ordnance permitted to be boarded and lodged in his house. In his manner of teaching he had a peculiar and happy address, a certain dignity and perspicuity, tempered with such a degree of mildness as engaged the attention, esteem, and friendship of his scholars. He therefore acquired great applause from his superiors in the discharge of his duty. His application and close confinement, however, injured his health. Exercise and a proper regimen were prescribed to him, but to little purpose; for his spirits sunk gradually, till he became incapable of performing his duty, or even of reading the letters of his friends. The effects of this decay of nature were greatly increased by vexation of mind, owing, it is said, to the haughty behaviour of his superior, the first professor of mathematics. This person, greatly his inferior in mathematical accomplishments, did what he could to make his situation uneasy, and even to depreciate him in the public opinion; but it was a vain endeavour, and only served to depress himself. At length his physicians advised his native air for his recovery, and he set out in February 1761; but was so fatigued by his journey, that upon his arrival at Market-Bosworth, he betook himself to his chamber, and grew continually worse till the day of his death, which happened on the 14th of May, in the 51st year of his age.

SIMSON, DR ROBERT, professor of mathematics in the University of Glasgow, was born in the year 1687, of a respectable family, which had held a small estate in the county of Lanark for some generations. He was, we think, the second son of the family. A younger brother was professor of medicine in the University of St Andrews, and is known by some works of reputation, particularly a *Dissertation on the Nervous System*, occasioned by the dissection of a brain completely ossified.

Dr Simson was educated in the University of Glasgow under the eye of some of his relations who were professors. Eager after knowledge, he made great progress in all his studies; and, as his mind did not, at the very first openings of science, strike into that path which afterwards so strongly

attracted him, and in which he proceeded so far almost without a companion, he acquired in every walk of science a stock of information, which, though it had never been much augmented afterwards, would have done credit to a professional man in any of his studies. He became at a very early period an adept in the philosophy and theology of the schools, was able to supply the place of a sick relation in the class of oriental languages, was noted for historical knowledge, and one of the most accomplished botanists of his time.

It was during his theological studies, as preparatory for his entering into orders, that mathematics took hold of his fancy. He used to tell in his convivial moments how he amused himself when preparing his exercises for the divinity hall. When tired with vague speculation, in which he did not meet with certainty to reward his labours, he turned up a book of oriental philology, in which he found something which he could discover to be true or to be false, without going out of the line of study which was to be of ultimate use to him. Sometimes even this could not relieve his fatigue. He then had recourse to mathematics, which never failed to satisfy and refresh him. For a long while he restricted himself to a very moderate use of the cordial, fearing that he would soon exhaust the small stock which so limited and abstract a science could yield; till at last he found, that the more he learned, a wider field opened to his view, and scenes that were inexhaustible. Becoming acquainted with the subject far beyond the elements of the science, and with numbers of names celebrated during that period of ardent research all over Europe, he found it to be a manly and important study, by which he was as likely to acquire reputation as by any other. About this time, too, a prospect began to open of making mathematics his profession for life. He then gave himself up to it without reserve.

His original incitement to this study as a treat, as something to please and refresh his mind in the midst of more severe tasks, gave a particular turn to his mathematical studies, from which he never could afterwards deviate. Perspicuity and elegance are more attainable, and more discernible, in pure geometry, than in any other parts of the science of measure. To this, therefore, he chiefly devoted himself. For the same reason he preferred the ancient mode of studying pure geometry, and even felt a dislike to the Cartesian method of substituting symbols for operations of the mind, and still more was he disgusted with the substitution of symbols for the very objects of discussion, for lines, surfaces, solids, and their affections. He was rather disposed, in the solution of an algebraical problem, where quantity alone was considered, to substitute figure and its affections for the algebraical symbols, and to convert the algebraic formula into an analogous geometrical theorem. And he came at last to consider algebraic analysis as little better than a kind of mechanical knack, in which we proceed without ideas of any kind, and obtain a result without meaning, and without being conscious of any process of reasoning, and therefore without any conviction of its truth. And there is no denying, that if genuine unsophisticated taste alone is to be consulted, Dr Simson was in the right; for though it must also be acknowledged, that the reasoning in algebra is as strict as in the purest geometry of Euclid or Apollonius, the expert analyst has little perception of it as he goes on, and his final equation is not felt by himself as the result of ratiocination, any more than if he had obtained it by Pascal's arithmetical mill. This does not in the least diminish our admiration of the algebraic analysis; for its almost boundless grasp, its rapid and certain procedure, and the delicate metaphysics and great address which may be displayed in conducting it. Such, however, was the ground of the strong bias of Dr Simson's mind to the analysis of the ancient geometers. It increased as he went forward; and his veneration for the ancient geometry was carried to a degree of idolatry. His chief labours were exerted in efforts to restore the works of the ancient geometers; and he has nowhere bestowed much pains in advancing the modern discoveries in mathematics. The noble inventions, for example, of fluxions and of logarithms, by which our progress in mathematical knowledge, and in the useful application of this knowledge, is so much promoted, attracted the notice of Dr Simson; but he has contented himself with demonstrating their truth on the genuine principles of the ancient geometry. Yet was he thoroughly acquainted with all the modern discoveries; and there are to be seen amongst his papers, discussions and investigations in the Cartesian method, which show him thoroughly acquainted with all the principles, and even expert in the *tours de main*, of the most refined symbolical analysis.[1]

About the age of twenty-five, Dr Simson was chosen professor of mathematics in the University of Glasgow. He went to London immediately after his appointment, and there formed an acquaintance with the most eminent men of that bright era of British science. Amongst these he always mentioned Captain Halley (the celebrated Dr Edmund Halley) with particular respect; saying, that he had the most acute penetration, and the most just taste in that science, of any man he had ever known. And, indeed, Dr Halley has strongly exemplified both of these in his divination of the work of Apollonius *de Sectione Spatii*, and the eighth book of his *Conics*, and in some of the most beautiful theorems in Sir Isaac Newton's *Principia*. Dr Simson also admired the wide and masterly steps which Newton was accustomed to take in his investigations, and his manner of substituting geometrical figures for the quantities which are observed in the phenomena of nature. It was from Dr Simson that the writer of this article had the remark which has been oftener than once repeated in the course of this work, "That the thirty-ninth proposition of the first book of the *Principia* was the most important proposition that had ever been exhibited to the physico-mathematical philosopher;" and he used always to illustrate to his more advanced scholars the superiority of the geometrical over the algebraic analysis, by comparing the solution given by Newton of the inverse problem of centripetal forces, in the forty-second proposition of that book, with the one given by John Bernoulli in the Memoirs of the Academy of Sciences at Paris for 1713. We have heard him say, that to his own knowledge Newton frequently investigated his propositions in the symbolical way, and that it was owing chiefly to Dr Halley that they did not finally appear in that dress. But if Dr Simson was well informed, we think it a great argument in favour of the symbolical analysis, when this most successful practical artist (for so we must call Newton when engaged in a task of discovery) found this process conducive either to dispatch or perhaps to his very progress.

Returning to his academical chair, Dr Simson discharged the duties of a professor for more than fifty years, with great honour to the university and to himself.

It is almost needless to say, that in his prelections he fol-

[1] In 1752 the writer of this article, being then his scholar, requested him to examine an account which he gave him of what he thought a new curve (a conchoid having a circle for its base). Dr Simson returned it next day with a regular list of its leading properties, and the investigation of such as he thought his scholar would not so easily trace. In this hasty scrawl the lines related to the circle were familiarly considered as arithmetical fractions of the radius considered only as unity. This was before Euler published his *Arithmetic of the Sines and Tangents*, now in universal use.

lowed strictly the Euclidian method in elementary geometry. He made use of Theodosius as an introduction to spherical trigonometry. In the higher geometry, he prelected from his own Conics, and he gave a small specimen of the linear problems of the ancients, by explaining the properties, sometimes of the conchoid, sometimes of the cissoid, with their application to the solution of such problems. In the more advanced class, he was accustomed to give Napier's mode of conceiving logarithms, that is, quantities as generated by motion, and Coats's view of them, as the sums of ratiunculæ; and to demonstrate Newton's lemmas concerning the limits of ratios, and then to give the elements of the fluxionary calculus; and to finish his course with a select set of propositions in optics, gnomonics, and central forces. His method of teaching was simple and perspicuous, his elocution clear, and his manner easy and impressive. He had the respect, and still more the affection, of his scholars.

With respect to his studies, we have already informed the reader that they got an early bias to pure geometry, and to the elegant but scrupulous methods of the ancients. We have heard Dr Simson say, that it was in a great measure owing to Dr Halley that he so early directed his efforts to the restoration of the ancient geometers. He had recommended this to him, as the most certain way for him, then a very young man, both to acquire reputation and to improve his own knowledge and taste; and he presented him with a copy of Pappus's *Mathematical Collections*, enriched with some of his own notes. The perspicuity of the ancient geometrical analysis, and a certain elegance in the nature of the solutions which it affords, especially by means of the local theorems, soon took firm hold of his fancy, and made him, with the sanguine expectation of a young man, direct his very first efforts to the recovery of this *in toto;* and the restoration of Euclid's *Porisms* was the first task to which he set himself. The accomplished geometer knows what a desperate task this was, from the scanty and mutilated account which we have of this work in a single passage of Pappus. It was an ambition which nothing but success could justify in so young an adventurer. He succeeded; and as early as 1718, seemed to have been in complete possession of this method of investigation, which was considered by the eminent geometers of antiquity as their surest guide through the labyrinths of the higher geometry. Dr Simson gave a specimen of his discovery in 1723, in the *Philosophical Transactions;* and after this time he ceased not from his endeavours to recover that choice collection of Porisms which Euclid had collected, as of the most general use in the solution of difficult questions. What some of these must have been, was pointed out to Dr Simson by the very nature of the general proposition of Pappus, which he has restored. Others were pointed out by the lemmas which Pappus has given as helps to the young mathematician towards their demonstration. And, being thus in possession of a considerable number, their mutual relations pointed out a sort of system, of which these made a part, and the blanks of which now remained to be filled up.

Dr Simson, having thus gained his favourite point, had leisure to turn his attention to the other works of the ancient geometers; and the porisms of Euclid now had only an occasional share. The *loci plani* of Apollonius was another task which he very early engaged in, and completed about the year 1738. But, after it was printed, he imagined that he had not given the *ipsissimæ propositiones* of Apollonius, and in the precise spirit and order of that author. The impression lay by him for some years; and it was with great reluctance that he yielded to the entreaties of his mathematical friends, and published the work, in 1746, with some emendations, where he thought he had deviated farthest from his author. He quickly repented of this scanty concession, and recalled what he could of the small number of copies which he had given to the booksellers, and the impression again lay by him for years. He afterwards recorrected the work, and still with some reluctance allowed it to come abroad as the *Restitution of Apollonius.* The public, however, had not been so fastidious as Dr Simson, and the work had acquired great celebrity, and he was now considered as one of the first and the most elegant geometers of the age; for, in the meantime, he had published his *Conic Sections,* a work of uncommon merit, whether we consider it as equivalent to a complete restitution of the celebrated work of Apollonius Pergæus, or as an excellent system of this important part of mathematics. It is marked with the same features as the *loci plani,* the most anxious solicitude to exhibit the very text of Apollonius, even in the propositions belonging to the books which had been completely lost. These could be recovered in no other way but by a thorough knowledge of the precise plan proposed by the author, and by taking it for granted that the author had accurately accomplished this plan. In this manner did Viviani proceed in the first attempt which was made to restore the conics of Apollonius; and he has given us a detail of the process of his conjectures, by which we may form an opinion of its justness, and of the probability how far he has attained the desired object. Dr Simson's view in his performance was something different, deviating a little in this one case from his general track. He was not altogether pleased with the work of Viviani, even as augmented by the eighth book added by Halley, and his wish was to restore the ancient original. But, in the meantime, an academical text-book for conic sections was much wanted. He was much dissatisfied with those in common use; and he was not insensible of the advantage resulting from the considerations of these sections, independent of the cone first introduced by Dr Wallis. He therefore composed this excellent treatise as an elementary book, not to supersede, but to prepare for the study of Apollonius; and accordingly he accommodates it to this purpose, and gives several important propositions in their proper places, expressly as restitutions of Apollonius, whom he keeps constantly in view through the whole work.

Much about this time, Dr Simson seriously began to prepare a perfect edition of Euclid's *Elements.* The intimate acquaintance which he had by this time acquired with all the original works of the ancient geometers, and their ancient commentators and critics, encouraged him to hope that he could restore to its original lustre this leader in mathematical science; and the errors which had crept into this celebrated work, and which still remained in it, appeared of magnitude sufficient to merit the most careful efforts for their removal. The *data* also, which were in like manner the introduction to the whole art of geometrical investigation, seemed to call more loudly for his amending hand. For it appears that the Saracens, who have preserved to us the writings of the ancients, have contented themselves with admiring these celebrated works, and have availed themselves of the knowledge which they contain; but they have shown no inclination to add to the stock, or to promote the sciences which they had received. They could not do anything without the synthetical books of the geometers; but, not meaning to go beyond the discoveries which they had made, they neglected all the books which related to the analytic art alone, and the greatest part of them (about twenty-five out of thirty) have irrecoverably perished. The data of Euclid have fortunately been preserved, but the book was neglected, and the only ancient copies, which are but three or four, are miserably erroneous and mutilated. Fortunately, it is no very arduous matter to reinstate this work in its original perfection. The plan is precise, both in its extent and its method. It has been restored, therefore, with success by more than one author. But Dr Simson's comprehensive view of the whole analytical system pointed out to him many occasions for amend-

ment. He therefore made its restitution a joint task with that of the elements. All the lovers of true geometry will acknowledge their obligations to him for the edition of the *Elements* and *Data* which he published about 1758. The text is corrected with the most judicious and scrupulous care, and the notes are inestimable, both for their information, and for the tendency which they must have to form the mind of the student to a true judgment and taste in mathematical subjects. The more accomplished reader will perhaps be sometimes disposed to smile at the axiom which seems to pervade the notes, "that a work of Euclid must be supposed without error or defect." If this was not the case, Euclid has been obliged to his editor in more instances than one. Nor should his greatest admirers think it impossible, that in the progress of human improvement, a geometrical truth should occur to one of these latter days which escaped the notice even of the lynx-eyed Euclid. Such merit, however, Dr Simson nowhere claims, but lays every blame of error, omission, or obscurity, to the charge of Proclus, Theon, and other editors and commentators of the renowned Grecian.

There is another work of Apollonius on which Dr Simson has bestowed great pains, and has restored, as we imagine, *omnibus numeris perfectum*, namely, the *Sectio Determinata;* one of those performances which are of indispensable use in the application of the ancient analysis. This also seems to have been an early task, though we do not know the date of his labours on it. It did not appear till after his death, being then published along with the great work, the *Porisms* of Euclid, at the expense of the Earl Stanhope, a nobleman intimately conversant with the ancient geometry, and zealous for its reception amongst the mathematicians of the present age. He had kept up a constant correspondence with Dr Simson on mathematical subjects, and at his death in 1768, engaged Clow, professor of logic in the University of Glasgow, to whose care the doctor had left all his valuable papers, to make a selection of such as would serve to support and increase his well-earned reputation as the restorer of ancient geometry.

We have been thus particular in our account of Dr Simson's labours in these works, because his manner of execution, whilst it does honour to his inventive powers, and shows his just taste in mathematical composition, also confirms our former assertion, that he carried his respect for the ancient geometers to a degree of superstitious idolatry, and that his fancy, unchecked, viewed them as incapable of error or imperfection. This is distinctly to be seen in the emendations which he has given of the texts, particularly in his editions of Euclid. Not only every imperfection of the reading is ascribed to the ignorance of copyists, and every indistinctness in the conception, inconclusiveness in the reasoning, and defect in the method, is ascribed to the ignorance or mistake of the commentators; but it is all along assumed that the work was perfect in its kind, and that by exhibiting a perfect work, we restore the genuine original. This is surely gratuitous; and it is very possible that it has, in some instances, made Dr Simson fail of his anxious purpose, and give us even a better than the original. It has undoubtedly made him fail in what should have been his great purpose, namely, to give the world a connected system of the ancient geometrical analysis, such as would, in the first place, exhibit it in its most engaging form, elegant, perspicuous, and comprehensive; and, in the next place, such as should engage the mathematicians of the present age to adopt it as the most certain and successful conductor in those laborious and difficult researches in which the demands of modern science continually engage them. And this might have been expected, in the province of speculative geometry at least, from a person of such extensive knowledge of the properties of figure, and who had so eminently succeeded in the many trials which he had made of its powers. We might have expected that he would at least have exhibited in one systematic point of view what the ancients had done in several detached branches of the science, and how far they had proceeded in the solution of the several successive classes of problems; and we might have hoped, that he would have instructed us in what manner we should apply that method to the solution of problems of a more elevated kind, daily presented to us in the questions of physico-mathematical science. By this he would have acquired distinguished honour, and science would have received the most valuable improvement. But Dr Simson has done little of all this; and we cannot say that great helps have been derived from his labours by the eminent mathematicians of this age, who are successfully occupied in advancing our knowledge of nature, or in improving the arts of life. He has indeed contributed greatly to the entertainment of the speculative mathematician, who is more delighted with the conscious exercise of his own reasoning powers than with the final result of his researches. Yet we are not even certain that Dr Simson has done this to the extent he wished and hoped. He has not engaged the liking of mathematicians to this analysis, by presenting it in the most agreeable form. His own extreme anxiety to tread in the very footsteps of the original authors has, in a thousand instances, precluded him from using his own extensive knowledge, that he might not employ principles which were not of a class inferior to that of the question in hand. Thus, of necessity, did the method appear trammelled. We are deterred from employing a process which appears to restrain us in the application of the knowledge which we have already acquired; and, disgusted with the tedious, and perhaps indirect path, by which we must arrive at an object which we see clearly over the hedge, and which we could reach by a few steps, of the security of which we are otherwise perfectly assured. These prepossessions are indeed founded on mistake; but the mistake is such, that all fall into it, till experience has enlarged their views. This circumstance alone has hitherto prevented mathematicians from acquiring that knowledge of the ancient analysis which would enable them to proceed in their researches with certainty, despatch, and delight. It is therefore deeply to be regretted that this eminent genius has occupied, in this superstitious palæology, a long and busy life, which might have been employed in original works of infinite advantage to the world, and honour to himself.

Our readers will, it is hoped, consider these observations as of general scientific importance, and as intimately connected with the history of mathematics; and therefore as not improperly introduced in the biographical account of one of the most eminent writers on this science. Dr Simson claimed our notice as a mathematician; and his affectionate admiration of the ancient analysis is the prominent feature of his literary character. By this he is known all over Europe; and his name is never mentioned by any foreign author without some very honourable allusion to his distinguished geometrical elegance and skill. Dr James Moor, professor of Greek in the University of Glasgow, no less eminent for his knowledge in ancient geometry than for his professional talents, put the following apposite inscription below a portrait of Dr Simson:—"Geometriam, sub Tyranno barbaro sæva servitute diu squalentem, in libertatem et decus antiquum vindicavit unus."

Yet it must not be understood that Dr Simson's predilection for the geometrical analysis of the ancients did so far mislead him as to make him neglect the symbolical analysis of the present times; on the contrary, he was completely master of it, as has been already observed, and frequently employed it. In his academical lectures to the students of his upper classes, he used to point out its proper province, which he by no means limited by a scanty boun-

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dary, and in what cases it might be applied with safety and advantage even to questions of pure geometry. He once honoured the writer of this article with the sight of a very short dissertation on this subject, perhaps the one referred to in the preface to his *Conic Sections*. In this piece he was perhaps more liberal than the most zealous partizans of the symbolical analysis could desire, admitting as a sufficient equation of the Conic Sections $L = \frac{p^2 c}{x^2}$, where L is the *latus rectum*, x is the distance of any point of the curve from the focus, p is the perpendicular drawn from the focus to the tangent in the given point, and c is the chord of the equicurve circle drawn through the focus. Unfortunately this dissertation was not found amongst his papers. He spoke in high terms of the analytical works of Cotes, and of the two Bernoullis. He was consulted by Maclaurin during the progress of his inestimable *Treatise of Fluxions*, and contributed not a little to the reputation of that work. The spirit of that most ingenious algebraic demonstration of the fluxions of a rectangle, and the very process of the argument, is the same with Dr Simson's in his dissertation on the limits of quantities. It was therefore from a thorough acquaintance with the subject, and by a just taste, that he was induced to prefer his favourite analysis, or, to speak more properly, to exhort mathematicians to employ it in his own sphere, and not to become ignorant of geometry, while he successively employed the symbolical analysis in cases which did not require it, and which suffered by its admission. It must be acknowledged, however, that in his later years, the disgust which he felt at the artificial and slovenly employment on subjects of pure geometry, sometimes hindered him from even looking at the most refined and ingenious improvements of the algebraic analysis which occur in the writings of Euler, D'Alembert, and other eminent masters. But, when properly informed of them, he never failed to give them their due praise; and we remember him speaking, in terms of great satisfaction, of an improvement of the infinitesimal calculus, by D'Alembert and Lagrange, in their researches concerning the propagation of sound, and the vibration of musical cords.

And that Dr Simson was not only master of this calculus and the symbolical calculus in general, but held them in proper esteem, appears from two valuable dissertations to be found in his posthumous works; the one on logarithms, and the other on the limits of ratios. The last, in particular, shows how completely he was satisfied with respect to the solid foundation of the method of fluxions; and it contains an elegant and strict demonstration of all the applications which have been made of the method by its illustrious author to the objects of pure geometry.

We hoped to have given a much more complete and instructive account of this eminent geometer and his works, by the aid of a person fully acquainted with both, and able to appreciate their value; but an accident has deprived us of this assistance, when it was too late to procure an equivalent. And we must request our readers to accept of this very imperfect account, since we cannot do justice to Dr Simson's merit unless almost equally conversant in all the geometry of the ancient Greeks.

The life of a literary man rarely teems with anecdote; and a mathematician, devoted to his studies, is perhaps more abstracted than any other person from the ordinary occurrences of life, and even the ordinary topics of conversation. Dr Simson was of this class; and, having never married, lived entirely a college life. Having no occasion for the commodious house to which his place in the university entitled him, he contented himself with chambers, good, indeed, and spacious enough for his sober accommodation, and for receiving his choice collection of mathematical writers, but without any decoration or commodious furniture. His official servant sufficed for valet, footman, and chambermaid. As this retirement was entirely devoted to study, he entertained no company in his chambers, but in a neighbouring house, where his apartment was sacred to him and his guests.

Having in early life devoted himself to the restoration of the works of the ancient geometers, he studied them with unremitting attention; and, retiring from the promiscuous intercourse of the world, he contented himself with a small society of intimate friends, with whom he could lay aside every restraint of ceremony or reserve, and indulge in all the innocent frivolities of life. Every Friday evening was spent in a party at whist, in which he excelled, and took delight in instructing others, till increasing years made him less patient with the dulness of a scholar. The card-party was followed by an hour or two dedicated solely to playful conversation. In like manner, every Saturday he had a less select party to dinner at a house about a mile from town. The doctor's long life gave him occasion to see the *dramatis personæ* of this little theatre completely changed, whilst he continued to give it a personal identity; so that, without any design or wish of his own, it became, as it were, his own house and his own family, and went by his name.

Dr Simson was of a good stature, with a fine countenance; and even in his old age he had a graceful carriage and manner, and always, except when in mourning, dressed in light coloured clothes. He was of a cheerful disposition; and though he did not make the first advances to acquaintance, had the most affable manner, and strangers were at perfect ease in his company. He enjoyed a long course of uninterrupted health; but towards the close of life suffered from an acute disease, and was obliged to employ an assistant in his professional labours for a few years preceding his death, which happened in 1768, at the age of eighty-one. He left to the university his valuable library, which is now arranged apart from the rest of the books, and the public use of it is limited by particular rules. It is considered as the most choice collection of mathematical books and manuscripts in the kingdom, and many of them are rendered doubly valuable by Dr Simson's notes. (J. R.)

Sinai.

SINAI (Heb. סִינַי, Gr. Σινά), a celebrated mountain in Arabia Petræa. The name, however, is frequently applied to the whole peninsula in which the mountain stands; lying between the two northern arms of the Red Sea, the Gulf of Suez (anc. *Heroopoliticus Sinus*) on the west, and that of Akabah (anc. *Aelaniticus Sinus*) on the east, and terminating to the south in the promontory of Ras Mohammed (anc. *Posidium*). The northern part of this peninsula, from Suez to Akabah, consists of a tableland of chalk formation, called *Et-Tih*, or the Wilderness of the Wandering. This plateau is bounded on the south by a line of mountains called *Jebel Tih*, extending across the whole breadth of the peninsula, and curving slightly to the south. South of this lies a mountainous and granitic region, which extends on the east to the Gulf of Akabah, but is separated from that of Suez, on the west, by a narrow alluvial strip called *El-Kaa*. The Wilderness of Paran, in which the Israelites wandered for a great part of the forty years, is the northern part of *Et-Tih;* that of Sin through which they passed, between the Red Sea and Sinai, is probably to be placed in the north-west of the granitic region; while Zin, or the Wilderness of Kadesh, lay to the north of the Gulf of Akabah. The mountainous part of the peninsula is commonly called Sinai by Christians of the present day, but the Arabs designate it *Jebel et-Far*. In a more restricted sense the name Sinai is applied to the loftiest ridge among these mountains, running between two valleys from Horeb, on the north, to the summit called *Jebel Katherina*, on the south. Which of the several particular mountains in the district of Sinai is the actual one from which the law was delivered to the Jews, is a question on which there are at

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least two different theories or traditions. One of these identifies the Mount Sinai of the Scripture history with Serbal, at the north-west corner of the mountains, rising with five sharp peaks, above the fertile oasis of *Wady Pharan;* the other place is in the very centre of the group, about 30 miles south-east of the former. The first of these views, which was held by Burckhardt and Lepsius, is supported by the testimony of Cosmas Indicopleustes, and is believed by its maintainers to derive countenance from the remarkable inscriptions found in the vicinity of Gerbal. The latter opinion has the sanction of all the traditions, from the time of Justinian downwards, and is upheld by most modern travellers and scholars. *Jebel Músa* rises to the height of 6452 feet, but there are several much loftier summits in the group, that of Horeb being 7688, and that of *Jebel Katherina* 8848 feet high. The convent of St Catherine, said to have been founded by the empress Helena, near the traditionary spot where the law was given, stands at the foot of *Jebel Músa*, but it is more probable that Horeb was the actual site, as *Jebel Músa* is three miles distant, and not visible from the plain where the Israelites must have been encamped. As to the singular inscriptions on the rocks about Gerbal, which form the strongest arguments in favour of that mountain, it is by no means certain that they are the work of the Israelites, for they may be attributed, with at least as much probability, to the early Arabians, among whom, before the time of Mahomet, this region was resorted to as a place of peculiar sanctity. The character in which they are written resembles the ancient Arabic, and we know that the practice of graving such memorials prevailed anciently in those countries.

SINCLAIR, Sir John, *Baronet*, was born at Thurso Castle, in the county of Caithness, on the 10th of May 1754. He received his education successively at Edinburgh, Glasgow, and Oxford. Having completed his preliminary studies, he became a member of the Scottish Society of Advocates, and was subsequently called to the English bar. He began his parliamentary career in 1780, when he was chosen member for his native county. He continued a member of the British Parliament for more than thirty years, during which time the country passed through a very eventful era. His reputation was soon fixed as a patron and promoter of Scottish agriculture, and as an enthusiastic student of politics, statistics, and medicine. The opinions of Sinclair on finance were highly esteemed by the prime minister Pitt, and he was before long elevated to the baronetage mainly through the influence of that statesman. He continued with amazing industry to organize societies for manufacturing and agricultural purposes, and exerted himself in an extraordinary manner to promote the general wellbeing of the Scottish people. His patriotic efforts in no degree fell short of his zeal for the material good of the country. He raised battalions of 1000 men each in the counties of Ross and Cromarty, which formed the first fencible regiments whose services were extended beyond the kingdom. His philanthropic pen was ever busy in suggesting "plans," "hints," and "observations," &c., for the amelioration of some national or social evil. Sir John Sinclair was the author of eighteen distinct works, of which the most extensive was his *History of the Public Revenue of the British Empire*, 3 vols., 1784. He was the author, either by suggestion or by endorsement, of 367 books and pamphlets, of which the largest was the *Statistical Account of Scotland, drawn up from the communications of the Ministers of the different parishes*, 1791–9, 21 vols. Sinclair was a man of talent rather than a man of genius, but what he wanted in native vigour of mind, he tried to make up by indomitable perseverance. He died on the 21st December 1835. (See *Memoirs of the Life and Works of Sir John Sinclair, Bart.*, by his son, the Rev. John Sinclair, 2 vols., 1837.)

Sindh.

Extent and boundaries.

SINDH. The province of Sindh, in the Bombay Presidency of British India, extends from N. Lat. 23. 37. to 28. 32., and from E. Long. 66. 43. to 71. 3. It is bounded on the N. by Bilúchistán and Bháwalpúr; on the E. by the Rájpút States of Jaysalmír and Jodhpúr; on the S. by Kachh and the Indian Ocean; and on the W. by Makrán and the other territories of the Khán of Kalát. It contains an area of 60,240 square miles,[1] being 360 miles long, and 270 miles broad in its greatest breadth.

The province derives its name from the Sindh, or Indus, without whose fertilizing waters the whole country would become a desert.

General aspect of the country.

In its general appearance Sindh much resembles the valley of the Nile.[2] It is one vast flat, bounded on the west by the Hála Hills, and on the east by the Great Desert, which girdles Rájpútána on the north and west. In the centre of this level valley flows the Indus, from which myriads of canals and water-courses are drawn, so as to intersect in all directions the adjacent country. Near Sakkar, in Upper or Northern Sindh, groves of palm-trees fringe the river, and lower down these are succeeded by dense forests of small trees, principally the *Babúr*, or Acacia Arabica, which were formerly used as *Shikárgáhs*, or "hunting grounds" by the Amírs, and are now carefully protected as supplying wood fuel for steamers, and preserving cultivated tracts from the encroaching sands of the desert. At about 60 miles in a direct line from the sea the Indus separates near Tháthá into two great branches, the Satá, or Eastern, and the Baghár, or Western, thus forming a delta, which is more arid and barren than the tract to the north of it as far as Sakkar.

The Indus.

The source of the Indus, the river of Sindh, whose total course is reckoned in round numbers at 1800 miles, is at the north of the Kailás Mountain, one of the loftiest peaks of the Himályas, in N. Lat. 32., E. Long. 81. 30. The stream near its rise is called the *Sinh Ká Báb*, or "lion's mouth." After a course of about 858 miles, through regions for the most part wholly unexplored by Europeans, the river reaches, in Lat. 33. 54., Long. 88. 48., the fort and small town of *Atak*, a word which signifies "stop," the Hindús believing that the sovereignty of their princes ought to extend thus far, and no farther. The name of Atak is applied to the river from the town so-called to Kálábágh, in Lat. 32. 57., Long. 71. 35. Thence to Sakkar the stream is called the Upper Indus, and from Sakkar to the sea the Lower Indus; but by the natives the *Daryá*, "Great river," or "Sea." The breadth[3] of the Indus from Atak to the sea, in the dry season, varies from 480 to 1600 yards, the usual width being 680. At this season the depth averages from 9 to 15 feet in the main channel, but in the freshes it is 24 feet. In some parts, however, the depth is very great. Thus, between Kálábágh and Atak 186 feet have been sounded; and near Sehwán, also, the river is very deep. Its rapidity during the freshes is 7 miles an hour, and about 3 in the dry season, and the maximum discharge per second is in August, when the river is at its height, 446,080 cubic feet, and in December 40,857. The fall per mile is from Atak to Kálábágh, 20 inches, thence to Mithan 8 inches, and thence to the sea 6. The temperature of the water during July and August is no less than 88°, or only 7° less than that of the air in those months. The Indus is easily navigable as far as Dera Isma'íl Khán, in N. Lat. 31. 50., above which there are

[1] *Bombay Selected Records*, No. xvii. of 1855, p. 43.

[2] The name "Young Egypt" has been applied to it, and is even used in the titles of books of travels in Sindh.

[3] *Bombay Selected Records*, No. xviii., 1855, p. 545.

Sindh. great difficulties, though boats may ascend even to Makkad in 33. 10., at all seasons. Hence to Atak the upward navigation is altogether restricted to the months when the river is low, and the current without force.

Climate. The climate of Sindh is remarkable for excessive heat and dryness. Lord[1] gives 98° 5′ as the mean maximum of temperature in the shade at Haidarábád during the six hottest months. At Sakkar it is much hotter, and between Shikárpúr and Bágh hotter still, the thermometer sometimes rising to 120° in a good tent. The monsoon reaches no farther than the north-western frontier of Kachh, and Sindh is never visited by the refreshing periodical rains that cool other parts of India. At Karáchí the annual fall of rain does not exceed 8 inches; at Haidarábád it averages about 3 inches; while in Upper Sindh a shower is of very rare occurrence. Thus Hamilton records that, at the period of his visit in 1699, the Larkhânah districts had been three years without rain. On the other hand, there was a remarkable fall of rain at Haidarábád in 1839, and on the 15th of July in that year, the day the Amírs signed the new treaty with the British,[2] many houses and part of the city-wall fell in consequence of the heavy rain, which continued at intervals for four days. The prevailing winds from April to September are from the south, and from the north during the rest of the year. An east wind seldom lasts twelve hours. A kind of samúm, or hot wind of the desert, is occasionally felt, and brings with it clouds of sand, that obscure the light of day. Notwithstanding the great heat, Upper Sindh is tolerably healthy, and though the climate is not well suited for Europeans, the natives, especially the Bilúchís, attain to great ages. Thus Mír Sohráb, the father of Mír Rustam, was a vigorous man when, at the age of a hundred years, he was killed by a fall from a high terrace; and Mír Rustam himself was approaching ninety when he died. In Lower Sindh there is much malaria, and fever is rife in September and October. Cholera, too, sometimes commits great ravages, especially at the otherwise healthy station of Karáchí.

Soil and cultivation. The soil of the delta is a light, loose clay, mixed with sand,[3] and except in cultivated spots, this is covered with a low tamarisk jungle. Near the river there are patches of a richer soil deposited by the waters, and this is the case along the whole course of the Indus. Eastward of Khairpúr, and west of Shikárpúr, there are sandy deserts wholly devoid of water, and differing only in that there are ranges of sand-hills in the former direction, and a perfectly dead-level to the west. With regard to cultivation, it has been justly remarked,[4] that "whatever is cultivated in Egypt, in Arabia, and in the countries bordering the Persian Gulf, may be grown with success in Sindh." There are two crops in the year—the vernal, sown from August to November, and the autumnal, sown from May to the end of July. The former is brought forward by the heavy dews and cool nights of the winter, and is reaped in March and April; while the latter, reaped in December, is wholly dependent on the inundation, which prevails from June to September.

Natural produce. Rice, wheat, barley, *jawárí*, or Indian millet, *bájrí* or zea mays, Bengal grain, vetches, safflowers are the principal crops. Rice is grown very abundantly in Sindh, and is of good quality, and *Panicum spicatum, arzam*, or *Panicum pilosum*, barley, sesamum, and various kinds of vetches, pulse, and millet, all yield good crops. Oats, too, have been found to thrive admirably; but it is for its *Jawárí*, or *Holcus sorgum*, that Sindh is especially famous. In the districts near Shikárpúr, tracts of miles in extent may be seen covered with a waving forest of this grain, in which even camels and their riders would be utterly lost to sight, the stalks being sometimes 20 feet in length.[5] Cotton of a very superior kind is grown in Chánduká,[6] as also sugar, indigo, and tobacco; but, according to Thornton, experiments made in the cultivation of American cotton and Mauritius cane, have been unsuccessful. Wool forms one of the chief exports from Sindh, but is brought chiefly from the country beyond the Hála Hills, subject to the Khân of Kalát. The pearl oyster has been found of late years in Karáchí harbour, and at the Piltí mouth of the Indus; but the pearls are extremely small, and, from their bad shape and colour, of little value even for seed-pearl.

Manufactures. The embroideries of Sindh are renowned, and the fabricants of silk tissues at Haidarábád gained medals both at the Great Exhibition of 1851 and at that of Paris. Enameling, seal-engraving, lacquered work, and the making of coloured tiles, are all carried to great perfection in Sindh, especially at Thatthá and Haidarábád. The manufacture of arms was very flourishing under the Amírs, but is now fast declining.

Zoology. The wild animals of Sindh are far less numerous than those of India. Tigers are not uncommon in the jungles to the north of Sakkar, and in the opposite district of Burdiká, but seldom wander southwards. Lieutenant James, however, speaks of having seen two in Chánduká, in 1846, and the one at the shrine of Lál Sháh Báz, at Sehwân, was probably captured in that neighbourhood. In the forests near the Indus, which were formerly the hunting preserves of the Amírs, wild-hog and hog-deer abound. The antelope is found farther from the river, and the ibex in the hills to the west. Wolves, foxes, jackals, and hares are common. The wild-ass, said in former years to have been met with in the desert beyond Roján, is probably now extinct. In the sand-hills east of Rohrí and Khairpúr, porcupines are plentiful. Amongst domestic animals the buffalo and camel take the first place. The latter animal is reared in great numbers in the delta of the Indus, and is thought to be of an uncommonly hardy kind. The dromedary, however, is brought from the Brahuí country, or from Rájpútáná. The horses, asses,[7] and cows are all much smaller than those of India. Of birds, the most remarkable species are the pelican, various kinds of falcons, and the *Ubáráh*, or bustard. The black and the grey partridge, quail, snipe, and wild-duck, are most numerous. The Indus abounds with fish, the most valuable kind being the *palla*, which resembles the salmon in appearance and flavour, and forms the chief food of a large part of the population of Sindh. The bolan, or river porpoise, is occasionally seen; it weighs upwards of two cwt., and has a projecting snout, armed with formidable teeth. The alligator is less common in the Indus than in the Ganges, but grows, perhaps, to a larger size. It is scarcely ever found to be dangerous to man. Among the reptiles may be mentioned the iguana, the river tortoise, and several kinds of snakes. Scorpions and centipedes are not common, but the plague of insects has called forth the anathemas of all travellers in Sindh. In the districts near the Manchar Lake the people sleep on platforms raised upon tall pieces of timber,[8] to escape the tormenting attacks of the musquitoes and sandflies. These insects are literally innumerable, and most venomous. In no country is the white ant more destructive; and instances have occurred of the roofs of buildings falling in, the beams being completely hollowed out by these pests. Thus, in 1840, the roof of the post-office at Shikárpúr fell suddenly without any warning, but fortunately when the rooms were empty of people, the only person injured being the sentry who was standing at the door.

Under the Amírs, Sindh was divided into three principalities, Khairpúr or Upper Sindh, Haidarábád, and Mír-

[1] *Med. Memoir*, p. 12. [2] Murray's *Handbook for Bombay*, p. 468. [3] *Bombay Selected Records*, No. xvii. of 1855, p. 197.
[4] Ibid., p. 591. [5] *Dry Leaves from Young Egypt*, p. 138. [6] *Bom. Sel.*, No. xvii., 1855, p. 720.
[7] Dr Heddle, however, in his Memoirs of May 1836, speaks of the mules and asses of Sindh as of unusual size and value.
[8] *Dry Leaves from Young Egypt*, p. 32.

Sindh.

Territorial divisions.

púr, which two latter were comprised in Lower Sindh. Under the British Government, the country has been apportioned into three chief collectorates, Shikárpúr, or Upper Sindh, Haidarábád, and Karáchí. These again are subdivided, Karáchí into 12 táluks, and Haidarábád into 13, of which 5 are in the deputy-collectorate of Mírpúr, and 3 in that of Hálá. Under the collectorate of Shikárpúr are the frontier districts of Kachhí, rendered famous by the inroads of the robber Bilúchís, and the entire subjugation of those tribes by General Jacob, who built and garrisoned the town of Jacobábád, in the centre of the country once held by the plundering Dumkís and Jakránís. These districts are bounded by a waving line drawn from Khairí Garhí, in Lat. 28. 8., Long. 67. 58., to Roján, in Lat. 28. 20., Long. 68. 20., and thence eastward, to the north of Khairí, in Lat. 28. 35., Long. 69. 40. The area of the Shikárpúr collectorate, including 5412 square miles of territory resumed from Mír Alí Murád, comprises 11,532 square miles;[1] that of the Haidarábád and Karáchí collectorates, 30,000 and 16,000 square miles respectively. Mír Alí Murád's territory is not included in the above estimates, and has an area of 5000 square miles, with a population of 105,000.

Revenue and population.

The revenue of Sindh, for the year 1855–56, is thus given: —Shikárpúr C., 1,127,641 rupees; Alí Murád's territory, 295,500 rs.; Haidarábád, 996,036 rs.; Karáchí, 534,375 rs. The first-named collectorate has a population of 693,259. Haidarábád has 703,296 inhabitants, and Karáchí 372,182.

Principal towns.

The principal towns are Shikárpúr, Larkhánah, Sakkar, Rohrí, and Khairpúr, in Upper Sindh; and Haidarábád, Thatthá, and Karáchí, in Lower Sindh.

Shikárpúr.

Shikárpúr, in Lat. 28., Long. 68. 39., was founded by the Dáúdputras in 1617, and now contains about 30,000 inhabitants. It is a mart of some importance, and much of the trade between India and Khurásán passes through it. The bázár extends about 800 yards through the centre. There are no edifices worth notice, and masses of ruins encumber the suburbs, and even the best streets in the town itself.

Larkhánah.

Larkhánah, in Lat. 27. 30., Long. 68. 10., has a population of 12,000, and is one of the principal grain-marts in Sindh. It is rudely fortified, and has a citadel at the western end. The surrounding country is thought to be one of the richest tracts in Sindh.

Sakkar.

Sakkar, in Lat. 27. 40., Long. 68. 54., is a town, once flourishing and populous, on the western bank of the Indus, opposite Rohrí. It was taken and destroyed about the year 1800, by Mír Rustam. In 1839 it became the site of a British cantonment, when many of the ruined edifices were cleared away, and a few rebuilt or repaired. The most remarkable edifices remaining are—the tomb of a Mughul princess, on a hill directly above the Presidency, and a tower 100 feet high, erected to the memory of Muhammad M'asúm, a celebrated nobleman of the Delhi court, who flourished during the early part of the seventeenth century, A.D.

Rohrí.

Rohrí, or Rorí, in Lat. 27. 38., Long. 68. 55., is situated on the eastern bank of the Indus, exactly opposite Sakkar; the island of Bakkar, on which is an ancient fort, being between them, and in mid-stream. Rorí has a population of 8000 inhabitants. In it are some curious buildings, worthy of inspection. The chief mosque was built during the time of Akbar, who conquered Sindh in 1572. An inscription of some length sets forth that the founder was Fath Khán. There is also a shrine where a hair from the prophet's head is preserved in a jewelled case. This building is about 300 years old, and seems to have been built by one 'Abu'l Báki, who came to Sindh from Constantinople.[2]

Khairpúr.

Khairpúr is 13 miles S. of Rorí, and 15 E. of the Indus. It has a population of 15,000 souls, and under the Amírs was the seat of the government of Upper Sindh. There is nothing remarkable about it.

Haidarábád.

Haidarábád is entitled to be considered the capital of Sindh, as it was of the Amírs, the principal branch of the Tálpúr family ruling there. It is situated in Lat. 25. 22., Long. 68. 28., and 4 miles E. of the eastern bank of the Indus, on a rocky ridge called the Ganjah Hills. The fort is about three-fourths of a mile in circumference, and was built or repaired by Fath Khan Tálpúr. Beyond the market-place are the tombs of the Tálpúrs, and of the family that preceded them, that of Ghulám Sháh Kalhora being the most beautiful of all. Haidarábád contains about 30,000 inhabitants. It is famous for its embroideries, enameling, lacquered work, and seal-engraving.

Thatthá.

Thatthá, vulgarly called Tatta, in Lat. 24. 44., Long. 68., is an ancient city, now greatly fallen to decay. It is probably not less than a thousand years since it was founded. In 1555 it was pillaged and partly burned by the Portuguese; but in 1699 Alexander Hamilton describes it as a great and populous city. The ruins of noble edifices are to be traced for miles around. Of those that remain the most remarkable are—the Grand Mosque of Sháh Jahán, begun in 1647 and finished by Aurangzeb in 1661; the 'I'dgáh of Yúsuf Khán, Governor of Sindh, built in 1633; the mosque of Tughral, and some others. Thatthá now contains about 10,000 inhabitants.

Karáchí.

Karáchí, the sea-port of Sindh, has grown up to importance under British rule. It is situated in Lat. 24. 51., Long. 67. 2., and being the only place of safety for vessels on the coast, the whole commerce of the Indus passes through it. The population has risen from 13,000 persons in 1813,[3] to nearly 25,000. The harbour is being improved at a vast outlay, and though the bar is a great obstacle to the trade of the place, there being but 16 feet water upon it at high tide, it is hoped that even this difficulty will be overcome, partly by dredging and partly by directing the full sweep of the ebb-tide upon it. The town is 3 miles from the landing-place at low-water, but a good communication has been made, by a mole and road, which cost upwards of L.30,000. The total trade of the place is now valued at about two millions sterling. The chief exports are wool, vegetable oils, and sugar, indigo and cotton, from the Panjáb. The place was annexed by the Governor-General, on receiving the report of Admiral Maitland, who, on the 5th of February 1839, with the fire of the Wellesley, 74, battered down Manorá Fort, from which no resistance was made—the garrison, indeed, consisting only of four or five men.

Races.

The population of Sindh is given at 1,873,737. The majority of these are Játs, or Sindhís, properly so called, numbers of whom are Muhammadans of the Hanífah sect, being the descendants of those who were converted from Hindúism after the conquest of Sindh by Muhammad bin Kásim, and in subsequent centuries. The general proportion of Hindús to the Muslims is about 1 to 4. Thus, the Hindú census exhibits a total of 363,295, and that of Muslims 1,354,891, but this latter is no doubt understated as regards females. There are, besides, 50,551 persons of other sects. The Sindhis are a tall, muscular race, but, according to Burton, "idle, apathetic, notoriously cowardly and dishonourable, addicted to intoxication, unclean and immoral in the extreme." Their language is a peculiar dialect, compounded of Sanskrit and Arabic words, with a grammatical structure—Sanskrit, as regards the nouns; and as to the verb, formed upon the Persian model. The character is a most corrupt Devanágarí, quite unreadable to the natives of India, and possessing the peculiarity of exhibiting no medial vowels. The same authority divides the Muslim population into, besides Sindhís, Saiyids, Afgháns, Bilúchís, Africans, Memons, and Khwájahs. The Saiyids are often Sh'íahs, and belong chiefly to four great

[1] According to another authority, 13,679 square miles.

[2] *Dry Leaves from Young Egypt*, p. 46.

[3] Pottinger's *Travels*, p. 344.

Singapore.

families, the Bakhárí, Mathárí, Shírází, and Lekhiráyí. The Afgháns are found chiefly about Haidarábád and Shikárpúr. They are a finer and fairer race than the Sindhís. The same must be said of the Bilúchís, who are men of great size and strength. They are of such vigorous constitutions as to live to great ages, even under the unparalleled heat of Upper Sindh. Thus, Turk 'Alí Jakrání, who headed an insurrection against the British in 1844, was then ninety years old, and in 1854 was still living and in robust health. The Bilúchí language is little known, but appears to be an Ugrian dialect, with abundance of Persian words incorporated. The chief Bilúch tribes are—the Bugtí, Chāng, Jakrání, Jatoí, Khosa, Laghárí, Marí, Magsí, Mazárí, Nizámání, Nothání, Rind, and Tálpúr. The Memons were originally Hindús, who entered Sindh during the Kalhora rule from Kach. They became converts to Islám. The Khwájahs are Persians by descent, of the Ism'ailiyah sect. The present Hindú race in Sindh is chiefly of Pánjábí origin. There are two orders of Bráhmans, and no out-castes. The rest are Vaisyas, of whom those who served the native government adopted Muslim costume. Some of the women are remarkably beautiful.

History.

The Rig-Veda mentions the Indus, and in such a manner as to leave no doubt that the Aryan nation was then settled on its banks. Sindh, therefore, 1400 years before the Christian era, was occupied by the people who had, in the time of Alexander the Great, extended their conquests to the mouth of the Ganges. Earthquakes, however, as attested by the buried city of Brahmanábád, and the natural dyke thrown across the Indus, called the Alláh band, and the inundations of the river, have so altered Sindh that the course of Alexander can no longer be traced. From his time, 326 B.C., to 711 A.D., nothing is known of the history of Sindh. In that year the Khalífah and son of Abdu'l Malik, according to the Másúm Námah, sent an army to invade Sindh. It was commanded by Muhammad bin Kásim, who soon captured Nirankot and Alor, and subdued the whole country. From that time till 1026, A.D., the governors of the Khalífs governed with greater or less success in Sindh; but in the latter year, 'Abdu 'r Razá, general of the Sultán Mahmúd of Ghazní, conquered the province. The dynasties of Ghazní and Ghúrí continued to hold Sindh until the end of the eleventh century. The Sumná tribe then rose to power, and seem to have ruled in Sindh till 1340, when they were succeeded by the Sammáo, another native tribe. These were overthrown in 1541 by Sháh Beg Arghun, who had been driven from Kandahár by Bábar. In 1590 Akbar conquered Sindh, which continued under the Mughul emperors of Delhi till 1736, when the Kalhoras made themselves independent of Delhi, though they acknowledged fealty to the Afghan kings of Kábul. The detestable cruelty of one of this race, named Ghulám Nabí, caused the Tálpúrs, under Fath Alí Khán, to revolt, and the sceptre now passed into their hands. In 1813 they entirely threw off all dependence on Kábul, whence the Saddozye family had been expelled by that which now rules there. Their sway continued until the conquest of Sindh by the British, on the 24th of March 1843. Of that conquest different accounts are given; some writers arguing, with Sir W. and Sir C. Napier, that the Amírs were rightly dethroned; and others, with Sir J. Outram, that the attack upon them was unjust and indefensible. The weight of evidence, however, is in favour of the latter view; and it seems now decided, that the treachery of one of the Amírs, aided by the ignorance of the language and customs of the country, which led the British general to decide against the Amírs on insufficient grounds, was the real cause of their downfall. (E. B. E.)

SINGAPORE, a British settlement in India beyond the Ganges, consisting principally of a small island lying off the southern extremity of the Malay peninsula, but including about fifty islets to the south and west, within the distance of 10 miles. The whole territory subject to the British has a circuit of about 100 miles, and lies between N. Lat. 1. 8. and 1. 32., E. Long. 103. 30. and 104. 10. The island of Singapore is about 25 miles long by 15 broad; and its area is estimated at 275 square miles. It occupies about half the space between the two capes Buru and Ramunia, in which the Malay peninsula terminates towards the south, and is separated from it by a strait called Salat Tabrao, about 40 miles long, and from a quarter of a mile to 2 miles broad. This was formerly the chief channel of navigation to the Chinese seas; but vessels now generally pass through the Strait of Singapore to the south of the island. The surface is undulating, rising in some places into low rounded hills. None of these exceed 400 feet in height; and the most of them are only about 100 feet above the sea. The highest peak is one called Bukit Tema, to the north-west of the town. The shores of the island are for the most part low, but in some places along the Salat Tabrao they are rock-bound. Several arms of the sea stretch into the land from three to six miles. Singapore has no lakes or rivers, but is watered by numerous small streams. The water of these, however, is very bad, being dark in colour, and disagreeable to the taste and smell; but, by sinking wells to some depth, water of a better quality is obtained. The geological structure of the greater part of the island consists of ironstone, resting upon a red sandstone, varied with a conglomerate containing large fragments and crystals of quartz; but towards the north and east granite is the prevalent formation. Iron ore is the only metal found here, but it is very abundant. Tin, which is so plentiful in the neighbouring regions, has not hitherto been found in Singapore. Besides granite and sandstone, a stiff kind of clay is obtained, useful for making pottery. Though exceedingly hot, the climate is remarkable for its salubrity. It is very equable, the annual range of the temperature being only from 73° to 85°. The atmosphere is uniformly serene, and the placid face of the ocean is only disturbed by the swell produced by distant tempests in the Chinese Sea or Bay of Bengal. Instead of the monsoons and typhoons of other eastern lands, there are here only varying land and sea breezes; and instead of a periodical rainy season, there are almost daily showers, which preserve the freshness and verdure of the island throughout the year. Many invalids resort to Singapore to get rid of the bad effects of the sultry climate of Hindostan. The soil is in general good, being composed of sand and clay, mixed with vegetable deposits, which give it a dark appearance. In many places there are extensive swamps. Except the comparatively small portion which has been cleared, the island is covered with that thick forest or jungle which occupied its whole extent before the settlement here of the British, and extended, with its luxuriant foliage, to the very edge of the water. Some of the trees furnish valuable timber for building purposes. Where the ground has been cleared all kinds of spices find a congenial soil; but of these only nutmegs, cloves, ginger, and pepper are raised. Indeed, with all its advantages of soil and climate, Singapore cannot be said to be a good agricultural country. The soil was at first considered unfavourable for culture; but considerable success has attended the labours of the Chinese settlers in raising various kinds of fruit and vegetables. The sugar-cane is also cultivated successfully here. Most of the domestic animals of Europe have been introduced, but not in very great numbers, as the pastures of Singapore are not extensive. Of wild beasts the most formidable is the tiger, which commits serious depredations. Deer, wild-hogs, sloths, monkeys, bats, squirrels, and various other animals, are denizens of the woods of Singapore. The chief species of birds are the partridge, pheasant, falcon, owl, parrot, heron, pelican, woodpecker,

and various others. Turtles, tortoises, crocodiles, and serpents among the reptiles; and soles, mullets, rays, and sharks among the fish, abound here. The manufactures are few and insignificant, being carried on chiefly by the Chinese; and the prosperity of the colony depends chiefly on its commerce. The most valuable productions of this country are the gutta-percha, which comes from the islands in the vicinity of Singapore, and a delicate sea-weed, called agaragar, which is used by the Chinese for making a kind of glue and varnish. The population of the settlement is very mixed; comprising Europeans, Indo-Britons, Portuguese, Armenians, Arabs, Jews, Hindoos, Malays, and Chinese. More than half of the people are Chinese; and they, along with the Europeans, who are few in number, compose the wealthier classes. The population, in 1852, was estimated at 59,043. The capital, and indeed the only town in the colony, is Singapore, which stands on the south coast. It occupies a narrow strip of low ground along the coast, about 2 miles long, but only 1000 yards broad, and enclosed by hills, rising to the height of 100 or 150 feet. The rivulets, Singapore and Rochor, divide it into three parts, connected with each other by bridges. The central of these parts is occupied by the Europeans, the eastern by the Malays, and the western by the Chinese. In the European quarter, which is much the best, stand all the principal buildings. These are the government-house, public offices, court-house, jail, custom-house, missionary and Armenian churches, several schools, and the Singapore Institution for instruction in English, Malay, and Tamil. This establishment was founded in 1823 by Sir Stamford Raffles; but is now ill supported, and falling into decay. The streets in this quarter are regularly laid out; and the houses are built either of brick or wood, and roofed with tiles. Many of the British merchants reside on the shore to the east of the town, and their large substantial dwellings contrast strikingly with the wretched habitations of the Malays not far off. The Chinese town consists chiefly of bamboo huts, in many cases raised on posts above the swampy ground. This is the most commercial part of the town; and it is also among the Chinese that the ordinary trades and manufactures are carried on. There are commodious quays; and good anchorage may be obtained in the roads from one to two miles from the town. The ships which lie there are laden and unladen by means of lighters. In a commercial point of view the importance of Singapore is great, and rapidly increasing. It is the principal station for steamers in the Indian seas; and there is now an active navigation between Singapore and Cochin-China, as well as between it and Borneo, Celebes, and the other East Indian islands. The recent treaty between Britain and Siam has also promoted the commerce between Singapore and that country. The number of vessels that entered the harbour in 1856 was 976; of those that cleared, 1042. In the same year the total value of the imports amounted to L.4,877,091, and that of the exports to L.4,301,386; while in the previous year the imports had been valued at L.4,430,770, and the exports at L.3,646,740. The trade may be divided into the Eastern, that of the Straits, and the Western trade. Of the first, the principal branches are those with China, Java, and Siam. The trade with China is carried on in junks, which leave the ports of that country in January, by the N.E. monsoon, and are wafted back again by the contrary wind, which prevails from April till October. The voyage from Canton takes from ten to twenty days. They bring tea, camphor, nankeen, in exchange for pepper, opium, tin, edible birds' nests, &c. From Java, Celebes, and Borneo, there are brought coffee, rice, gold-dust, birds' nests, &c.; and there are exported to these islands cotton, hardware, nankeen, opium, &c. The imports from Siam are sugar, gamboge, hardware, cocoa-nut oil, rice, salt, &c.; and the exports, bees-wax, cotton twist, raw silk, and specie. All the eastern trade is in the hands of the Chinese and the Bugis. The commerce of the Straits comprises the importation of pepper, salt, tin, &c., from the Malay peninsula; and bees wax, betel-nuts, coffee, sago, &c., from the Dutch settlements in Sumatra. The Western trade comprises that with Calcutta, Bombay, Madras, Ceylon, the Cape of Good Hope, Europe, and America; its most active branches being those with Calcutta and Great Britain. Antimony, tin, gold-dust, coffee, sugar, silk, ivory, gutta-percha, and other articles, are exported in exchange for woollen and cotton cloth, hardware, arms, gunpowder, and a variety of manufactured articles. Thus the trade of Singapore depends, not on the productions of the place itself, which are very limited, but on its being the great emporium for all the commerce of South-Eastern Asia, on its being, as it has been styled, the Liverpool of the East. And this position it owes, in a great degree, to its being a free port to all nations, burdened with no import or export duties, nor anchorage, harbour, or light-house fees. The settlement of Singapore is under the governor of the Eastern settlements, who generally resides at Penang, and is subject to the authorities of the Bengal presidency. He is assisted at Singapore by a council. The island was purchased from the Sultan of Johore by the British in 1819. Its history contains no event of any importance.

SINGING, in a general sense, means the production of appreciable and varied sounds by the voice. In a more limited sense, it means different inflexions of the voice through intervals admitted in music, and consistent with the rules of melodic modulation. It is well known that these inflexions differ from those of the voice in speaking. In singing, harshness of vocal *timbre* (see MUSIC), and falseness of intonation, are much more frequently met with than the opposite qualities, especially among persons not trained to sing. Musical training, when applied to a person possessed of a naturally good quality of voice, and a good ear, produces effects that can hardly be imagined by those who have not watched them attentively. Upon the subject of vocal-training, the reader may consult any of the best treatises on singing. For some remarks on the mechanism of the human voice in singing, and the compasses of voices, see MUSIC. (G. F. G.)

SINIGAGLIA, a town of the Papal States, in the legation of Urbino, at the mouth of the Misa, in the Adriatic, 16 miles W.N.W. of Ancona. It is regularly, but not very strongly, fortified, with ramparts, bastions, and a citadel. The buildings, which are almost all modern, are generally good, and the streets broad, straight, and regular. There are a cathedral in the Corinthian style, in the form of a Greek cross, several convents, a mint, a theatre, and a small harbour. Sinigaglia is celebrated for its annual fair, in the end of July and beginning of August. This has been established for several centuries, and attracts great crowds from all parts of Italy. The town occupies the site of the ancient Sena, surnamed Gallica, to distinguish it from the place of the same name, now Siena, in Etruria. It is infamous in history for the treacherous murder, in 1502, by Cæsar Borgia, of several chiefs who were in alliance with him. Pop. 9000.

SINISTER. See HERALDRY.

SINNA, SENNA, or SINENDRIJ, a town of Persia, in the province of Irak-Ajemi, 285 miles W.S.W. of Teheran. It has a somewhat imposing appearance on account of a palace standing on a hill, and surrounded by several other substantial houses. In the vicinity there are extensive public gardens. The town contains from 4000 to 5000 families.

SINOPE, a seaport of Asiatic Turkey, in the pashalic of Anatolia, on the shore of the Black Sea, 75 miles W.N.W. of Samsoun. It stands on a neck of land, connecting with the mainland a steep rocky peninsula, called Cape Sinope, which forms on its south-east side one of the best harbours

on the north coast of Asia-Minor. The town is defended by walls and batteries; but these have been nearly ruined by the Russian bombardment. There is here a ship-building yard, some fishery, and a considerable trade in timber, wax, silk, &c. Sinope is a station for the steamers between Constantinople and Trebizond. It is built for the most part out of the ruins of the old Greek city of the same name, which occupied the same site. It was a colony from Miletus, doubly so; for after the original settlers had been dispossessed by the Cimmerians, a second company was sent out, who recovered the town, in 632 B.C. Soon after its second colonization, Sinope rose to great power and wealth. It continued independent until, towards the end of the third century, its wealth and prosperity excited the cupidity of the kings of Pontus. Mithridates IV. assailed it unsuccessfully in 220, but his successor, Pharnaces, made himself master of the town in 183 B.C. From this time Sinope was the capital of the kings of Pontus, and was much embellished and strengthened by Mithridates the Great. The Romans conquered the town under Lucullus; and it was made a colony by Julius Cæsar. No other important historical event in ancient times is connected with the name of Sinope; but it has recently become notorious for the destruction of the Turkish fleet, and bombardment of the town, by the Russians, November 30, 1853, an act which precipitated the outbreak of war between this country and Russia. Pop. 12,000.

SINUESSA, an ancient town of Italy, on the shore of the Mediterranean, near the confines of Latium and Campania. There does not seem to have been any town here before the time when the Romans established a colony. This took place in the year 296 B.C., the object of the settlement being to prevent the Samnites from making hostile incursions from their mountain fastnesses in the interior down to the rich plains along the coast. Standing as it did on the Appian road, the great means of communication between Rome and the south, Sinuessa rapidly rose to considerable importance; but it suffered much during the invasion of Hannibal, who, in 217, carried his devastations up to the very gates. The country about Sinuessa was very fertile; and the Massic Hill, so celebrated for its wines, rose in the immediate vicinity. Sinuessa had thermal springs, which were much resorted to; but it never attained such a fame as Baiæ and the other fashionable watering-places in the Bay of Naples. Some ancient ruins still mark the site of the town.

SIOUT, or ASYOOT, the capital of Upper Egypt. See EGYPT.

SIPHANTO, or SIPHNO (anc. *Siphnos*), an island in the Ægean Sea, belonging to Greece, lying between N. Lat. 36. 50. and 37. 10.; E. Long. 25. 10.; to the S.E. of Serpho and N.E. of Milo. It is oblong in shape, and about 30 miles in circuit. A chain of mountains traverses the island from N.W. to S.E., the highest point of which, 3000 feet above the sea, is crowned with the small monastery of St Elias. On the eastern slope of these hills there is a plateau, about 1000 feet high, on which stand most of the villages of the island. Siphanto was anciently celebrated for its rich gold and silver mines; but these have long since been exhausted. The land is now chiefly laid out in vineyards, and supports a few horses, cattle, and sheep. The soil is fertile, and the climate salubrious. Many of the productions form articles of exportation from the island; such as corn, figs, honey, wax, sesame, silk, and cotton. The only considerable towns are Castro, the capital, and Stauri, both on the east side of the hills. At the south-east extremity of the island is a harbour, called Pharos, with a lighthouse. Siphnos was colonized by Ionians from Athens; and from its valuable mines it became one of the richest islands in the Archipelago. The inhabitants fought on the side of the Greeks at Salamis; and afterwards submitted to the Athenian supremacy. They were celebrated in ancient times for the manufacture of pottery. Pop. 7000.

SIPONTUM, or SIPUS, an ancient town of Italy, in Apulia, on the shore of the Adriatic, south of the mountain and promontory of Garganus. Its origin is ascribed by tradition to Diomede; but nothing is known of its real founders, and the earliest historical notice we have of it is, that it was captured about 330 B.C., by Alexander of Epirus. How it came into the power of the Romans, we are also ignorant; but a colony was established here in 194. It was deserted shortly after, but subsequently restored by a fresh body of colonists. Under the Romans, Sipontum seems to have been a flourishing town, governed by its own municipal authorities, possessing a good harbour, and a considerable trade in corn. The marshes in the vicinity must always have been very unhealthy; and these caused the decay of the place in the middle ages, and finally induced Manfred, king of Naples, in 1250, to remove the inhabitants to the new city of Manfredonia, not far off.

SIR, the title of a knight or baronet, which, for distinction's sake, is always prefixed to the knight's or baronet's Christian name, either in speaking or in writing to him. SIRE was a title of honour formerly given to the king of France as a mark of sovereignty. Sire was also anciently used in the same sense with *sieur* and *seigneur*, and applied to barons, gentlemen, and citizens.

SIREENNUGGUR, or SERINAGUR, a town of India, in the district of British Gurwhal, North-West Provinces, 1007 miles N.W. of Calcutta. It stands on the left bank of the Aluknunda, an affluent of the Ganges, in a valley about four miles long and two broad, enclosed by barren mountains. The form of the town is somewhat semicircular; the houses are generally of two storeys, built of stones cemented with mud; and the streets are all exceedingly narrow, with the exception of one which contains the bazaar. Altogether the place has a monotonous and gloomy appearance. The palace of the rajah of Gurwhall must have been at one time a very fine building, with three fronts adorned with porticoes; but it has been so much injured by earthquakes, that only the porticoes now remain. The numerous Hindu temples in the town are deserving of no special notice. Sireennuggur was at one time the capital and residence of the rajah of Gurwhal, and carried on a very active trade between the highlands of Tartary and the plains of India, but it has suffered very much from earthquakes, and has now no more than 3000 inhabitants.

SIRENS (Σειρῆνες), certain female mythical beings, who were supposed to partake of the character of divinity, and who were fabled to have the power of charming all who heard them sing. Some make them two in number, Aglaopheme and Thelxiepeia; while others allude to three of them, Peisinoë, Aglaope, and Thelxiepeia; and others make their names, Parthenope, Ligeia, and Leucosia. They are referred to as daughters of Phorcus, of Acheloüs and Sterope, of Terpsichore, of Melpomene, of Calliope, and of Gaea. Their residence was alike mythical and varied as their origin. According to Homer, their island-home was situated on the south-western coast of Italy, between Aeaea and the rock of Scylla. Other writers allude to them as having their proper home on Cape Pelorum, on the Island of Anthemusa, in the Sirenusian Islands, near Paestum, and in Capreae. Some writers connect the self-destruction of the Sirens with the expedition of the Argonauts and the story of Orpheus; others again join their suicide with the wanderings of Ulysses. According to the former legend, as the Argonauts sailed by them, the Sirens struck their lyres, and drew forth from them music of exquisite sweetness; while Orpheus sent back to them a flood of song so deep, and strong, and ravishing, that the Sirens, feeling their divine art had left them, flung themselves into the

sea, and were metamorphosed into rocks. The Homeric fable runs differently. When Ulysses steered his course close by the shore on which the Sirens sat, these fair creatures struck up the most melodious sounds, to lure him and his companions within their grasp; but the good old captain, counselled by Circe, stopped the ears of his mariners with wax, and tied himself firm to the root of the mast, until the ship had so far sped on her way that her crew could no longer hear the notes of their bewitching song. Thus balked of their prey, these singing maidens dashed down the lyre, and leaped headlong into the sea.

The upper half of their body is always represented as a lovely woman, while the lower part sometimes terminates in a fish, and sometimes in a bird. They are occasionally provided with wings, which they are represented as losing on occasion of a contest with the Muses, into which they had been injudiciously led by the advice of Juno. There was a temple dedicated to the Sirens near Surrentum, and the tomb of Parthenope was shown near the town of Neapolis.

SIRHIND, a large division of India, lying between N. Lat. 29. 3. and 31. 24., E. Long. 73. 50. and 77. 39.; bounded on the N. by the Punjab; E. by Sirmoor and other native states, and the British districts of Saharunpoor, Rohtuck, and Panipat; S. by those of Rohtuck and Hurreeana; and W. by the state of Bahawulpore. Length, about 220 miles from E. to W.; breadth 160; area, 17,000 square miles. A very small portion of the surface in the extreme north-east is occupied by the lowest range of the Himalayas; but the rest of the surface consists of a uniform plain, sloping very gradually towards the south-west, and interrupted only by sand-hills or water-courses. The mountains in the N.E. of Sirhind separate the Sutlej from the Jumna, the former the chief affluent of the Indus, and the latter of the Ganges. The whole of the region may thus be regarded as a sort of ridge, separating these two rivers, the one of which forms its northern and north-western, and the other its south-eastern boundary. The land is also traversed by a number of smaller streams, whose beds are all more elevated than those of the great rivers. These streams inundate the country during the rainy season, and tend to enhance the fertility of the soil; but a much greater benefit is derived from a series of artificial channels along the banks of the Jumna, in the east of Sirhind. The country is inhabited by Sikhs, and divided among a number of chieftains, differing in the extent of their territory and the amount of their power. Several parts of the land have, at various times, come into the possession of the British, and now form the districts of Ferozepoor, Umballah, Loodiana, and Kythul. These yield an annual revenue of L.180,000 or L.190,000.

SIRINAGUR, or Cashmere, the capital of Cashmere. See Cashmere.

SIRIS, an ancient city of Magna Graecia, at the mouth of the river of the same name, in the Gulf of Tarentum. The fertility and beauty of the spot seems to have attracted to it a body of Ionians, emigrating from Colophon, to escape the dominion of Gyges, king of Lydia, who had captured their city. This must have taken place between 690 and 660 B.C. The city was remarkable, like the more celebrated one of Sybaris on the same coast, for its prosperity and for the luxury and effeminacy of its people. This is nearly all we know about its history. Siris seems to have been destroyed by a league of the neighbouring cities against it about 550 B.C. In 480 B.C. it must have been quite in ruins; for the Athenians thought of emigrating thither bodily, if unsuccessful in resisting the Persians.

SIRMOUR, a native state of India, under British protection, lying between N. Lat. 30. 25. and 31. 2., E. Long. 77. 5. and 77. 53.; bounded on the N. by Bulsun and Joobul, E. by Deyra Dhoon, S. and W. by Sirhind. Area, 1075 square miles. The surface has a considerable slope downwards from N. to S., as there are two peaks in the north of the country which attain the heights of 12,150 feet and 11,689 feet respectively; while, on the southern frontier, the confluence of the Giree with the Jumna is only 1516 feet above the sea. In fact, Sirmour occupies the declivity of the great Himalayan range, and the higher of the two peaks above mentioned belongs to that chain, and forms the centre of some subordinate ramifications. Almost all the streams flow into the Jumna, which is here known by the name of the Tons, and flows along the eastern frontier. It receives here the Siree, and the smaller streams Minus and Naeraee. The geological formation of the country is various in different parts; in some places, a hard, compact sandstone; in others, slate, limestone; and in the loftier ridges, granite are found. The mineral treasures obtained here are not very great, though the prevalent rocks are usually metalliferous. Iron ore is found in abundance, and is smelted with charcoal; a lead mine is profitably wrought, but one of copper, formerly in operation, has been abandoned. Slate is found in abundance, and can be conveyed without much difficulty to the plains. In some parts, towards the south, the soil is deep, alluvial, and marshy, and the climate hot and unhealthy; while the lofty peaks in the north are covered with snow, and have a cold, dry climate. Dense forests clothe a great part of the low land, and the ground produces rice, cotton, tobacco, opium, ginger, &c. In the loftier regions, wheat, barley, hemp, and other crops are cultivated. Two annual crops are frequently raised. There is hardly any trade; and the roads are few and bad. The inhabitants belong to a race allied to the Hindoos, with some Mongolians in the N.E. of the land. Their religion is Brahminism, mixed with local superstitions; and the general standard of morality is very low, especially among the women. The country is governed by a rajah, who, like the most of his subjects, claims to be of Rajpoot origin; and has been since 1815 under British protection. Pop. estimated at 75,595.

SIROCCO. See Physical Geography.

SIRONJ, a town of India, in Malwa, 213 miles S. of Agra. It stands at the foot of a ghat, or descent from the highland to the north; but on all other sides it is environed with a rich open country. The walls which formerly surrounded it are now gone; but there are still a bazaar, two caravanserais, and numerous mosques. The trade of the town, which was formerly very great, has now greatly fallen off.

SISEBOLI, a seaport-town of European Turkey, Rumelia, on the coast of the Black Sea, 80 miles N.E. of Adrianople. It has a large harbour, and a considerable trade is carried on in wine and timber. The only manufacture is the preparation of salt from the sea-water. Siseboli occupies the site of the ancient Apollonia, afterwards called Sosopolis, whence the modern name. Pop. 8000, mostly Greeks.

SISMONDI, Jean Charles Leonard Simonde De, an eminent historian and political economist, was the last of the Sismondis, an old and a noble family of Tuscany, and was born at Geneva on the 9th of May 1773. His kindred were staunch Ghibellines, and, on the extinction of the republic of Pisa in the fourteenth century, they were compelled to seek refuge on this side the Alps, and accordingly took up their quarters at Dauphiné in France. The grandfather of the historian is reported to have borne arms in the troops of France; while his father chose to do battle with the armies of the prince of darkness, in the character of evangelical minister in the town of Bossex. As to his maternal ancestry less is known. His mother was a woman of a very superior mind, however, and, as is so often the case with great men, she seems to have transmitted to her son the better part of his genius. The Sismondis, at the birth of the historian, were in comfortable circumstances,

and occupied a country mansion, Chatelaine, near the city of Geneva, at the confluence of the Rhone and the Arve. Here the genius of the future annalist had the amplest room to develop itself. Of river, lake, and mountain he possessed one of the most fascinating views in the whole world. Add to this the delicious charm of an enchanting garden, in which he could wander as in the primeval bowers of paradise, and we have presented to the mind one of the very richest spots conceivable for the early growth of a man of genius. But the young dreams of Sismondi were destined to be rudely broken. His father, trusting to the financial policy of his friend Necker, had placed the whole of his moveable property in the French funds. The failure of the banking system of France plunged the Sismondis up to the lips in poverty. Leonardo became a clerk in a counting-house at Lyons, and bore his change of fortune with surprising firmness. The outbreak of the revolution, in 1792, drove the youth from his ledgers back to Geneva. The convulsions which shook the whole of Europe did not pass by this ancient city of the mountain land. The Sismondis, father and son, were heavily fined and imprisoned. On their liberation, in 1793, they resolved to turn their back on Switzerland till more prosperous times, and with this intent they sailed for England. A fit of home-sickness on the part of Sismondi's mother, put a check upon his inquiries into the life, literature, and manners of the English people. Returning again to Chatelaine, the father and son were again compelled to submit to a grievous incarceration. M. Caila, one of the most intimate friends of the family, had sought shelter in their house, and was subsequently dragged from under their roof to instant death. Unable to bear the horrid burden of existence, as it was then experienced in France, the Sismondis resolved to move to their ancestral country, and settled in Tuscany in 1795. The young historian purchased a small estate at Val Chiusa, near Pescia, whither he removed the rest of his family. He set to work with determined resolution to improve the condition of agriculture, and, if possible, to free the inhabitants of his country from the galling yoke to which they were then nationally subjected. He spent five years of incessant labour upon his farm and upon his books. Under the mild skies of Italy he began the study of history, and he resolved to dedicate his first efforts to a delineation of the glory and a representation of the disgrace of the Italian republics. In the meanwhile he entertained certain opinions, which cannot be designated as other than crude, vacillating, and hypothetical on political economy, which he resolved to give to the world. He returned to Geneva in 1801, and published his *Tableau de l'Agriculture de la Toscane* in 1801, which was succeeded by *De la Richesse Commerciale* in 1803. History, however, was his forte, and he devoted himself to it with untiring zeal to the end of his life. In 1807 appeared the first volume of his *Histoire des Républiques Italiennes*, and he completed the sixteen volumes in 1818. During the composition of this work he had much intercourse with the literary society which then flocked to Geneva from the adjoining country of France. The most distinguished of these exiles were Necker the financier, his daughter Madame de Staël, and Benjamin Constant. Sismondi had been appointed secretary to the Chamber of Commerce of the department of Leman, which then formed part of France. In 1810, after his father's death, Sismondi delivered in his native city a course of lectures *On the Literature of the South of Europe*, which were published in 1813, and which have since been rendered into English by T. Roscoe. This work is written in a luminous, free, independent style, and is very valuable wherever the author touches on Italian literature. With the literature of Spain and Portugal he had only a second-hand acquaintance, and of course no force of intelligence could make his book anything more than a second-hand estimate of the genius and influence of the writers of the countries of Cervantes and of Camoëns. This same year, 1813, marked his first visit to the French capital. During his residence in Paris he made the acquaintance of young Guizot, and attracted the notice of Napoleon by his brilliant articles in the *Moniteur* on the counter-revolution. In 1819 he visited England, and took home with him to Geneva a sister-in-law of Sir James Mackintosh, by his second marriage. Having removed his English bride to Chênes, near Geneva, he prosecuted his *Histoire des Français*, and completed all it was his lot to finish of it in twenty years after its first appearance, 1821–42, 29 vols. In 1822 he wrote a heavy historical novel, called *Julia Severa, or the Year* 492, in which he endeavoured to depict the fall of the Roman empire. He was shortly after elected a member of the legislative council of Geneva, and employed the influence of his eminent historical position to gain for his fellow-citizens those rights to which they held themselves entitled. In 1832 he wrote his abridgment of the *Italian Republics* for Lardner's *Cyclopædia*, and translated the same work into French. He published in English and French his *History of the Fall of the Roman Empire, and the Decline of Civilization from* 250 *to* 1000, 2 vols. 1835; and next year the first part of his *Etudes sur la Constitutions des Peuples Libres*, 3 vols., which he completed in 1838. He likewise finished his *Etudes sur l'Economie Politique* about the same period. In his later years he gained himself enemies by advocating the expulsion of Prince Louis Napoleon Buonaparte from the states of Switzerland. On the 25th of June 1842 this eminent historian died, in his seventieth year. Besides the works already mentioned, Sismondi wrote a large number of smaller pieces, critical, historical, philosophical, and biographical, numbering seventy-three in all.

SISTERON, a town of France, capital of an arrondissement in the department of Basses Alpes, in a valley between two hills, 18 miles N.W. of Digne. On a rock above the town stands an old castle, which has a very picturesque appearance. The town is also defended by walls and towers. It is an ancient place, but now small and dirty. A considerable trade in wine is carried on. Pop. (1856) 4213.

SISTOVA, or SISTOW, a town of European Turkey, Bulgaria, on the right bank of the Danube, 36 miles S.W. of Rustchuk. It rises from the water's edge on two undulating slopes, thus presenting a very fine appearance, the whole being crowned with an ancient and strong citadel on the summit. The manufacture of leather and cotton is carried on here, and much wine is produced in the vicinity. The trade of the place is very active. Sistova was the place where the treaty in 1791 between Austria and Turkey was signed. It was dismantled by the Russians in 1810, who gained a victory here over the Turks. Pop. 20,000.

SISTRUM (Σεῖστρον, *from* σείω, *I shake*), a kind of ancient musical instrument used by the priests of Isis and Osiris. It was usually of an oval form; in manner of a racket, with four sticks traversing it breadthwise, which playing freely by the agitation of the whole instrument yielded a kind of melodious sound.

SISYPHUS, in fabulous history, one of the descendants of Eolus, married Merope, one of the Pleiades, who bore him four sons. He resided at Epeyra in Peloponnesus, and was a very crafty man. Others say that he was a Trojan secretary, who was punished for discovering secrets of state; and others that he was a notorious robber, who was killed by Theseus. All the poets, however, agree that he was punished in Tartarus for his crimes, by rolling a great stone to the top of a hill, which constantly recoiling, compelled him eternally to renew his labour.

SITTINGBOURNE, a town of England, in the county

of Kent, 15 miles W. by N. of Canterbury, and 38 E.S.E. of London. It consists of one wide street on the road from London to Canterbury; and contains a spacious parish church, and another place of worship for Wesleyan Methodists. Several annual fairs are held here. Pop. 2897.

SIU-AN-HOA, a town of China, in the province of Chi-li, on the Yang-ho, near the Great Wall, 90 miles N.W. of Pekin. It has important manufactures of felt, and some trade in tobacco. In the neighbouring country there are several forts for the defence of the frontier.

SIVAS, or ROUM, the capital of a pashalic of Asiatic Turkey, on the north bank of the Kizil Irmak, 100 miles S.W. by W. of Trebizond. It covers a large area in a flat open plain, and the houses are intermingled with gardens and trees. Most of them are well built, and either flat-roofed or covered with tiles. The streets are narrow, crooked, and ill-paved. Two castles, each standing on a hill, command the town. The mosques are numerous; and some of their minarets and porches are very fine. The town has also large and well-stocked bazaars, khans, baths, &c. The manufactures of the place are few and unimportant; but the transit trade is very considerable, as it stands on the best route of communication from Bagdad to the west. European goods are the chief articles of commerce. The population of the town is estimated at 27,000, a large proportion of whom are Mohammedans. The pashalic of Sivas or Roum is 310 miles in length from E. to W., by 175 in breadth; and is bounded on the E. by those of Trebizond, Erzeroom, and Diarbekir; S. by those of Marash and Karamania; W. by that of Anatolia; and N. by the Black Sea. It extends from the Kizil Irmak, the ancient Halys, to the Euphrates; and comprises mountains, valleys, and plains, generally of great fertility. Iron, lead, copper, marble, and slate are dug from the ground; and the soil produces corn, flax, hemp, tobacco, silk, wine, &c. There are extensive pastures, on which are fed the flocks and herds of the Kurds and Turcomans. Pop. estimated at 800,000.

SIVASH, or the PUTRID SEA, a lagoon communicating with the Sea of Azoff, on the N.E. coast of the Crimea. It is separated from that sea by a narrow strip of land, stretching for the length of 70 miles from S.E. to N.W., and only leaving one opening, the Strait of Yenitchi, near the northern extremity of the lagoon. Its whole length is about 110 miles, and its breadth varies from 2 to 15, the western coast being very much indented. The Salghir, the chief river of the Crimea, falls into the Sivash. The depth of the lagoon is very small; and the water, which is muddy, gives rise in summer to very unhealthy exhalations.

SIWAH. See AMMON.

SIXTUS V., POPE, was born on the 13th of December 1521, in La Marca, a village in the seigniory of Montalto. His father, Francis Peretti, was a gardener, and his mother a servant-maid. He was their eldest child, and was called Felice. At the age of nine he was hired out to an inhabitant of the village to keep sheep; but disobliging his master, he was soon afterwards degraded to be keeper of the hogs. He was engaged in this employment when father Michael Angelo Selleri, a Franciscan friar, asked the road to Ascoli, where he was going to preach. Young Felice conducted him thither, and struck the father so much with his conversation and eagerness for knowledge, that he recommended him to the fraternity to which he had come. He pursued his studies with such unwearied assiduity, that he was soon reckoned equal to the best disputants. He was ordained priest in 1545, when he assumed the name of Father Montalto; soon afterwards he took his doctor's degree, and was appointed professor of theology at Sienna. It was then that he so effectually recommended himself to Cardinal Carpi, and his secretary Bossius, that they ever remained his steady friends. Meanwhile the severity and obstinacy of his temper incessantly engaged him in disputes with his monastic brethren. His reputation for eloquence, which was now spread about this time over Italy, gained him some new friends. Amongst these were the Colonna family, and father Ghisilieri, by whose recommendation he was appointed inquisitor-general at Venice; but he exercised that office with so much severity, that he was obliged to flee precipitately from that city. Upon this he went to Rome, where he was made procurator-general of his order, and soon afterwards accompanied Cardinal Buon Compagnon into Spain, as a chaplain and consultor to the Inquisition. There he was treated with great respect, and liberal offers were made to induce him to continue in Spain, which, however, he could not be prevailed on to accept. In the meantime news was brought to Madrid that Pius IV. was dead, and that father Ghisilieri, who had been made Cardinal Alexandrino by Paul IV., had succeeded him under the name of Pius V. These tidings filled Montalto with joy, and not without reason, for he was immediately invested by the pontiff with new dignities. He was made general of his order, Bishop of St Agatha, soon afterwards raised to the dignity of cardinal, and received a pension. About this time he was employed by the Pope to draw up the bill of excommunication against Queen Elizabeth.

Peretti began now to cast his eyes upon the papacy; and, in order to obtain it, formed and executed a plan of hypocrisy with unparalleled constancy and success. He became humble, patient, and affable. He changed his dress, his air, his words, and his actions, so completely, that his most intimate friends declared him a new man. Never was there such an absolute victory gained over the passions; never was a fictitious character so long maintained, nor the foibles of human nature so artfully concealed. He courted the ambassadors of every foreign power, but attached himself to the interests of none; nor did he accept a single favour that would have laid him under any peculiar obligation. He had formerly treated his relations with the greatest tenderness, but he now changed his behaviour altogether. When his brother Anthony came to visit him, he lodged him in an inn, and sent him home next day, charging him to inform his family that he was now dead to his relations and the world. When Pius V. died in 1572, he entered the conclave with the other cardinals, but seemed altogether indifferent about his election, and never left his apartments except to his devotion. When solicited to join any party, he declined it, declaring that he was of no consequence, and that he would leave the choice of a pope entirely to persons of greater knowledge and experience. When Cardinal Buon Compagnon, who assumed the name of Gregory XIII., was elected, Montalto assured him that he never wished for anything so much in his life, and that he would always remember his goodness, and the favours he had conferred on him in Spain. But the new Pope treated him with the greatest contempt, and deprived him of his pension. The cardinals also, deceived by his artifices, paid him no greater respect, and used to call him, by way of ridicule, the Roman beast, the ass of La Marca. He now assumed all the infirmities of old age; his head hung down upon his shoulders, he tottered as he walked, and supported himself on a staff. His voice became feeble, and was often interrupted by a cough so exceedingly severe, that it seemed every moment to threaten his dissolution. He interfered in no public transactions, but spent his whole time in acts of devotion and benevolence. Meantime he constantly employed the ablest spies, who brought him intelligence of every particular. When Gregory XIII. died in 1585, he entered the conclave with the greatest reluctance, and immediately shut himself up in his chamber, and was no more thought of than if he had not existed. When he went to mass, for which purpose alone he left his

apartment, he appeared perfectly indifferent about the event of the election. He joined no party, but flattered all. He knew early that there would be great divisions in the conclave, and he was aware that when the leaders of the different parties were disappointed in their own views, they all frequently agreed in the election of some old and infirm cardinal, the length of whose life would merely enable them to prepare themselves sufficiently for the next vacancy. These views directed his conduct, nor was he mistaken in his hopes of success. Three cardinals, the leaders of opposite factions, being unable to procure the election which each of them wished, unanimously agreed to make choice of Montalto. When they came to acquaint him with their intention, he fell into such a violent fit of coughing, that every person thought he would expire on the spot. He told them that his reign would last but a few days; that, besides a continual difficulty in breathing, he wanted strength to support such a weight, and that his small experience rendered him very unfit for so important a charge. He conjured them all three not to abandon him; but to take the whole weight of affairs upon their own shoulders; and declared that he would never accept the mitre upon any other terms. "If you are resolved," added he, "to make me pope, it will only be placing yourselves on the throne. For my part I shall be satisfied with the bare title. Let the world call me pope, and I make you heartily welcome to the power and authority." The cardinals swallowed the bait, and exerted themselves so effectually that Montalto was elected. He now pulled off the mask which he had worn for fourteen years. No sooner was his election secured, than he started from his seat, flung down his staff in the hall, and appeared almost a foot taller than he had done for several years.

After his accession to the pontificate he sent for his family to Rome, with express orders that they should appear in a decent and modest manner. Accordingly his sister Camilla came thither, accompanied by her daughter and two grandchildren. Some cardinals, in order to pay court to the pope, went out to meet her, and introduced her in a very magnificent dress. Sixtus pretended not to know her, and asked two or three times who she was. Upon this one of the cardinals said, "It is your sister, holy father." "I have but one sister," replied Sixtus with a frown, "and she is a poor woman at Le Grotte; if you have introduced her in this disguise, I declare I do not know her; yet I think I would know her again, if I saw her in the clothes she used to wear." Her conductors at last found it necessary to carry her to an inn, and strip her of her finery. When Camilla was introduced a second time, Sixtus embraced her tenderly, and said, "Now we know indeed that it is our sister; nobody shall make a princess of you but ourselves." He stipulated with his sister, that she should neither ask any favour of matters of government, nor intercede for criminals, nor interfere in the administration of justice, declaring that every request of that kind would meet with a certain refusal. These terms being agreed to, and punctually observed, he made the most ample provision, not only for Camilla, but for his whole relations.

This great man was also an encourager of learning. He caused an Italian translation of the Bible to be published, which raised a good deal of discontent amongst the Catholics. When some cardinals reproached him for his conduct in this respect, he replied, "It was published for the benefit of you cardinals who cannot read Latin."

Sixtus died in 1590, after having reigned little more than five years. His death was ascribed to poison, said to have been administered by the Spaniards; but the story seems rather improbable. It was to the indulgence of a disposition naturally formed for severity that all the defects of this wonderful man are to be ascribed. Clemency was a stranger to his bosom; his punishments were often too cruel, and seemed sometimes to border on revenge. But though the conduct of Sixtus seldom excites love, it generally commands our esteem, and sometimes our admiration. He strenuously defended the cause of the poor, the widow, and the orphan; he never refused audience to the injured, however wretched or forlorn their appearance was. He never forgave those magistrates who were capable of partiality or corruption; nor suffered crimes to pass unpunished, whether committed by the rich or the poor. He was frugal, temperate, sober, and never neglected to reward the smallest favour which had been conferred on him before his exaltation. When he mounted the throne, the treasury was not only exhausted, but in debt; at his death it contained five millions of gold. Rome was indebted to him for several of her greatest embellishments, particularly the Vatican library; it was by him, too, that trade was first introduced into the ecclesiastical state.

SIZAR, an appellation by which the lowest order of students in Cambridge and Dublin are distinguished, is derived from the word *size*, which has a peculiar meaning. To size, in the language of the university, is to get any sort of victuals from the buttery, which the students may want in their own rooms, or in addition to their commons in the hall, and for which they pay the cooks or butchers at the end of each quarter. A size of anything is the smallest quantity of that thing which can be thus bought. In Oxford, the order similar to that of sizar is denominated servitor, a name evidently pointing to the menial order from which the class originated. The sizars are not upon the foundation, and therefore, whilst they continue sizars, are not capable of being elected fellows; but they may at any time, if they choose, become pensioners, and they generally sit for scholarships immediately before they take their first degrees. If successful, they are then on the foundation, and are entitled to become candidates for fellowships, when they have got their degree.

SKALITZ, a town of Hungary, in the country of Upper Neutra, on the March, near the frontier of Moravia, 47 miles N. of Pressburg. It stands on a lofty height, and is surrounded by walls. Here are several Protestant and Roman Catholic churches, a town-hall, gymnasium, &c. Weaving and shoemaking are carried on; and hemp is raised in the vicinity. Pop. 7000.

SKELETON (σκέλλω, *I dry*), is the name given to the frame-work of organized bodies, to which the tissues are attached.

SKELTON, JOHN, an old English poet, descended from an ancient Cumberland family, was born probably at Norfolk about the year 1460. Little is known of his life, and from the almost total want of the first editions of his poems, it is impossible to ascertain when it was he wrote the different pieces which have handed down his name to our time. He graduated at Cambridge probably in 1484, and seems subsequently to have proceeded to the sister university of Oxford. His lines on *The Death of the Noble Prince Kynge Edwarde the Forth*, who died in 1483, were probably among the earliest of his productions. In 1489 he wrote an elegy on the death of the Earl of Northumberland, who had been slain during a popular insurrection in Yorkshire. Skelton was admitted a laureate of Oxford and *ad eundem* at Cambridge, and he alludes with a self-satisfied vanity in many of his poems to the badge "enrolde with silke and golde, I dare be bolde thus for to were." The dignity in question, however, was merely a university degree in grammar, and not, as now, an honour conferred by the crown. He was probably also court-poet to Henry VIII., whom he had educated. It was in the latter capacity he had the ode dedicated to him by Erasmus, in which he alludes to Skelton as the *lumen ac decus* of British letters. He was immoderately vain, and exceedingly sarcastic, two gifts which kept him in constant broils. Of

both qualities he has left but too strong evidence. No poet but Skelton has left some sixteen hundred lines in praise of himself. Yet the *Garland of Laurell* is by no means the worst of his poems. His attack on Cardinal Wolsey, who had formerly been his friend and patron, and who had more than once guided the exercise of his pen, as in *Why come ye nat to Courte?* is, considering the time it was written, perhaps the boldest piece of vituperation in the language. Skelton sometimes surpasses even himself in the abundance of his sarcastic ideas, and the perfect torrent of abusive language which he pours upon the head of the offending cardinal. It is impossible to read Skelton's rude and bitter taunts against Barclay, or his onslaught against Garnesche, his ironical allusions to Gaguin, or his angry lampoon on Lilly, without feeling that these writers were no match for him in rough banter or in keen invective.

Skelton had taken holy orders in 1498, and had been appointed rector of Diss in Norfolk, but how long he remained there does not appear. He was at least nominally rector of Diss on his decease. Anthony a Wood affirms that he was esteemed fitter "for the stage than for the pew or pulpit;" and there can be little doubt, without giving credence to that obviously mythical collection known as the *Merie Tales of Skelton*, that the freedom of his observations, his occasional deflections into questionable by-paths, and the scorn which he flung so freely at all around him, and especially at the Dominicans, must have kept him in perpetual broils, and added greatly to the severity of their judgments of the satirist, and perhaps ultimately to his suspension from the church. The ostensible charge brought against the poet was that of keeping a concubine, by whom he had several children. The fact was, however, that Skelton had secretly married the woman, as he confessed on his death-bed, and was withheld only from making an open confession of his priestly crime by the terrors of his church. This affords us a glimpse of the ecclesiastical morality of those times, when it was accounted more respectable for a priest to cohabit with a woman than it was for him to marry her. It likewise shows us the free and unfettered thought of the poet, who could dare to think for himself in the midst of a whole kingdom, who accepted their faith without question, as they did the air they breathed. Besides those pieces already alluded to, he wrote likewise a drama entitled *Magnyfycence; The Bowge of Court; Colyn Cloute; Ware the Hawk; Speke, Parrot; The Tunnyng of Elynour Rummyng;* and *Phyllyp Sparowe*, which Coleridge justly calls "an exquisite and original poem." Skelton is very severe on the Scotch, and on all enemies of Henry VIII. According to Caxton, he translated several of the Latin authors, but these versions have not come down to us. The poet took sanctuary at Westminster from the resentment of Cardinal Wolsey, where he was protected by his old friend Abbot Islip, till his death on the 21st of June 1529.

Skelton was emphatically a satirical poet. He tries various kinds of verse, serious, pathetic, and religious; but in none of them does he rise often above the dead-level of dulness and prosy solemnity. When he gets into his vein again, dulness finds no quarter. He flings, with an apparent carelessness, a rude sort of humour over his page that keeps a perpetual grin upon the countenance of the reader. He hesitates not about the employment of a vulgar word when it suits his purpose, and the thick maccaronic doggrel that frequently bestrews his verse, renders his phraseology, which is almost always grotesque, as amusing as it is racy and pungent. There is, besides, a wild, airy, lawlessness about his *Skeltonical* verse, which, with its quick returning rhymes, the drollery of the words and phrases, and the general playfulness of the diction, renders it as rich a treat as a reader of this age can find. There is one remarkable feature in Skelton's poetry, namely, the lavishness and apparent carelessness with which he pours forth his endless treasure of words. (See *The Poetical Works of John Skelton, with an account of his Life*, by the Rev. Alexander Dyce, 2 vols., 1843.)

SKENE, Sir John, a Scottish lawyer, was the second son of James Skene of Ramore, and of Janet the second daughter of Alexander Burnet of Leys, and was born about the year 1540. He is said to have been partly educated at King's College, Aberdeen; but he is known to have been incorporated at St Andrews in the year 1556, and in this university he took the degree of A.M. In 1564 and 1565 he taught as one of the regents of St Mary's College. According to Dempster's *Historia Ecclesiastica Gentis Scotorum*, he spent a great part of his youth in Norway, Denmark, and Poland. Skene mentions that, after spending seven years abroad, he returned from the University of Wittemberg in 1574, honoured with an annual pension from the Elector of Saxony, and imbued with some knowledge of the civil law. On revisiting his native country, he finally made choice of the legal profession, and was admitted as an advocate on the 19th of March 1575. He speedily acquired some degree of distinction as a lawyer.

The Earl of Morton, then regent of the kingdom, had formed a plan for reducing the laws into a more easy form and method. The execution of the plan was committed to Skene and to Sir James Balfour, president of the Court of Session. The labours of Skene, whatever may have been their nature or extent, were, on the 10th of June 1577, rewarded by the grant of an annual pension of "ten chalders of meal," payable out of the revenues of the abbey of Aberbrothock. Skene accompanied the Earl Marischal on an embassy to Denmark, to negotiate a marriage with a Danish princess, in 1589. Dr Craig, physician to the king, addressed a letter to Tycho Brahe, recommending to his friendly attentions Skene, Swinton, Nicolson, and Fowler, who were all attached to this mission. In the course of the same year, Skene was conjoined with David Makgill for executing the office of his Majesty's advocate; and in 1590 he was associated with Colonel Stewart in an embassy to some of the princes of Germany (Moysie's *Memoirs of the Affairs of Scotland*, p. 84, Edinb. 1830, 4to). During the same year he was employed on an embassy to the States-General (Maidment's *Analecta Scotica*, vol. i. p. 51). In 1592 an act of parliament authorized the chancellor, assisted by other commissioners, of whom Skene was one, to institute a general examination of the municipal laws, to consider what laws and acts should be known to the king's subjects, and to take the necessary steps for printing them (*Acts of the Parliaments of Scotland*, vol. iii., p. 564). The most laborious part of this undertaking devolved upon Skene; and, after an interval of five years, he published *The Lawes and Actes of Parliament maid be King James the First and his Svccessovrs, Kinges of Scotland: visied, collected, and extracted furth of the Register*, Edinb. 15 Martii A.D. 1597, fol. According to our present mode of reckoning, the book was published in the year 1598. With a separate title it includes a treatise, *De Verborum Significatione. The Exposition of the Termes and difficill Wordes, conteined in the fovre bvikes of Regiam Majestatem, and vthers, in the Actes of Parliament, Infeftments, and vsed in Practicque of this Realme, with diverse rules and common places, or principalles of the Lawes: collected and exponed be M. Iohn Skene, Clerke of our Soveraine Lordis Register, Councell and Rolles.*

In September 1594 he had been appointed to the office of clerk-register, in the room of Alexander Hay of Easter Kennet, whom he also succeeded as one of the judges of the Court of Session. In 1604 he was associated with other commissioners for discussing the terms of a union between the two kingdoms. About the beginning of the year 1607 he had

prepared another work for the press; and "the meanness of his estaite and fortune not answerand to his witt, ingyne, and literature," the privy council, after having examined it, addressed a letter to the king, requesting him to provide the means for its publication (Brunton and Haig's *Historical Account of the Senators of the College of Justice*, p. 232). His manuscript was afterwards presented to Parliament, and, having been highly approved, was ordered to be printed. It was at length published, under the title of *Regiam Majestatem*, Edinb., 1609, fol. A Scottish translation speedily followed during the same year.

Skene's publications are deficient in critical accuracy, and even in editorial fidelity. It is well known that the treatise *De Legibus et Consuetudinibus Regni Angliæ*, commonly ascribed to Glanville, was at an early period adopted in Scotland, with a few changes and modifications; and that, under this new form, it bears the title of *Regiam Majestatem*, from the initial words of the prologue. Skene was, however, anxious to exhibit *Regiam Majestatem* as the original, and to represent it as having been composed and divulged by the authority of David I., who closed his reign in the year 1153. From what manuscripts he derived his text, he has not thought proper to specify; but several are to be found which contain a reference to Glanville by name, but no more. Having reached an advanced age, he became anxious to secure for his eldest son James the office of clerk-register; but his attempt was defeated by the dexterity of Sir Thomas Hamilton, afterwards successively Earl of Melrose and of Haddington. Skene, or Lord Curriehill, for such was his title on the bench, resigned his office in the year 1612, and he survived till the 16th of March 1617. His last descendant, Elizabeth Skene, bequeathed to the Advocates' Library a collection of family papers, together with a very curious collection of ancient music, which appears to have belonged to this ancestor. The *Skene Papers* have been carefully bound in a folio volume; and the music has since been published by William Dauney, who has added a copious and elaborate introduction, together with notes and illustrations.

SKERRIES, a seaport of Ireland, in the county and 17 miles N.N.E. of Dublin. It is built on a small headland, and has a very neat and clean appearance, containing a parish church with a pinnacled tower, and other places of worship for Roman Catholics and Methodists. The men are mostly employed in fishing, and a large number of the women in embroidery. There are in the town corn-mills, malting kilns, and a brewery. The harbour is safe; and a considerable coasting trade is carried on in potatoes, limestone, and coal. Opposite the town lie the four Skerry Islands, on the largest of which is a Martello tower. Pop. 2327.

SKEW BRIDGE. In the article BRIDGE the theory has been given of those arches which stand at right-angles to their abutments, and which were the only arches in use until the requirements of canal and railroad engineering suggested the idea of building bridges obliquely across the streams or roads which they have to span.

In these oblique, or *skewed arches*, as they are called, the plan of the soffit, instead of being rectangular, as in the ordinary bridge, is rhomboidal. Now, if the joints were made to run parallel to the abutments, the directions of the pressures would not be normal to them, and the stability of the arch would depend on the friction of the surfaces, and on the induration of the mortar.

The first attempts to secure the stability of the skewed arch consisted in forming the joints in helical lines, the pitch of the screw being so taken that the line, as it crossed the crown of the arch, might be perpendicular to the parapet, and a lively disputation was carried on in the pages of the *Civil Engineer and Architect's Journal*, during the years 1838, 1839, 1840, by the advocates of different methods of carrying this idea into effect. Yet a very slight attention to the subject is enough to convince us that the helical joint can only be perpendicular to the lines of pressure at one point, and that, therefore, it cannot satisfy the condition of stability.

The true theory of the oblique arch was first given, by the writer of the present article, in a series of papers read before the Society of Arts for Scotland, in 1835, 1836, 1838, an abridgment of which was published in their "Transactions," in the *Edinburgh New Philosophical Journal* for April 1840, and which was reprinted in the *Civil Engineer and Architect's Journal* for July 1840.

Let ABDC (fig. 1) be the plan of a skewed arch; AB,

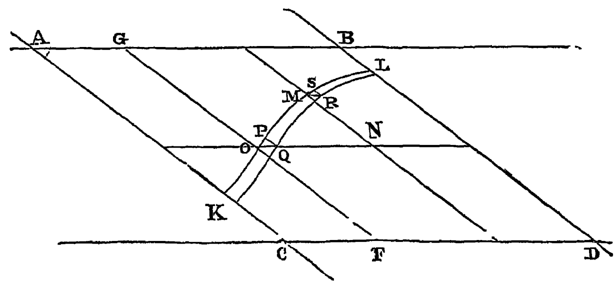

Fig. 1.

CD, being the abutments; AC, BD, the parapets; and KOML the horizontal projection of one of the joints crossing the crown line ON at O. Then, while the lines of pressure must be contained in planes GF, MN, &c., parallel to the parapets, the joint KOML should cross all these upon the surface of the vault, at right angles.

If another joint line be drawn contiguous to KOML, so that the included space may represent the lower faces of an exceedingly thin course of arch-stones, and if MR be drawn parallel to ON, the intercepted distance MR must clearly be equal to OQ. Draw now, on the surface of the vault, the arcs QP, RS, parallel to the parapets, then it can be shown that these minute arcs ought to be proportional to the cosines of their inclinations to the horizon, or that, since O is on the crown of the arch,

$$\text{arc QP} : \text{arc RS} :: \text{R} : \text{cos-incl at M}$$

Hence, if a be taken to represent the length of the arc NM, v the distance ON, and i the inclination of the line of pressure at M to the horizon, so that MR may be the differential of v, and the arc RS the differential of a, s also being put for the angle of the skew,

$$\sin s \,.\, \delta v : \delta a :: 1 : \cos i; \text{ or,}$$
$$\delta a = \sin s \,.\, \cos i \,.\, \delta v \qquad (1.)$$

But the projection of the arc RS upon the horizontal plane is less than RS in the ratio of the cosine of the obliquity; wherefore, if u represent the horizontal projection of NM, and δu that of RS, we have

$$\delta u = \sin s \,.\, \cos i^2 \,.\, \delta v \qquad (2.)$$

Let fig. 2 be the side elevation of the same arch, that is,

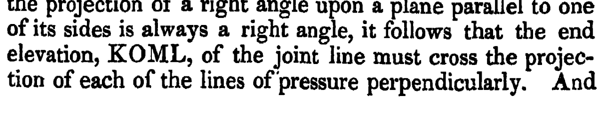

Fig. 2.

its projection upon one of the parapet planes, then, since the projection of a right angle upon a plane parallel to one of its sides is always a right angle, it follows that the end elevation, KOML, of the joint line must cross the projection of each of the lines of pressure perpendicularly. And

hence this very remarkable fact, that the configuration of the projection of a joint upon the plane of the parapet is entirely independent of the angle of the skew, and is deducible from the character of the vault alone.

The equations (1) and (2) are universal; they apply alike to circular, elliptical, parabolic, or catenarian arches; the first giving, on being integrated, the development of the surface of the vaults; the second giving the plan.

In the case of the cylindroid arch, when the lines of pressure are circular, the radius being r, we have $a=r\,i$, so that equation (1) becomes

$$r\delta i=\sin s \,.\, \cos i \,.\, \delta v\,; \text{ or,}$$
$$\sin s \,.\, \delta v=r \,.\, \sec i \,.\, \delta i$$

whence by integration

$$v \,.\, \sin s=r \text{ nep} \,.\, \log \tan\left(45°+\frac{i}{2}\right)$$

or, using common logarithms,

$$\log \,.\, \tan\left(45°+\frac{i}{2}\right)=\frac{\text{M} \,.\, \sin s}{r}\, v \qquad (3.)$$

from which equation the positions and dimensions of the arch-stones may be computed with great ease.

The second equation becomes, in the same case,

$$\sin s \,.\, \delta v=\frac{r^3\,\delta u}{r^2-u^2},$$

whence by integration,

$$\sin s \,.\, v=r \,.\, \text{nep} \log\sqrt{\left(\frac{r+u}{r-u}\right)} \qquad (4.)$$

So that the horizontal projection of the joint of a skewed circular arch is midway between two logarithmic curves; and in this respect it bears some analogy to the catenary, which is also midway between two logarithmic curves: to this curve I have given the name of double logarithmic.

The projection of the joint of a circular skewed arch, upon the plane of the parapet, is, evidently, the well-known curve called the tractory.

In order to obtain the configuration of the joints for any other kind of arch, we have only to determine, from the nature of the case, the value of cos i, in terms of a or of u, and substitute it in equations (1) and (2), which will then, on being integrated, give the development, and the projection on the horizontal plane. (E. S.)

SKIBBEREEN, a market-town of Ireland, on the River Ilan, in the county and 45 miles S.W. of Cork, 210 S.W. of Dublin. It is for the most part well built of stone; and contains, besides the parish church, places of worship for Roman Catholics and Wesleyans, two national schools, a market-house, court-house, jail, custom-house, dispensary, and work-house. Near the town are several flour-mills and a brewery. The weaving of coarse frieze is also carried on by many of the inhabitants. Several fairs are held, where these coarse stuffs are disposed of. The river is navigable for boats up to Skibbereen; but large vessels must lie at Aldcourt, its port, 2 miles farther down. Corn, flour, and provisions are exported. Skibbereen suffered very much during the famine of 1846-7; and it contains a large proportion of paupers. Pop. 6440.

SKINNER, JOHN, a Scottish Episcopal clergyman, but better known as a poet, and the author of *Tullochgorum*, was born at Balfour, in the parish of Birse, and county of Aberdeen, on the 3d of October 1721. His father, John Skinner, was parish schoolmaster there, and had married the widow of Donald Farquharson of Balfour. About two years after the birth of this their only son, the mother died, and Mr Skinner removed to the parish of Echt, in the same county, where he continued to discharge the duties of parish schoolmaster for upwards of fifty years. He had the character of being a very efficient teacher, and is said to have "fitted out more young men for the university than most country schoolmasters of his day." By a second marriage which he contracted he had a numerous family.

John received the earlier part of his education at his father's school, and made so rapid progress, especially in the Latin language, that when only thirteen he gained a considerable *bursary* at the annual competition in Marischal college. For the intimate knowledge of the Latin tongue, which he afterwards displayed in his writings, he was, doubtless, in great measure indebted to the careful training of his father. After completing his academical curriculum at the university, he acted for a few months as teacher in Kemnay, and afterwards became assistant schoolmaster in the neighbouring parish of Monymusk. While here some of his poetical effusions having come under the notice of the lady of Sir Archibald Grant, the proprietor of the parish, she generously took him into her favour, placed the library at his command, and afforded "him in the house of Monymusk every accommodation for prosecuting his studies, and improving his mind in the attainment of useful learning." Here also he enjoyed the friendship and fellowship of an Episcopalian clergyman, and was thus led to connect himself with the Scottish Episcopalian communion. In June 1740 he accepted an invitation to become tutor to the only son of Mr Sinclair of Scalloway, a gentleman of considerable property in Shetland. In consequence of the death of his pupil's father, he only remained here about twelve months, but within that time he wooed and wedded Grace, eldest daughter of Mr Hunter, the only Episcopal clergyman in these islands. Returning to Aberdeenshire, he completed his studies for the ministry, and was ordained a presbyter of the Episcopal Church, by Bishop Dunbar, at Peterhead. A vacancy having occurred in the congregation at Longside, he accepted an unanimous call to be their pastor; and in November 1742, when only twenty-one years of age, he entered upon the charge, which he continued to hold for nearly sixty-five years. Soon after his settlement at Longside, perceiving the sufferings that his neighbours frequently endured for want of medical attendance, there being no practitioner within 4 or 5 miles of Longside, he set himself to the study of medicine; and with the aid of an eminent physician in Aberdeen (Dr Thomas Livingston), who approved of his design, he soon acquired such a knowledge of the healing art as enabled him to afford to the poor suffering under disease such relief as they could not otherwise have easily obtained, and the want of which might sometimes have proved fatal. Nor were his labours confined merely to the members of his own congregation, but he cheerfully administered relief to all within his reach, ever refusing to accept of any fee for his services.

After the rebellion of 1745, the Episcopalians being in general Jacobites, were subjected to the most barbarous treatment. Their clergy, in particular, were special objects of persecution. Their houses were plundered, their chapels destroyed, and their very lives endangered by bands of ruthless soldiers. To avoid falling into their hands, Mr Skinner had frequently to resort to stratagems; and one evening, on returning home from visiting at some distance, "he found his house in the possession of a military party; some of them guarding the door with fixed bayonets, and others searching the several apartments, even the bed-chamber where Mrs Skinner was lying-in of her fifth child." They "pillaged the house of everything they could carry with them, hardly leaving a change of linen to father, mother, or child in the family." The chapel with all its furniture was burned; and a lady of some rank is said to have manifested her zeal, by riding in triumph round the blazing pile, and shouting to the infuriated soldiers to "Hold in the Prayer Books." For several years the congregation had no place to meet in for public worship but the clergyman's house; and to prevent his

flock from being scattered, Mr Skinner published a small tract, entitled a *Preservative against Presbytery*. In consequence of the penal enactments against Episcopacy in Scotland, Mr Skinner could only minister to his flock with the utmost caution; and in 1753 he was apprehended and subjected to six months' imprisonment in Aberdeen jail, for officiating to more than four persons besides his own family.

For some years before and after his imprisonment he had devoted much of his leisure time to the study of the Hebrew language; and the first fruit of his labours in this field was a *Dissertation on Jacob's Prophecy*, published in 1757. About 1758, with the view of bettering his straightened circumstances, he entered upon a farm in the neighbourhood—Mains of Ludquharn; but after a hard struggle of nearly seven years, he gave it up in disgust. The next considerable work which Mr Skinner published was *An Ecclesiastical History of Scotland, from the First Appearance of Christianity in that Kingdom to the Present Time, in a Series of Letters to a Friend*, 2 vols. 8vo, London, 1788.

During the autumn of 1799 he had the misfortune to lose his wife, who had been the beloved partner of his joys and sorrows for the long term of fifty-eight years. After this event the weight of years continued to press more and more heavily upon him, and at length, at the pressing invitation of his son, Bishop Skinner, he agreed to come to Aberdeen. Resigning his flock to the care of another, and bidding adieu to the scene of his labours for so long a period, he came to Aberdeen on the 4th of June 1807. But he did not long enjoy his changed circumstances, for, after a slight illness, he expired without a struggle or a groan, on the 16th of the same month, in the eighty-sixth year of his age. In compliance with his own request, his remains were interred in the churchyard of Longside; and a marble monument was erected to his memory by the members of his congregation.

Mr Skinner was a man of a very amiable and cheerful disposition, and is said by Burns to be " one of the worthiest of mankind." In his lowly cottage at Linshart, with its *but and ben*, he passed his days contented and happy, as he has sung in his *Old Man's Song*, which is entirely descriptive of his own condition and feelings. He possessed great fluency in conversation, and a rich fund of wit and humour, that made his company always desirable and pleasant. He had no mean share of learning, and was frequently consulted by Dr Gleig, when acting as editor of a previous edition of this work. In the composition of Latin verse he had attained to great facility and considerable skill; and in the Hebrew language his knowledge was profound and critical. Of his songs some have been and still are very popular. His *Tullochgorum*, said by Burns to be "the best Scotch song Scotland ever saw," will exist as long as the language in which it is written. *John o'Badenyon* and the *Ewie wi' the Crookit Horn* have also enjoyed a great share of popularity. Speaking of his poetical effusions, he says, in one of his letters to Burns, "A small portion of taste in this way (poetry) I have had almost from childhood, especially in the old Scottish dialect, and it is as old a thing as I remember my fondness for *Chryste-Kirk on the Green*, which I had by heart ere I was twelve years of age, and which, some years ago, I attempted to turn into Latin verse. While I was young I dabbled a good deal in these things, but on getting the black gown I gave it pretty much over, till my daughters grew up, who, being all tolerably good singers, plagued me for words to some of their favourite tunes, and so extorted those effusions which have made a public appearance beyond my expectations, and contrary to my intentions; at the same time, that I hope there is nothing to be found in them uncharacteristic or unbecoming the cloth, which I would always wish to see respected." Not long after his death his theological works appeared in two volumes, with a life of the author prefixed, and soon after a third volume, containing a miscellaneous collection of fugitive pieces of poetry, &c. Very recently (1859) his songs and poems have appeared in a small volume, with a life by H. G. Reid.

SKIPTON, a market-town of England, in the West Riding of Yorkshire, in a valley near the Aire, 38 miles W. of York. It is an ancient town, for the most part well built of stone, and consisting of one main street of considerable breadth. The principal public building is the town-hall, in which the quarter sessions for the West Riding are held. The parish church is a large substantial building, some parts of which are of great antiquity. A district church was erected in 1838; and there are also places of worship for Primitive and Wesleyan Methodists, Independents, Swedenborgians, and Roman Catholics. The Free Grammar School of Skipton, founded in 1548, had, in 1854, upwards of sixty scholars, and an endowment of L.600 a year. There are also in the town national and British schools, a mechanics' institute, library, and savings' bank, as well as several charitable institutions. Many of the inhabitants find employment in the cotton factories of the town, but not a few of them are employed in agriculture. At the weekly markets there is a considerable traffic in corn; and numerous fairs are held for cattle and sheep. The general trade of the place is facilitated by the Leeds and Liverpool canal, which passes near the town. The old castle of Skipton, still used as a residence, is a large quadrangular edifice, the most part of which dates from the reign of Edward II. First founded in the time of William the Conqueror, it was a place of great strength in the seventeenth century, and held out for three years against the Parliamentary forces. In 1649 it was dismantled, but subsequently rebuilt by the Countess of Pembroke. Pop. of the town, 4962.

SKYE, the largest of the western islands of Scotland, included in Inverness-shire, of which it forms a considerable portion, lies between N. Lat. 57. 2., and 57. 41.; W. Long. 5. 37. and 6. 40.; separated from the mainland by the Sound of Sleat and the narrow straits called Kyle Rhea and Kyle Akyn. Its form is exceedingly irregular. The length of a line drawn from the point of Aird, its northern, to that of Sleat, its southern extremity, is about 44 miles; its breadth in the northern or broadest portion is more than 20 miles; and its area is about 535 square miles. But so much is the coast indented with lochs and creeks, that there is hardly any place in the island more than 5 miles distant from the sea. The coast is lofty, bold, and rocky, lined in many places with vast masses of trap-rock, or perpendicular basaltic columns. These are especially prevalent on the north-east coast of the island, occupying the whole district of Trotternish, from Portree northwards to the point of Aird. The island may be generally characterized as a great tract of mountainous moorland; but there are several districts of a different character—plains, green hills, and tracts of arable land occupying some portions of the surface. The plain of Kilmuir, in the north-west, and another of smaller size near Bracadale, are the only considerable level portions. The chief tract of arable land lies in the south-east along the coast of the Sound of Sleat. A valley, called the strath, stretches across the island from shore to shore, not much above the level of the sea, near the south of the island. The mountains of Skye form three principal groups; one of which occupies the peninsula of Sleat, in the south-east; another, the district of Minginish, near the centre; and a third, the peninsulas of Trotternish, Waternish, and Kilmuir, in the north. The hills in the southern part of Sleat have an average height of only 1200 feet; but further north there are five

united mountains which rise to the elevation of 2000 feet. The mountains of Minginish, however, compose the largest as well as the most rugged and imposing group in the island, and they form a conspicuous object from almost every part of it. Here rise the Cuchullin Hills, near the south of the district, forming a group encircling Loch Coruisk. These hills are remarkable for their bold and serrated character; and Scuir-na-Gillean, which is generally regarded as the highest summit, has been estimated to attain an elevation of 3200 or 3220 feet above the sea. Another summit, called Blaven, east of the Cuchullin Hills, is believed to be the loftiest peak in the whole island. The Red Hills rise further to the north, and are more tame and rounded in outline than the Cuchullin Hills. They derive their name from the streaks of red with which they are mostly covered. In the north of Skye, the loftiest and most remarkable mountain is the Storr in Trotternish. It is quite perpendicular to the side of the sea; and forms a number of detached pinnacles of the most gigantic size and fantastic appearance; one of them being very similar in form to a spire, and forming a conspicuous sea-mark. The height of the Storr is 2348 feet. There are no considerable rivers in the island, but a vast number of rivulets; and of the lakes the chief is Loch Coruisk, already mentioned, celebrated for its wild and barren scenery. The arms of the sea are numerous. On the Sound of Sleat is Loch-in-Daal; on the south-west coast of the island, Loch Eishart, Loch Slapin, Loch Scavaig, Loch Brittle, Loch Eynort, and Loch Bracadale; on the north-west coast, Loch Follart, Loch Bay, and Loch Snizort; and on the north-east, Portree Loch, Loch Sligachan, Loch Ainort, and Broadford Bay. The islands of Rona, Raasay, and Scalpa, which lie to the east of Skye, are separated from it by the sounds called by their respective names. The district of Sleat consists of stratified rocks, including gneiss, chlorite slate, mica, and horn-blende slate, extending regularly from S.W. to N.E. The central and northern parts of the island, however, are quite different in their geological structure. Large masses of trap-rock there lie above and around portions of sandstone. All the mountains in Trotternish are formed of amygdaloid trap; and among the other formations in this district there are basalt, lias, oolite, shale, &c. Although Skye contains several beds of coal, yet these are so small that they are of very slight value. The only mineral worked is the limestone of the district of Strath. In this district, also, there are quarries of marble; but these, though at one time worked, are now greatly neglected. The marble is generally gray in colour, but there are some blocks as pure and white as the best used for statuary. In the limestone of this region there are many caves; one of which, called the Spar Cave, is remarkable for the beauty of the stalactites, with which it is encrusted. Another cave in Skye, near Portree, is adorned with similar crystallizations; and is also memorable as having afforded a refuge to Prince Charles Stuart after the battle of Culloden. The climate of the island is remarkably moist and variable, three days out of four being in general rainy. The hills are frequently enveloped in clouds and mists; and some of the loftier summits are covered with snow for a great part of the year. The soil is not well suited for cultivation, as a great proportion of it is moist and boggy. Indeed agriculture is almost confined to a few districts, including some parts of Trotternish and Sleat, the plain of Bracadale, and patches of ground at Broadford, Snizort, Portree, and other places. And even in these places no great amount of skill is expended in the cultivation of the ground; and the crops raised are far from being plentiful. The farming implements are in many instances of the rudest possible description, and many of the farms or crofts are so small as hardly to render it worth while to introduce the plough or the harrow. Instead of the former, the *caschrome*, or ancient crooked spade, is much used by the poor; and the place of the latter is frequently supplied by rakes. Except the alternation of oats and potatoes, and even this is not universally practised, there is no such thing as a rotation of crops in a great part of the island, though in the larger farms this is practised. In some of the more remote districts the only method of grinding the corn is by the *quern* or hand-mill. In fact, it is not agricultural produce, but cattle, sheep, and kelp that form the chief riches of Skye. By far the greater part of the surface, consisting of moorlands and grassy tracts, is devoted to the rearing of cattle and sheep. The breeds of both have been much improved, and the latter are mostly Cheviots. Kelp is obtained by drying sea-ware in the sun, and afterwards burning it in small pits. From these pits, while in use, dense clouds of smoke are continually given out. Fishing is also carried on to some extent in Skye, though the people cannot be said in any sense to be a fishing community. Even their dress is not suited for seafaring pursuits, although they are for a great part of their time on the sea; and except the herring fishery, during its season, they pay very little attention to any other. Oysters, however, are found in abundance in the Sound of Scalpa and Loch Snizort; lobsters on the west coast; cockles, mussels, limpets, &c., in various places. The men frequently leave the island in summer in search of work, either on farms or in the fisheries of the east coast; and the women sometimes leave during the harvest. Owing to the system of subdividing the land into very small crofts, the island is overpeopled, and many of the inhabitants reduced to a state of poverty. Their houses are frequently very mean and wretched; and the failure of the potato crop, which forms here an important article of sustenance, has caused great distress. A gradual alteration is taking place in the system of small crofts; many clearances have been effected, and many of the people have been obliged to emigrate. No manufacture, except that of kelp is carried on in Skye; and the only markets for the disposal of cattle are held at Portree. This town, the largest in the island, has a good harbour, and communicates regularly by means of steamers with Glasgow. The island is divided into seven parishes, and contains also seven churches belonging to the Free Church. The most of it belongs to Lord Macdonald, or to the M'Leod family. Armadale Castle, the residence of the former, and Dunvegan Castle that of the latter, are the principal seats in the island. Parts of the latter are very ancient, and it is one of the finest mansions in the Highlands of Scotland. Brochel Castle, in the island of Raasays, is an interesting ruin, occupying a ledge of rock overhanging the sea. The population of Skye is 21,521.

SLAITHWAITE, a village of England, in the West Riding of Yorkshire, in the valley of the Colne, 5 miles W.S.W. of Huddersfield. It contains a large but plain church with a tower, a national and a free school, woollen and cotton mills, and quarries of freestone in the vicinity. Here too are mineral-springs, closely resembling those of Harrowgate. In connection with them, baths and lodging-houses have been erected, and fine gardens and pleasure-grounds laid out. Slaithwaite forms a station of the Leeds and Manchester railway. Pop. 2852.

SLANDER, is the malicious defamation of a man's character by spoken words, as libel is by written words. (See LIBEL.) Slanderous words are of two kinds. First, those actionable in themselves; and second, those which are naturally calculated to occasion damage to the person of whom they are spoken. Of the former class are all words imputing to a man some crime punishable in the temporal courts, tending to injure him in his profession, trade, or calling by which he gains his livelihood; tending to his exclusion from society, or to disparage him in an office of public trust. It is presumed by the law, that all such words have a natural

and necessary tendency to injure the person of whom they have been spoken, and allows any party to sue for damages, without proving that any have been in fact occasioned. To say of a man that he has committed a crime for which one can transport him; to say that he has an infectious disease; to call a lawyer a knave, a physician a quack, or a tradesman a bankrupt, or charge a magistrate or judge with corruption, is actionable. "Lord Campbell's Act," as it is called (Statute 6 & 7 Vict., c. 96), was passed in 1843, for the better protection of private character from slander and libel. By 15 & 16 Vict., c. 76, § 70, it is enacted that, in all cases of slander, the defendant is precluded from paying money into court by way of compensation or amends.

SLAVE LAKE, Great, a lake in the Hudson's Bay Company's territory, North America, lying between N. Lat. 60. 40. and 63.; W. Long. 109. and 117. 30. Its form is very irregular; its length from E. to W. about 250 miles, average breadth 50, area upwards of 12,000 square miles. Its northern shores are steep and rugged; and there are many rocky islands on its surface. Its largest affluent is the Slave River, from Lake Alhabasca, and it discharges its waters by the Mackenzie River into the Polar Ocean.

Slavery defined.

SLAVERY is a word, of which, though generally understood, it is not easy to give a proper definition. An excellent moral writer has defined it to be "an obligation to labour for the benefit of the master, without the contract or consent of the servant." But may not he be properly called a slave, who has given up his freedom to discharge a debt which he could not otherwise pay, or who has thrown it away at a game of hazard? In many nations, debts have been legally discharged in this manner; and in some savage tribes, it is no uncommon thing for a man, after having lost at play all his other property, to stake, on a single throw of dice, himself, his wife, and his children. That persons who have thus lost their liberty are slaves, will hardly be denied; and surely the infatuated gamester is a slave by his own contract. The debtor, too, if he was aware of the law, and contracted debts larger than he could reasonably expect to be able to pay, may justly be considered as having come under an obligation to labour for the benefit of a master with his own consent; for every man is answerable for all the known consequences of his voluntary actions.

But this definition of slavery seems to be defective as well as inaccurate. A man may be under an obligation to labour through life for the benefit of a master, and yet that master have no right to dispose of him by sale, or in any other way to make him the property of a third person; but the word slave, as used amongst us, always denotes a person who may be bought and sold like a beast in the market.[1]

Inequalities of rank inevitable.

As nothing can be more evident than that all men have, by the law of nature, an equal right to life, liberty, and the produce of their own labour, it is not easy to conceive what can have first led one part of them to imagine that they had a right to enslave another. Inequalities of rank are indeed inevitable in civil society; and from them results that servitude which is founded in contract, and is of temporary duration. He who has much property has many things to attend to, and must be disposed to hire persons to assist and serve him; whilst those who have little or no property must be equally willing to be hired for that purpose. And if the master be kind, and the servant faithful, they will both be happier in this connection than they could have been out of it. But from a state of servitude, where the slave is at the absolute disposal of his master in all things, and may be transferred without his own consent from one proprietor to another, like an ox or an ass, happiness must be for ever banished. How then came a traffic so unnatural and unjust as that of slaves, to be originally introduced into the world?

The common answer to this question is, that it took its rise amongst savages, who, in their frequent wars with each other, either massacred their captives in cold blood, or condemned them to perpetual slavery. In support of this opinion etymologists observe, that the Latin word *servus*, which signifies not a hired servant, but a *slave*, is derived from *servare*, to preserve; and that such men were called *servi*, because they were captives, whose lives were preserved on the condition of their becoming the property of the victor.

Origin of slavery.

That slavery had its origin from war, we think extremely probable, nor are we inclined to controvert this etymology of the word *servus;* but the traffic in men prevailed almost universally, long before the Latin language or Roman name was heard of; and there is no good evidence that it began amongst savages. The word עבד, in the Old Testament, which in our version is rendered servant, signifies literally a slave, either born in the family or bought with money, in contradistinction to שכיר, which denotes a hired servant; and as Noah makes use of the word עבד in the curse which he denounces upon Ham and Canaan immediately after the deluge, it would appear that slavery had its origin before that event. If so, it may be plausibly conjectured that it began amongst those violent persons whom our translators have called *giants*,[2] though the original word נפלים literally signifies *assaulters of others.* Those wretches seem to have first seized upon women, whom they forcibly compelled to minister to their pleasures; and from this kind of violence the progress was natural to that by which they enslaved their weaker brethren amongst the men, obliging them to labour for their benefit, without allowing them fee or reward.

Prior to the deluge.

Nimrod enslaved his captives.

After the deluge the first dealer in slaves seems to have been Nimrod. "He began," we are told, "to be a mighty one in the earth, and was a mighty hunter before the Lord." He could not, however, be the first hunter of wild beasts; nor is it probable that his dexterity in the chase, which was then the universal employment, could have been so far superior to that of all his contemporaries, as to entitle him to the appellation of "the mighty hunter before the Lord." Hence most commentators have concluded, that he was a hunter of men; an opinion which they think receives some countenance from the import of his name, the word Nimrod signifying a rebel. Whatever be in this, there can be little doubt that he became a mighty one by violence; for it appears from Scripture, that he invaded the territories of Ashur the son of Shem, who had settled in Shinar; and, obliging him to remove into Assyria, he seized upon Babylon, and made it the capital of the first kingdom in the world. As he had great projects in view, it seems to be in a high degree probable that he made bond-servants of the captives whom he took in his wars, and employed them in building or repairing the metropolis of his kingdom; and hence may perhaps be dated the origin of postdiluvian slavery.

Slavery in the days of Abraham.

That it began thus early can hardly be questioned; for we know that it prevailed universally in the age of Abraham, who was born within seventy years after the death of Nimrod. That patriarch had three hundred and eighteen servants or slaves, born in his own house, and trained to arms, with whom he pursued and conquered the four kings who had taken captive his brother's son.[3] And it appears from the conversation which took place between him and the king of Sodom after the battle, that both believed the conqueror had a right to consider his prisoners as part of his spoil. "Give me," says the king, "the *persons*, and take the *goods* to thyself." It is indeed evident from numberless passages

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[1] The Roman orator's definition of slavery, Parad. V. is as accurate as any that we have seen. "Servitus est obedientia fracti animi et abjecti et arbitrio carentis suo;" whether the unhappy person fell into that state with or without his own contract or consent.

[2] Gen. vi. 4.

[3] Gen. xiv.

of scripture, that the domestics whom our translators call servants, were in those days universally considered as the most valuable part of their master's property, and classed with his flocks and herds.

Authorised by the Mosaic law.

That the practice of buying and selling servants thus early begun amongst the patriarchs descended to their posterity, is known to every attentive reader of the Bible. It was expressly authorised by the Jewish law, in which are many directions how such servants were to be treated. They were to be bought only of the heathen; for if an Israelite grew poor and sold himself either to discharge a debt, or to procure the means of subsistence, he was to be treated not as a slave עבד, but as a hired servant שכיר, and restored to freedom at the year of Jubilee. Unlimited as the power thus given to the Hebrews over their bond-servants of heathen extraction appears to have been, they were strictly prohibited from acquiring such property by any other means than fair purchase. "He that stealeth a man and selleth him," said their great lawgiver, "shall surely be put to death."[1]

Spread over the whole world.

Whilst slavery, in a mild form, was permitted amongst the people of God, a much worse kind of it prevailed amongst the heathen nations of antiquity. With other abominable customs, the traffic in men quickly spread from Chaldea into Egypt, Arabia, and over all the east, and by degrees found its way into every known region under heaven.

Of this hateful commerce we shall not attempt to trace the progress through every age and country, but shall content ourselves with taking a transient view of it amongst the Greeks and Romans, and a few other nations, in whose customs and manners our readers must be interested.

Slavery amongst the Greeks.

One can hardly read a book of the Iliad or Odyssey, without perceiving that, in the age of Homer, all prisoners of war were liable to be treated as slaves. So universally was this cruel treatment of captives admitted to be the right of the conqueror, that the poet introduces Hector, in the very act of taking a tender and perhaps last farewell of his wife, when it was surely his business to afford her every consolation in his power, telling her, as a thing of course which could not be concealed, that, on the conquest of Troy, she would be compelled

To bear the victor's hard commands, or bring
The weight of water from Hyperia's spring..

At that early period, the Phœnicians, and probably the Greeks themselves, had such an established commerce in slaves, that, not satisfied with reducing to bondage their prisoners of war, they scrupled not, for supplying their foreign markets, to kidnap persons who had never kindled their resentment. In the fourteenth book of the Odyssey, Ulysses represents himself as having narrowly escaped a snare of this kind laid for him by a false Phœnician, who had doomed the hero to Lybian slavery; and as the whole narrative, in which this circumstance is told, is an artful fiction, intended to have the appearance of truth to an Ithacan peasant, the practice of kidnapping slaves could not then have appeared incredible to any inhabitant of that island.

Such were the manners of the Greeks in the heroic age; nor were they much improved in this respect at periods of greater refinement. Philip of Macedonia, having conquered the Thebans, not only sold his captives, but even took money for permitting the dead to be buried;[2] and Alexander, who had more generosity than his father, afterwards razed the city of Thebes, and sold the inhabitants, men, women, and children, for slaves.[3] This cruel treatment of a brave people may indeed be supposed to have proceeded, in the first instance, from the avarice of the conqueror; and in the second, from the momentary resentment of a man who was savage and generous by turns, and who had no command of his passions. We shall not positively assign it to other causes; but from the manner in which the Spartans behaved to their slaves, there is little reason to imagine that, had they received from the Thebans the same provocation with Alexander, they would have treated their captives with greater lenity.

Slavery amongst the Romans.

It has been said, that in Athens and Rome slaves were better treated than in Sparta. But in the former city their treatment cannot have been good, or their lives comfortable, when the Athenians relished that tragedy of Euripides in which Hecuba, the wife of Priam, is introduced as lamenting that she was chained like a dog at Agamemnon's gate. Of the estimation in which slaves were held in Rome, we may form a tolerable notion from the well-known fact, that one of those unhappy beings was often chained at the gate of a great man's house, to give admittance to the guests invited to a feast. In the early periods of the commonwealth it was customary, in certain sacred shows exhibited on solemn occasions, to drag through the circus a slave, who had been scourged to death, holding in his hand a fork in the form of a gibbet.[4] But we need not multiply proofs of the cruelty of the Romans to their slaves. If the inhuman combats of the gladiators admit of any apology on account of the martial spirit with which they were thought to inspire the spectators, the conduct of Vedius Pollio must have proceeded from the most wanton and brutal cruelty. This man, who flourished not in the earliest periods of the republic, when the Romans were little better than a savage banditti, but in the polished age of Augustus, frequently threw such slaves as gave him the slightest offence into his fishponds to fatten his lampreys; and yet he was suffered to die in peace. The emperor, indeed, upon coming to the knowledge of his cruelty, ordered his lampreys to be destroyed, and his ponds to be filled up; but we do not recollect that any other punishment was inflicted on the savage master.

Origin of Roman Slavery.

The origin of slavery in Rome was the same as in every other country. Prisoners of war were of course reduced to that state, as if they had been criminals. The dictator Camillus, one of the most accomplished generals of the republic, sold his Etrurian captives to pay the Roman ladies for the jewels which they had presented to Apollo. Fabius, whose cautious conduct saved his country when Hannibal was victorious in Italy, having subdued Tarentum, reduced thirty thousand of the citizens to slavery, and sold them to the highest bidder. Coriolanus, when driven from Rome, and fighting for the Volsci, scrupled not to make slaves of his own countrymen; and Julius Cæsar, among whose faults wanton cruelty has never been reckoned, sold at one time fifty-three thousand captives for slaves. Nor did the slaves in Rome consist only of foreigners taken in war. By one of the laws of the twelve tables, creditors were empowered to seize their insolvent debtors, and keep them in their houses till, by their services or labour, they had discharged the sum they owed. The children of slaves were the property not of the commonwealth, or of their own parents, but of their masters; and thus was slavery perpetuated in the families of such unhappy men as fell into that state, whether through the chance of war or the cruelty of a sordid creditor. The consequence was, that the number of bondmen belonging to the rich patricians was almost incredible. Caius Cæcilius Isidorus, who died about seven years before the Christian era, left to his heirs four thousand one hundred and sixteen slaves; and Augustus once put twenty thousand of his own slaves on board the corn ships.

Its duration.

Though many laws were enacted by Augustus and other patriotic emperors to diminish the power of creditors over their insolvent debtors; though the influence of the mild spirit of Christianity tended much to meliorate the condition of slaves even under Pagan masters; and though the emperor Hadrian made it capital to kill a slave without a just reason, yet this infamous commerce prevailed univers-

[1] Lev. xxi. 16. [2] Justin, lib. iii. cap. 4. [3] Justin et Arrian. [4] Cicero de Div. lib. i. cap. 26.

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ally in the empire for many ages after the conversion of Constantine to the religion of Christ. It was not indeed completely abolished even in the reign of Justinian; and in many countries which had once been provinces of the empire, it continued long after the empire itself had fallen to pieces.

Slavery amongst the ancient Germans.

Amongst the ancient Germans, it was not uncommon for an ardent gamester to lose his personal liberty by a throw of the dice. This was indeed a strong proof of savage manners; but the general condition of slaves among those barbarians seems to have been much better than among the polished Greeks and Romans. In Germany the slaves were generally attached to the soil, and only employed in tending cattle, and carrying on the business of agriculture; for the menial offices of every great man's house were performed by his wife and children. Such slaves were seldom beaten, or chained, or imprisoned. Sometimes indeed they were killed by their masters in a fit of sudden passion; but none were considered as materials of commerce, except those who had originally been freemen, and lost their freedom by play.

In England and Scotland.

Such is the account which Tacitus[1] gives of slavery amongst the ancient Germans. The Anglo-Saxons, however, after they were settled in this island, seem not to have carried on that traffic so honourably. By a statute of Alfred the Great,[2] the purchase of a man, a horse, or an ox, without a voucher to warrant the sale, was strictly forbidden. That law was, doubtless, enacted to prevent the stealing of men and cattle; but it shows us that so late as the ninth or tenth century a man, when fairly purchased, was, in England, as much the property of the buyer as the horse on which he rode, or the ox which dragged his plough. In the same country, now so nobly tenacious of freedom and the rights of man, a species of slavery similar to that which prevailed amongst the ancient Germans, subsisted even to the end of the sixteenth century. This appears from a commission issued by Queen Elizabeth in 1574, for inquiring into the lands and goods of all her bond-men, and bond-women, in the counties of Cornwall, Devon, Somerset, and Gloucester, in order to compound with them for their manumission, that they might enjoy their lands and goods as freemen. In Scotland there certainly existed an order of slaves, or bond-men, who tilled the ground, were attached to the soil, and with it were transferable from one proprietor to another, at a period so late as the thirteenth century: but when or how those villeins, as they were usually called, obtained their freedom, is a question not yet completely solved. Colliers and salters were, in the same country, in a state little removed from slavery, till near the end of the eighteenth century, when they were manumitted by the British legislature, and restored to the rights of freemen and citizens. Before that period the sons of colliers could follow no business but that of their fathers; nor were they at liberty to seek employment in any other mines than those to which they were attached by birth, without the consent of the lord of the manor, who, if he had no use for their services himself, transferred them by a written deed to some neighbouring proprietor.

Slavery amongst the Carthaginians.

That the savage nations of Africa were at any period of history exempted from this opprobrium of our nature, which spread over all the rest of the world, the enlightened reader will not suppose. It is indeed in that vast country that slavery has in every age appeared in its ugliest form. We have already observed, that about the era of the Trojan war, a commerce in slaves was carried on between Phœnicia and Libya; and the Carthaginians, who were a colony of Phœnicians, and revered the customs, manners, and religion of their parent state, undoubtedly continued the Tyrian traffic in human flesh with the inland tribes of Africa.

Slavery amongst the Numidians.

With the ancient state of the other African nations we are but very little acquainted. The Numidians, Mauritanians, Getulians, and Garamantes, are indeed mentioned by the Roman historians, who give us ample details of the battles which they fought in attempting to preserve their national independence; but we have no particular account of their different manners and customs in that age when Rome was disputing with Carthage the sovereignty of the world. All the African states of which we know any thing, were in alliance with one or the other of those rival republics; and as the people of those states appear to have been less enlightened than either the Romans or the Carthaginians, we cannot suppose that they had purer morals, or a greater regard for the sacred rights of man, than the powerful nations by whom they were either protected or oppressed. They would, indeed, insensibly adopt their customs; and the ready market which Marius found for the prisoners taken in the town of Capsa, although Sallust acknowledges[3] that the sale was contrary to the laws of war, shows that slavery was then no strange thing to the Numidians. It seems indeed to have prevailed through all Africa from the very first peopling of that unexplored country; and we doubt if in any age of the world the unhappy negro was absolutely secure of his personal freedom, or even of not being sold to a foreign trader.

Slave-trade with the coast of Guinea.

It has been often said, that the practice of making slaves of the negroes is of a very modern date; that it owes its origin to the incursions of the Portuguese on the western coast of Africa; and that, but for the cunning or cruelty of Europeans, it would not now exist, and would never have existed. It is quite certain, however, that the negroes themselves, like all other savage tribes, have from ancient times enslaved their prisoners; and the establishment of a trade by foreigners in African slaves, may at an early period have tempted them, in some quarters, to make captives expressly for the purpose of selling them. But Christians were not the first tempters. It has been proved, that from the coast of Guinea a great trade in slaves was carried on by the Arabs some hundreds of years before the Portuguese embarked in that traffic. Even the wandering Arabs of the desert, who never had any friendly correspondence with the Christians of Europe, have from time immemorial been served by negro slaves. In all probability, indeed, these tribes have, without interruption, continued the practice of slavery from the days of their great ancestor Ishmael; and it seems evident, that none of the European nations had ever seen a woolly-headed negro till the year 1100, when the crusaders fell in with a small party of them near the town of Hebron in Judæa, and were so struck with the novelty of their appearance, that the army burst into a general fit of laughter.[4] Long before the crusades, however, we know with certainty that the natives of Guinea had been exposed to sale in foreign countries. In 651 the Mohammedan Arabs of Egypt so harassed the king of Nubia or Ethiopia, who was a Christian, that he agreed to send them annually, by way of tribute, a vast number of Nubian or Ethiopian slaves into Egypt. Such a tribute as this at that time, we are told, was more agreeable to the khalif than any other, as the Arabs then made no small account of these slaves.[5]

On the beginning of this commerce, or the dreadful cruelty with which it has been carried on to the present day, it is impossible to reflect without horror; but there is more consolation, however small, in knowing that its original authors were not Europeans. The purchase of Guinea blacks for slaves by foreign nations, commenced ages before the Portuguese had laid that country open to the intercourse of Europe. Even after they had made many incursions into

[1] De Mor. Germ. 24, 25.
[2] Wilkins' Collection of Laws from Ethelbert to Henry III.
[3] Da Bello Jugurth. cap. 91.
[4] Malmsbury, fol. p. 83.
[5] Modern Universal History, vol. i. p. 525.

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it, the inhabitants were as regularly purchased for slaves by some of the adjoining states, as they were afterwards by the maritime Europeans.

Present state of slavery.

Without prosecuting farther the history of slavery, we pass to the consideration of its present state in the world, and, in particular, the revolutions which have taken place in that worst department of the system which we have been last occupied in examining.

Slavery of white men.

Before describing the altered position now held by negro slavery, it must be remarked that the slavery of white men is by no means yet extinct. Details on this subject will be found in the articles devoted to those countries in which, under various modifications, bondage still prevails; and here a sentence or two must suffice for summing up the result. The nature of that slavery which still prevails among most Asiatic nations, modified in the Mohammedan states by some precepts of their religion, but nowhere entirely extirpated, is familiarly known to most readers, and information regarding it is sufficiently easy of access. The branch of it in which Europeans are most nearly interested, is that atrocious system of piracy which, carried on for centuries by Algiers and the other Barbary states, filled the cities of Northern Africa with Christian prisoners, but has in the present generation been nearly destroyed by the exertions of our own government, aided by the subsequent expeditions of the French. But the snake is scotched only, not killed; and European captives are still said to pine in Morocco, Tunis, and Tripoli. In a preceding paragraph we have considered the villeinage of the dark and middle ages as being a species of slavery. There is no sound reason for regarding it in any other light; and, however far the serf's condition may be superior to that of the slave who belonged to a Roman patrician or a West Indian planter, his servitude is still so utterly repugnant both to humanity and religion, as to make us ashamed of the fact that, in a shape not much improved, it exists still in Christian provinces of northern Europe. The article Russia has described the status of the boors or unfree peasants in that empire; and in more than one kingdom bordering on it, villeinage has never been completely abolished till our own times.

Negro slavery.

But slavery in its most horrible shape, long averted by the spirit of Christianity from those whom Christians were compelled to consider as their fellow-men, has, in regard to the unfortunate people of Africa, been maintained with unrelenting severity by men and nations professing to be disciples of the gospel. The present age has seen the truth mightily triumph in reference to this dark blot of the civilized world; but the evil is not yet entirely eradicated, even where its atrocities have been most decisively condemned; and in several extensive regions of the globe, no acknowledgment of error has yet been extorted.

Negro slavery in North and South America.

Slavery is still lawful over a large part of the American continent. It extends throughout the empire of Brazil, and is general in the southern provinces of the United States. On the declaration of independence, however, seven of the thirteen British provinces which then formed the confederation, abolished slavery absolutely; and the example was followed by two or three of the rest, as well as by several of those afterwards added to the Union. On the whole, including the remnants of bondage in some of the Spanish republics, it has been calculated that the continent of America now contains 4,000,000 of black and coloured slaves. Of these the United States possess about 2,000,000, making about a sixth part of their whole population; but, as the slaves are unequally distributed, they amount in several provinces to half the number of the free whites, and in some places make up a much larger proportion. The French and Spanish colonies in the West Indies, in which likewise slavery remains unabolished, have a slave population amounting to at least 400,000 souls.

Slavery in the British colonies.

For the British colonies, the exertions of benevolent and enlightened men during the last fifty years, have at length effected a mighty change, the history of which can here be but too briefly told.

Commencement of efforts for abolition of slave-trade.

1. The Slave Trade. If the merit of originating the great scheme of abolition is to be shared by every one who, either through word or writing, has expressed convictions of the inhuman injustice involved in the slave-trade, or suggested means for its destruction, our list of emancipationists would both be long, and would commence at an early date. But the honour of having planned that systematic co-operation, which alone could effect the end, does clearly belong to the Society of Friends; and in the series of efforts by which that religious body heralded the exertions of our eminent statesmen, the leading part was acted by Anthony Benezet, a French protestant, who, educated in England, became a Quaker and a citizen of Philadelphia; and to William Dillwyn, an American, and a member of the same sect. The former, besides unwearied personal exertions, published, in 1762, the work which first attracted in this country general notice to the slave-trade; the other, visiting England in 1774, opened communications between the American philanthropists and those of our own countrymen who had already engaged in the same cause Among these latter, the foremost place belongs to the honoured name of Granville Sharp.

Granville Sharp and the slave Somerset.

This able and excellent man had been induced to interest himself in a class of questions, which arose about the middle of the eighteenth century. West Indian planters, after having brought negro slaves to England, were accustomed to carry them back to the colonies, or even to sell them to others for that destination; and the opinion of eminent lawyers had sanctioned the practice as legal. Instances of crying hardship aroused the sympathy of individuals: Granville Sharp rescued several victims; and, in the year 1772, he obtained a decision of the English judges in the famous case of the negro Somerset, that, as soon as a slave sets his foot on English ground, he becomes free.[1]

Society for the Suppression of the Slave-Trade, 1787.

At length, in May 1787, there was instituted in London a Society for the Suppression of the Slave Trade. Besides Dillwyn and Sharp, its most distinguished member was Thomas Clarkson, a young graduate of Cambridge, who, led to study the subject as the theme of an academical essay, had solemnly devoted his life to the cause of negro emancipation. But the Society immediately numbered among its supporters several men of rank and influence; and, among other converts, its founders had gained, even before their organization, William Wilberforce, then member of Parliament for Hull, and afterwards for Yorkshire.

State of public opinion.

Although our own days have witnessed a sharp contest in the last stages of those measures, it is not very easy for us to conceive the magnitude of the obstacles which then opposed themselves, even to the most cautious approach towards the subject. Fear of exposure felt by individuals who knew themselves guilty of malpractices, was aided by fear of pecuniary ruin, felt by many who had no other reason for dreading inquiry; and, among the public men of the nation, the corrupt influence of private interests biassed many, while others were influenced by more honest fears for the effects which change might have on the prosperity of the colonies. The Society determined, from the first, to keep the question of slave emancipation studiously in the background. They proclaimed their aim to be, simply, the abolition of the trade in slaves; maintaining, and endeavouring to convince the public, that the slave population of the colonies could be

[1] It must be noticed, however, that, a very few years ago, it was decided by Lord Stowell, that slaves who had gained freedom in this way did, on their return to the colonies, become slaves anew.

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effectually kept up without new importations; and that, indeed, such importation was in itself not only injurious to the real interests of the planters, but eventually pregnant with ruin to the West India Islands as British dependencies. These topics, with others appealing more directly to moral principle and humane feeling, had already been treated in various publications, and they were now anxiously disseminated through the whole of Britain in pamphlets, newspaper articles, and personal communications; while the indefatigable Clarkson travelled everywhere collecting information as to the state of the slave trade.

Government inquires into the Slave Trade.

An excitement was produced which enforced the attention of the government; and its results were still farther aided by the circumstance that Mr. Pitt, who was the intimate friend and political chief of Wilberforce, had already examined the question, and privately declared himself favourable to the views of the society. In February 1788, an order of the crown directed that a committee of the Privy Council should inquire into the state of the slave trade, and its consequences both to Africa, to the colonies, and to the general trade of the kingdom. Before the end of that season, there lay on the table of the House of Commons one hundred and three numerously signed petitions, praying for the abolition of the traffic in human life.

Slave Trade mooted by Mr. Pitt in Parliament

Mr. Wilberforce's ill health detaining him in the country, Mr. Pitt, on the 9th of May 1788, declining to state his own opinion, moved a resolution that the House would, early in the next Session, take into consideration the circumstances of the slave trade complained of in the petitions. This, excepting a motion made by David Hartley some years before, against slavery in the abstract, was the first time the subject had ever been mentioned in the British Legislature. The prayer of the petitions was warmly supported, and delay opposed by Mr. Fox, Mr. Burke, and others. In the meantime, a bill was introduced by Sir William Dolben, and carried through both Houses after virulent opposition, for regulating the burden of the slave-ships, and otherwise diminishing the horrors of the Middle Passage, as it was called, between Africa and the West Indian islands.

Mr. Wilberforce's efforts in Parliament

On the 12th of May 1789, Wilberforce made his first speech in the House upon the subject, introducing twelve resolutions deduced from the evidence which had been taken before the Privy Council. The propositions, all condemnatory of the trade, were supported by Burke, by Fox, by Granville, and by Pitt, who now declared his opinion unalterable; but the opponents gained their end of delay, by obtaining an order for hearing evidence. It was not till the spring of 1791, that Wilberforce was able to move for leave to bring in a bill, for preventing the further importation of slaves into the colonies in the West Indies. After a stormy debate, the motion was lost by 88 to 163. The enthusiasm of the people, and the favourable dispositions of the legislature, had alike cooled; insurrections of the negroes had broken out in Dominica, the leaders of the French revolution had corresponded with some members of the society, Clarkson had not only visited France, but was the friend of Brissot; and every means had been used for prepossessing the public against the abolitionists.

The abolitionists repeatedly defeated.

But the defeated party bated "no jot of hope;" and the public mind became calmer. In April 1792 the House of Commons received from England 330 petitions, and from Scotland 187; and Wilberforce moved an opinion of the House that the slave trade ought to be abolished. He was met by one of the most dangerous enemies of the measure, Mr. Dundas, afterwards Lord Melville, under whose dexterous management an amendment for *gradual* abolition was carried by a large majority; and a few days afterwards the House passed a resolution for abolishing the trade in 1796; but in the House of Lords even this tardy justice was frustrated by a resolution to hear further evidence.

In 1793 the House of Commons refused to repeat their resolution of the previous year: in 1795, and each of the four following years, the motion for abolition was made and lost; and the abolitionists then resolved to wait for better times. And thus a measure, calculated to wipe off in part a foul disgrace from the nation,—a measure supported by men of all parties and of all sects,—a measure openly and encouragingly advocated, not only by all the men of highest talent in the country, but by the minister of the day himself, was defeated, after a struggle which, at the time, was aptly called the battle of the pigmies against the giants. Of the sincerity of the other great promoters of the scheme, no doubt has been expressed; but on Mr. Pitt's sincerity there have been thrown very grave suspicions, which it is not possible entirely to dispel. For, although the charge of absolute duplicity is sufficiently rebutted, both by his unbending character and by his admirable speeches on the question, it is unaccountable how he, the most peremptory of all rulers, should not, if he pleased, have forced to silence those subalterns, who trembled to oppose him in any plan but this. The proud son of Chatham loved truth and justice not a little, but he loved power and place greatly more; and he was resolved that negro emancipation should not lose him either a shred of political influence, or a beam of royal favour.

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Character of them and their opponents.

But the triumph was already at hand. The excitement of the war, indeed, still for a time diverted public attention; and, though the principles which had been so convincingly promulgated were silently making converts everywhere, nothing of importance took place for some years, except the appearance of a new and most able advocate in the person of Mr. Stephen, Wilberforce's friend and brother-in-law. In 1804, however, the annual motion of Wilberforce was renewed. The first reading of his Bill for immediate abolition was carried by 124 to 49, the majority containing all the Irish members; and the votes for the third reading were 99 to 33. On the second reading of the Bill in the House of Lords, it was adjourned, without a division, till the following session. In that session, (the spring of 1805,) a new Abolition Bill was thrown out by the House of Commons on the second reading; but, in the same year, a measure of Pitt's for abolishing, by an Order in Council, the slave trade in the newly conquered colonies, which had no charters, was carried into effect without the smallest resistance.

The abolition of the Slave Trade carried, 1807.

The next two years were to witness the final victory. Pitt died; and the ministry of Fox and Lord Grenville was formed. In June 1806, resolutions proposed by the new ministers, pledging the House of Commons to abolition "with all practicable expedition," were carried by more than 100 to 41; and an address to the king, for obtaining the co-operation of foreign powers, was adopted without a division. A bill, founded on the resolutions, was successful in both Houses, and received the royal assent on the 25th of March 1807.

Slave Trade of foreign powers.

The great measure of the British legislature was imitated, in the first instance, by the United States, who were next followed successively by the new South American Republics of Venezuela, Chili, and Buenos Ayres, by Sweden and Denmark, Holland and France. But Spain was brought no farther than to promise in 1814 that she would abolish the slave trade in eight years; while Portugal in 1815 abolished to the north of the equator, promising to abolish finally eight years afterwards, and receiving a sum of money as the price of her acquiescence.

Inefficiency of the Abolition Act; and improvements on it.

In the meantime, the abolitionists in England soon had the disappointment to discover, that the law had no sanction sufficient for enforcing its provisions; whilst the fact, that the horrible trade must now, if conducted at all, be carried on as an act of smuggling, augmented all its miseries, and introduced atrocities not less shocking than those

which had prevailed before the passing of Sir William Dolben's carrying act. An energetic remedy was necessary, and such an one was suggested by Mr. Brougham, who, in 1811, introduced a bill, (carried unanimously through both Houses,) declaring the trade in slaves to be felony, and punishable with fourteen years' transportation, or five years' imprisonment. After a time, even this decided measure seemed not decided enough; an act of 1824 made slave-trading a capital offence, by the name of piracy; and the recent acts of 1837, for mitigating the criminal law, have left it punishable with transportation for life. "There is every reason to think," says Lord Brougham, "that no British subjects are now, or have for many years been, directly engaged in this execrable traffic, with the exception of those belonging to the Mauritius. In that island it is certain, that, with the connivance, if not under the direct encouragement, of the higher authorities of the colony, slave-trading to an enormous extent was for some years openly carried on."

Treaties with foreign powers for suppression of the Slave Trade.

The treaties with foreign powers, crippled by national jealousies, were found equally inefficient with our own law. The king of Spain, one of the two great offenders, after having had the meanness to accept, by a treaty of 1817, a large sum from our treasury, as the price of his promise to abolish his slave-trade on the north of the equator immediately, and to put a final stop to the traffic in 1820, had next the effrontery to refuse all performance of the engagement for which he had thus received the consideration; and a vote of abolition, passed by the Cortes in 1822, remained of course inoperative. The great difficulty,—the right of one nation's cruisers to search vessels under the flag of another power, when suspected of slaving,—was however mutually conceded in 1817, between Great Britain on the one hand, and Portugal and Spain (within the limits embraced in the subsisting treaties) on the other; and a similar treaty was effected with Holland in the succeeding year.

Faults and defects of our treaties

But, besides other faults, there were, in our treaties of this sort, two main defects, which, of themselves, rendered the whole system of checks quite inoperative. First, the cruisers, except under our treaty with the Netherlands, had no power to capture vessels not having slaves on board, although it might be fully proved that they were slaving-ships, or even that they had just delivered a cargo. In consequence of this, not only were notorious slavers frequently dismissed after examination, but, in several instances, which have been fully authenticated, the wretches in command were known to throw their slaves overboard on a chase, in the hope of thus removing the only ground on which their detention could be legally justified. Secondly, condemned vessels, instead of being broken up, were sold, and, being fitted for no trade but their own, fell again almost invariably into the hands of the slave-dealers.

New and more effectual treaties since 1830.

In neither of these particulars was any improvement effected till after the late revolution in France, whose subjects, since the restoration, had begun to rank amongst the most active of the contraband slave merchants. In 1833 a treaty was concluded between our government and that of France, by which the breaking up of the vessels was agreed to; and it was also declared, that all vessels ascertained by certain equipments to be intended for the slave trade, might be lawfully detained and confiscated, even though slaves had not been found on board, nor even embarked. France and England have since taken the lead in urging all other Christian powers to accede to these conventions; but as yet their success has been far from general. The five powers with which this country previously had conventions on the subject have come very reluctantly into the additional measures; and one of them, namely, Portugal, has shown a most disgraceful want of faith in fulfilling her engagements. The protection of the Portuguese flag was and is sold by the authorities of that government on the African coast; and miscreants, thus furnished with papers apparently regular, and not having yet received their slave-cargoes, insolently defy our cruisers, or even prosecute our captains for damages, on account of illegal detention. Our government, however, have recently shown a determined front; and we may perhaps hope that the feeble and faithless power which insults us and outrages humanity, will at length suffer condign punishment. As to Spain, between 1823 and 1832, her slavers imported into Cuba 100,000 slaves at least. The equipment clause was always refused by the cabinet at Madrid; and it was not till 1835, after the death of Ferdinand, that our minister at that court was able to extort the accession of the Spanish government to that essential article. The effects of this new treaty have been exceedingly encouraging: within six months after its execution, as many Spanish slavers lay waiting the sentence of our Confiscation Court at Sierra Leone, as had been taken during any three years under the previous conventions. The Brazilian government, although professedly anxious to discourage the importation of new slaves, on account of the danger the whites already incur from an increasing black population, have pleaded, with some plausibility, their want of power to check the trade effectually, so long as the Portuguese flag shall be allowed to protect the slavers. Sweden and the Netherlands were not prevailed on to accede to the French conventions till the year 1838.

Of those powers with which we had previously no agreement, Denmark and the Sardinian States both acceded in 1834. Prussia has shewn a reluctance, for which it is not easy to account. The display of the same spirit by Russia was not so much matter of surprise. Austria, though the emperor has imitated our laws, declaring any slave free who touches Austrian ground, and also making the slave-trade heavily punishable, has acted with its accustomed jealousy, in refusing co-operation with other states. Tuscany and the Two Sicilies joined the league in 1838. With the republics of the New World our negociations have been exceedingly unsuccessful. The United States have peremptorily refused to combine with any foreign power for the suppression of the slave-trade; and, amongst the Spanish commonwealths, Venezuela is the only one which has come cheerfully forward, although the objections started by some of the rest do not seem to be insuperable.

Disappointing results of the measures for suppressing the Slave Trade.

Altogether, those efforts which philanthropists have so long continued for removing this blot from the name of Christianity, have not yet by any means produced such results as can allow us to believe that the struggle is nearly at an end. Partly through defects in the machinery of the laws and treaties,—partly through dishonesty or lukewarmness in the contracting powers or their officials,—partly through causes which can never be removed while the foul shape of slavery itself darkens any corner of the earth,—the traffic in human blood still goes on with an activity that is incredible to all but those who have studied the subject. The proofs of this lamentable fact are nowhere so convincingly stated as in a work on *The African Slave Trade*, published in 1839, by Mr. Fowell Buxton, from which we can afford to abstract but a very few statements, observing, at the same time, that there is not one of them but is below the truth. According to the highest of those estimates which have been founded on assured data, the Christian slave trade still robs Africa every year of 250,000 human beings. According to the very lowest computation, it absorbs 150,000. To this number must be added that of the Mohammedan trade, which exports at least 50,000 annually; so that we are much below the mark when we assert, that, in the course of every year, 200,000 negroes, at least, are carried off into hopeless slavery. But this is not all. It may be safely asserted, that, for every slave who is exported, there is

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sacrificed one human life, and perhaps much more. Mr. Buxton's calculation is the following: First, the slaughter of the wars which supply the slaves, the ill-usage of the captives on their march, and their sufferings while detained on the coast, cause together a mortality of 100 per cent. Secondly, the disease and cruelty of the voyage, now worse than ever it was, carries off, at the very least, 25 per cent. Thirdly, the loss after landing in the colonies, and during what planters used to call the "seasoning," amounts to at least 20 per cent. Upon these assumptions, "for every 1000 negroes alive at the end of a year after their deportation, and available to the planter, we have a sacrifice of 1450. Of 150,000 negroes, landed annually in Cuba, Brazil, &c. 30,000 die in the seasoning, leaving 120,000 available to the planter. If 150,000 were landed, there must have been embarked 37,500 more, who perish in the passage; and if 187,500 were embarked, 187,500 more must have been sacrificed in the seizure, march, and detention. It is impossible for any one to reach this result, without suspecting, as well as hoping, that it must be an exaggeration; and yet there are those who think that this is too low an estimate." Putting these facts in another shape, we find, that the slave trade between Africa and America subjects annually to the miseries of permanent bondage, no fewer than 120,000 negroes; whilst, during the same period, it destroys the lives of 255,000 more.

II. Slavery. But, leaving here the consideration of the slave trade, we pass to the history of those measures which, following up its abolition in our own colonies, have destroyed it effectually as to them, by eradicating slavery itself.

Commencement of measures for emancipation of the negro slaves.

Immediately on the passing of the act 1807, there was formed by the abolitionists a new association, which they called "The African Institution." Besides objects connected with the recent measure, and embracing the tasks of watching its execution, of prevailing on foreign powers to imitate our policy, and of aiding in the civilization of Africa, this body gradually began to bestow great attention on the state of slavery in our own colonies, having an especial view to its ultimate abolition, which was afterwards taken up by the Anti-Slavery Society; for their hopes soon waxed very low as to that progressive amelioration in the treatment and even the enlightenment of the slaves, to which some among them had looked forward as one consequence to flow from the stoppage of the foreign supply. The abolitionists were speedily united in the great aim of emancipation; Clarkson renewed his agitation in the provinces; local societies were formed every where, and tracts and larger works were circulated; while in Parliament, Wilberforce, the apostle of the cause, was now seconded by Messrs. Brougham, Mackintosh, Buxton, Lushington, William Smith, and others, in pressing vainly on the House of Commons the adoption of measures tending to prepare the slave for eventually obtaining freedom.

First proceedings in Parliament for emancipation.

At length the trenches were opened in Parliament; and in this new attack, as in the former, the van was led by the Quakers, whose petition for the extinction of slavery was presented by Mr. Wilberforce to the House of Commons in March 1823. Soon afterwards, a motion by Mr. Buxton, for a resolution declaring slavery repugnant both to Christianity and to the British constitution, was defeated by Mr. Canning on counter resolutions, recommending certain necessary reforms. These and other improvements, it was asserted, might be safely left to the colonial legislatures; and the ministry at the same time intimated, that, if the West Indian Assemblies refused to do their duty, it would become necessary for the British Parliament determinedly to interfere.

That no effectual reforms could proceed from the planters themselves, the abolitionists had been long convinced. The government and their supporters, said they, had forgotten two of the prominent features of society in the West Indies; the management of estates by agents for absentee proprietors, and that spirit of reckless adventure which was at once a cause and an effect of West Indian embarrassments. It might have been added, and some had the firmness to add it, that the planters, supposing them ever so well disposed, dared not to introduce any such mitigation of rigour as would afford sufficient protection against individual oppression. The slavery of multitudes was never in any country maintained but by the reign of terror; and, when an enslaved population has reached a certain limit in strength and intelligence, society must inevitably undergo one or another of three changes;—inhumanly increased severity, or universal emancipation, or universal revolution.

Case of the Missionary Smith.

In 1824, Mr. Canning, who, though he had been a zealous abolitionist, acted in regard to the new question a part totally unworthy of him, defeated, by a ministerial majority, Mr. Brougham's very guarded motion of censure on the authorities of Demerara for the infamous and cruel injustice which destroyed the missionary Smith. But the publicity which the debates in Parliament, in this case, gave to the atrocities which, although certainly not common in the colonies or any where upon earth, the colonial laws allowed, when they did occur, to pass with perfect impunity, did more than any thing ever yet had done to excite the indignation of the British people.

New state of public opinion.

The question, in fact, was surprisingly narrowed. When, in 1788, the abolitionists attacked the outworks which flanked the edifice of slavery, the fortress itself was pronounced by its defenders to be absolutely impregnable. The good of the empire, the good of the slave, the principles of all governments, the very Bible itself, were appealed to as authorising the property in human flesh. But now, for many years, no man had breathed any argument of the sort. It was plain that emancipation must come, and that speedily; the parties were only at issue as to the time and the manner. Even the more intelligent among the planters, who saw the negroes swarming around them in hundreds of thousands, and already beginning to think dangerously, (that is, justly,) seem scarcely to have extended their hopes farther than to obtaining liberal compensation for all their losses, present or prospective, certain or conjectural. But the attitude which they chose, almost universally, to assume, was that of defiance towards the mother-country; and, accordingly, the right of the Colonial Assemblies to legislate for their own islands, and the danger which would be incurred by irritating them, were urged alternately with those other topics, of the risk of revolution through hasty changes, the unfitness of the uninstructed negroes to act as freemen, and such other grounds, which now became the arguments of those who wished the British Parliament to decline interfering.

Review of reforms effected in the slave-law of the colonies from 1823 to 1830.

Down to the year 1830, how much had been done, either in the chartered colonies, or in those governed immediately by the crown, for carrying into effect the reforms embodied in the resolutions of 1823, and in the subsequent recommendations of the government?—1. For providing the means of education and religious instruction for the slaves, no one effectual measure had been taken in the colonies of either class. The consolidated slave law for the crown colonies, contained in an Order in Council, dated 8th February 1830, was held out as an improvement on the Trinidad Order in Council of 1824, and was proposed to the chartered colonies as a model for their adoption. It contained no provision for this purpose. 2. The Sunday markets were abolished in the crown colonies by the order of 1830, and they were also abolished by Grenada and Tobago, two of the chartered islands. The other colonies of this class had expressly legalised them. 3. Even this partial abolition was rendered useless, by the total omission of any allowance of equivalent time to the negroes in lieu of Sunday, for marketing or for cultivating their provision grounds. 4. The new order wisely made the evidence of slaves admissable in the crown colonies to the same extent as that of free persons, subject on-

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Parliamentary proceedings in 1830–31–32. In July 1830, Mr. Brougham brought forward his motion, that the House should resolve, at the earliest possible period in next session, to take into consideration the state of the slaves, in order to the mitigation and final abolition of slavery, and more especially in order to the amendment of the administration of justice. It was lost by a large majority, in a very thin House. The great changes in the ministry soon came on; and, during the eventful years 1831 and 1832, the subjects of Great Britain and Ireland had their own battles to fight at home, instead of extending aid to foreign dependents. The only steps taken in that period were, the issuing of new orders in council by the Whig ministry in 1831, which proved as ineffectual as those of their predecessors; and the appointment of committees, both in the Lords and Commons, before both of which a large mass of evidence was taken.

Introduction of the measure for the abolition of slavery, 1833. At length, after the friends of emancipation had repeatedly pressed the ministry to redeem their pledge of bringing forward a government measure, the ministerial proposition was introduced in May 1833, by Mr. Stanley, then secretary for the colonies. The parts of the resolutions on which the emancipationists were most divided were two; first, the plan of an intermediate state, called an apprenticeship, into which the slave was to be received on his manumission, and which, according to the first draft of the measure, was to last for no less than twelve years; secondly, the proposal of compensation to the slave-owners, which, brought forward at first hesitatingly, at last developed itself into a grant of twenty millions sterling. On the principle of compensation most men were agreed; there was guilt, it is true, in the very act upon which the claim was grounded, but the nation was a thousand times guiltier than the planters, and it would have ill become us to make the minor offenders the only sufferers. The amount and application of the grant were matters less certain. On the question of the apprenticeship there was much more room for doubt; and the most consistent opponents of slavery were decidedly against it. Lord Howick, the under secretary for the colonies, threw up his place rather than advocate it; and it was strenuously resisted in the House by him, Mr. Buxton, and Mr. O'Connell, whose opposition, however, was defeated by an overwhelming majority. Among those who advocated the great principle of the resolutions, the most prominent were, besides the members already named, Mr. Buckingham, Dr. Lushington, Admiral Fleming, and Mr. T. B. Macaulay. The opposition, which scarcely amounted to more than exhortations to caution, with insinuations of insurmountable difficulties, was headed temperately and skilfully by Sir Robert Peel, whose most decided supporters were, Sir Richard Vyvyan, Mr. Godson, Mr. W. E. Gladstone, and Mr. Hume. No division was attempted on any question involving the principle.

The resolutions, on being communicated to the House of Lords, where they were carried without a vote, were supported by the Earl of Ripon, Lord Suffield, Earl Grey, and Lord Chancellor Brougham, and cautiously opposed by the Duke of Wellington, the Earl of Harewood, Lord Ellenborough, and Lord Wynford.

A bill was next brought forward, founded on the resolutions. In the discussion on this bill in the Commons, the most important change effected was, the limitation of the apprenticeship to the term of six years for the plantation-negroes, and four for all others. In the House of Lords, the amendments unsuccessfully proposed by the Duke of Wellington were moderate in themselves, and candidly advocated. On the 28th of August 1833, William the Fourth, giving his royal assent to the act, atoned in some measure for the opposition which, in his early days, he, in common with his whole family, except the Duke of Gloucester, had offered to the abolition of the slave trade. William Wilberforce died while the resolutions preparatory to the bill were at their last stage in the House of Commons.

The leading provisions of the great measure for the abolition of slavery were the following.

Summary of the act for abolishing slavery in the British dominions. The act was to take effect on the first day of August 1834, on which day slavery was to cease throughout the British colonies. And, in the first place, all registered slaves, who should at that date be within any of our colonies, and should appear to be six years old and upwards, were to become "apprenticed labourers" to those who had been their owners in slavery; while slaves who had been

already brought, or apprenticed labourers who hereafter might be brought, into the United Kingdom, with the consent of their possessors, were to be absolutely free from the date of the act. The apprentices were divided into three classes. The first two classes, called "prædial apprenticed labourers," comprised all slaves "usually employed in agriculture, or in the manufacture of colonial produce," upon the lands in the colonies; the first class being slaves of this sort, who were usually employed on lands belonging to their owners, and who were declared to be "attached to the soil;" the second class, declared to be "not attached to the soil," being such slaves as were similarly employed on lands not belonging to their owners. The third class, called "non-prædial apprenticed labourers," embraced all slaves not included in either of the two other classes. The apprenticeship of the first and second classes was not to continue beyond the first day of August 1840; and such apprentices were not to be liable, in virtue of their apprenticeship, to labour for their employers for more than forty-five hours in any one week. The apprenticeship of the third class was not to continue beyond the first day of August 1838. Voluntary discharges by the employers, before the expiration of these periods, were allowed, under provisions to secure old and infirm apprentices against destitution; and the apprentice was to be entitled to claim his discharge, even against his employer's consent, on payment of the appraised value of his services. No apprentices were to be removed from the colony to which they belonged; and those of the first class were not to be removable even from their own plantation, except that they might be removed to other plantations of the same owner in the same colony, on a certificate of justices of the peace that the removal would not injure their health or welfare, nor separate members of the same family. Under similar restrictions and conditions, the services of the apprentices during their term were to be transferable property. It was conditioned that the employers were to furnish the apprentices with food, clothing, lodging, and other necessaries, according to the existing laws of the several colonies, and to allow them sufficient provision-ground, and time for cultivating it, in cases where that mode of maintenance was adopted. Children born upon or after the first of August 1834, as also all those under six years of age at that date, although they became at once free, might, if proved destitute to the satisfaction of a magistrate, be bound out by the magistrate as apprentice to the employer of the mother, by indenture, to continue in force till the child had completed its twenty-first year. For giving effect to the act, the crown was declared entitled to name, or to authorise governors of colonies to name, justices of the peace by special commission, and to give salaries not exceeding L.300 a-year, to such justices, not exceeding one hundred in all.

The act limited itself to general principles, such as those now specified, declaring that, for carrying the principles into effect, enactments by the several local authorities were the most proper means; and it therefore provided for having such regulations made by the local legislatures for the colonies which had charters, and by the king in council for the crown colonies. It was provided, however, that no such local acts were to authorise the employers, or any one but the special justices, to punish the apprentices by whipping, beating, imprisonment, or addition to the hours of labour; and that they were not to authorise corporal punishment of females on any account, or by sentence of any court. The special justices were made exclusive judges, in the first instance, in all questions between the employer and the apprentices; and no sentence was to impose as punishment extra-work for more than fifteen hours in any week, nor prolongation of apprenticeship, except in the case of runaways, whose prolonged service should not be compellable after the termination of seven years from the end of the apprenticeship. No apprentice was, whether under the act, or by way of punishment, or otherwise, to be compelled to labour on Sundays, except for certain necessary purposes; and none was to be prevented from attending anywhere on Sundays for worship at pleasure.

The remaining sections of the act provided for the raising and application of the twenty millions of compensation-money. The sum might be raised by loans, under the usual restrictions on the government; and commissioners, not fewer than five, were to be appointed by the crown for distributing it, while assistant commissioners were to act for the same purpose in the colonies. No money was to be payable to any slaveholder in any colony, until it should have been declared by an order in council, that satisfactory provision had been made by law in such colony, for giving effect to the act by special or supplementary regulations. The whole money was to be divided into nineteen shares, one for each of the colonies, each share being proportional to the number of registered slaves in the colony, taken in connection with the market-price of slaves in each colony, on an average of eight years ending with 1830.

Proceedings taken under the act.

In virtue of this act, upon the first of August 1834, nearly 800,000 negroes became nominally free; but both the friends and the opponents of emancipation watched with much anxiety what would be their conduct during that probationary state which it had been deemed proper for them to pass through,—a state which, by the very removal of some evils, opened the way for certain others, and which, while it gave increased protection against some kinds of oppression, left the negroes more helpless against severities and neglect of other kinds. Two subsequent acts of Parliament provided as far as possible against abuse; and, although many conflicting accounts have reached this country, there does seem to be no sufficient reason for believing that the treatment of the apprentices was really in any material respect worse than it had been during their slavery; while there appears to be as little reason for doubting, that the slaves in general conducted themselves with thankfulness and decency on their change of condition.

Shortening of the apprenticeship by some colonial legislatures.

But in different islands the policy of the local legislature was very various. Many of the colonists were as well satisfied as the most zealous members of the Anti-Slavery Society, that the apprenticeship was wrong and dangerous. Antigua had the honour of leading the way in making this opinion operative. The legislature of that island declined to take advantage of the apprenticeship at all; its slaves were emancipated at once, and "on Christmas-day 1834, for the first time these thirty years, martial law was not proclaimed in Antigua." Bermuda followed the example, which was next imitated by the small isles, and afterwards by the great island of Barbadoes. Still some colonies held out, with Jamaica at their head; and, particularly from this island, there reached us not only threatening resolutions of the Assembly, but reports of extreme severities towards the slaves, and of decided hostility to the stipendiary magistrates; while one or two of the colonies would not even condescend, for several years, to take such steps as the act declared to be necessary for entitling their landholders to payment of the compensation-money.

In the spring of 1838, the question of immediate abolition of the apprenticeship was stirred, on those and other grounds, in both Houses of Parliament. Lord Brougham's motion to this effect, supported by Lord Lyndhurst and others, was met by the previous question. Sir George Strickland's, in the House of Commons, was also negatived; and, although a similar resolution was afterwards carried in the Commons, the ministry intimated that they would throw every obstacle in the way of any measure founded on it, and the attempt was therefore given up.

Final and complete emancipation of the negroes, 1838.

But the colonists were warned in time, by the spirit which reigned here, and by that which appears to have been rising among the negroes. They proceeded forthwith to aboli-

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tion; and, on the 1st of August 1838, there was not a slave left in any British colony, except the Mauritius alone, in which instructions from the home government have since carried the enfranchisement into effect. (W. S.)

Results of emancipation.

From authentic official returns published during the last year or two regarding the state of the West India Islands, it appears that on the whole the state of free labour and of free trade, which the inhabitants now enjoy, have not only increased the production of sugar, but have materially increased the domestic and social comforts of the coloured population of those islands. It appears from a Sugar Return of 1858, that while in the last two complete years of slavery, viz., 1832 and 1833, the exports of sugar from the West Indies to great Britain was 8,471,744 cwt., while the exports for the two recent years of 1856 and 1857 are 8,736,654 cwt. These returns are limited to Great Britain alone, no account being taken of the recent and very promising trade with Australia and the United States. Exclusive of Jamaica and the Mauritius, the remaining fifteen islands of the West Indies produced during 1855, 1856, 1857, 7,427,618 cwt., while the same islands produced during the last three years of slavery, 7,405,849 cwt. of sugar.

The Mauritius has had the advantage of a large importation of coolies, by whom the sugar has been mainly produced. One of the signal benefits of emancipation is that it opens up a free entrance to all and sundry who choose to take their chance of getting employment for themselves or comfort for their families. Jamaica, again, has long been in a state of great financial disorder and general mismanagement. This is the verdict of Sir Henry Barkly and of Sir Charles Grey. The recent changes which have been introduced have already shown a marked improvement in the exports and imports of the colony; but it will require long years of very careful and cautious government to set Jamaica abreast of the other islands of the West Indies. "Flourishing," "most satisfactory," "highly flourishing," and so forth, are the reports from the labour markets of the various islands. Detailed extracts regarding the present condition of the West India Islands may be seen in "An Inquiry into the Results of Emancipation," published in the April number of the *Edinburgh Review* for 1859. There is one fact which shows the sound commercial state of the West Indies, namely, that in 1857, the year of the severe commercial crisis, the Colonial Bank received bills amounting to L.1,300,000, and less than L.8000 were returned. There was no failure during that year in the West India trade; and coffee, cotton, wool, sugar, rum, cocoa, were all exported in increased quantities. The exports of Great Britain alone, as shown by the Trade and Navigation Accounts for 1858, to the West Indies, have averaged more than half a million over the preceding ten years. These official statistics go to prove that the West Indies are rapidly advancing in wealth and prosperity since the year of their emancipation. The general character and habits of the people are likewise improved. From two to three hundred villages have gone up by the unaided exertion of the negroes in the island of Jamaica alone, and upwards of 100,000 acres of land have been purchased in that island by the colonial inhabitants. The legislative Assembly of Jamaica, which counts some fifty members, is likewise graced by some ten or a dozen gentlemen of colour, and they have found their way into the police force, among the officers of the penitentiary, of the courts of justice, among the barristers, and among the magistracy. Education is gradually making way, and crime of an atrocious character is very rare in these islands. There can be but one opinion regarding the results of emancipation entertained by any man who will dispassionately investigate the condition of the coloured populations in the West Indies; and that opinion will redound in the highest degree to the sagacity as well as the generosity of those who then advocated the deliverance of the slave. England, by freeing her slaves, performed a politic as well as a very just act. Men may now find practically exemplified what was frequently scouted in the heat of the debates on emancipation, that however wildly theoretical, or absurdly philanthropical the position might then appear, the past twenty years have demonstrated, that when a nation has courage to be just, it need have no fear in the long run of its commercial prosperity.

Slavonia.

SLAVONIA, or SCLAVONIA, KINGDOM OF, a portion of the Austrian empire, formerly incorporated with Hungary, but now forming along with Croatia a separate crown-land. It consists of a narrow strip of land, bounded on the N. by Hungary, from which it is separated by the Drave; E. by the Servian Woiwodina, on the other side of the Danube; S. by the Military Frontier, except for a very small distance where it borders on Croatia. Length about 150 miles; greatest breadth, 30; area, 2988 square miles. If it were not that a long narrow track on the south is occupied by the Military Frontier, Slavonia might be said to occupy the whole land between the Drave, Danube, and Save; and to be definitely limited on three sides by these great rivers. But, as it is, only the two former touch it at all; and its southern as well as its western frontier is left to be marked out by artificial lines rather than by any natural feature of the country. Slavonia is traversed from W. to E. by a branch of the Carnic Alps, which divides the affluents of the Drave from those of the Save. The hills are not very high, the loftiest summit, Mount Papuk, towards the west of the country, being only 2700 feet above the Danube; but they have in many places sharp peaks, and descend abruptly on either side. The central ridge is succeeded by an undulating expanse of hill and dale; and that again by low level tracts along the rivers' banks. Besides the rivers which form its boundaries, Slavonia is watered by other streams, but these are few and of small size. The Karasicza flows into the Drave, the Buka into the Danube, and the Olyava into the Save. The mountains are composed entirely of limestone, except in a few places where serpentine and porphyry occur. They are, for the most part, covered with forests of excellent timber up to the very summits. The soil of the country is of very great fertility; the lower hills are covered with orchards, vineyards, and corn-fields; and the plains along the margin of the rivers form wide and rich meadows. Some portions, however, of these lower grounds are marshy and unhealthy. The climate is mild, and many tropical fruits thrive here. Wheat, rye, oats, barley, and other grains, as well as wine, tobacco, hemp, flax, and madder, are raised. The best wine is that of the district of Syrmia, in the extreme east of Slavonia. This, which also goes by the name of Karlowitz, is for the most part red, and similar to that of Hungary. The district of Syrmia derives its name from the ancient Sirmium, which was once the chief city in Pannonia; and the culture of the vine was first introduced into this country by the Emperor Probus, a native of Sirmium, in the third century A.D. Fruit is grown in great abundance in Slavonia, and there is a beverage made from plums which forms a favourite drink of the people. The people are chiefly employed in agriculture and the breeding of live stock, especially hogs, which are fed in the forests. Large herds of cattle and horses are also kept on the meadows. The mineral wealth of Slavonia is very great, but little developed. Copper, argentiferous lead, iron, and fine marble, exist here in abundance, though worked only to a very limited extent. Indeed, nature has done very much more than art or industry for the country. Few manufactures are carried on, except those of glass, earthenware, and potash. The chief articles of export are the raw pro-

duce of the land; cattle and pigs, hides, grain, tobacco, madder, honey and wax, timber, &c. In exchange for these articles there are imported iron, salt, and oil. There is also a considerable transit trade; and the internal communications are facilitated by good roads. Slavonia is divided into two counties, Essek and Posega, and is subject to the government of the crown-land, which has its seat at Agram. In this town also are the supreme courts of law for Slavonia. Most of the inhabitants are either of Slavonian or of Servian origin; and in religion the great majority are Roman Catholics; only a few belong to the Greek, the Reformed, or the Lutheran Church. The country anciently formed part of the province of Pannonia; and its earliest inhabitants, as far as we know, were a Celtic tribe, called Scordisci. Subsequently it was occupied by the Pannonians, a race probably of Illyrian origin. During the barbarian migrations, the land was overrun now by one and now by another tribe, and at length remained in the possession of the Avars. These, however, were conquered about the end of the eighth century by Charlemagne, who settled in their place a tribe of Slavonians from Dalmatia. After their settlement in this country the Slavonians received the knowledge of Christianity; and two Byzantine ecclesiastics, Cyril and Methodius, entered the land as missionaries in 864. The latter became afterwards bishop of Sirmium. When, in the tenth century, the Hungarians conquered Pannonia, they also made themselves masters of the whole of Slavonia, except Syrmia, which still remained subject to the eastern emperors. It was, however, the object of contention, and the scene of bloody conflicts between the Greeks and the Hungarians, until after various vicissitudes, it was finally ceded to the latter in 1165. From 1526, when it was conquered by the Turks, Slavonia remained in their possession till it was restored to Hungary by the peace of Carlovitz in 1699. In 1734 its size was diminished by the formation of the Military Frontier, and in 1848 it was separated from Hungary. Pop. (1854) 252,414.

SLEAFORD, New, a market-town of England, in the county of Lincoln, on the river Slea, 18 miles S. by E. of Lincoln, and 115 N. by W. of London. It is a neat and prosperous place, consisting of three well-paved streets. The parish church is remarkable for its antiquity and its architecture. It is a large cruciform edifice, and was founded in 1271. The oldest portion, consisting of a tower at the west end, is in the early English style; the spire is of later date; the chancel is in the perpendicular; the aisles and transept in the decorated style; and each of the parts in its own way is very good. Sleaford has also places of worship for Independents and other sects, a grammar school, national schools, and an hospital. The town-hall is a handsome modern building. Quarter sessions and a county court are held here. Pop. 3729.

SLEIDAN, Johann, the popular name of Johann Philipson, received from Sleida, near Cologne, where he was born in 1506. Passing from the gymnasium of his native town, he studied successively at Liège, Cologne, Louvain, Paris, and Orleans. The main drift of his studies had been directed to the law, but disliking the practice of the bar, he had allowed a considerable share of his attention to be drawn into classical channels. He had an opportunity of distinguishing himself in 1535, at the diet of Haguenau, and at the diet of Ratisbon, whether he had been induced to proceed by the recommendations of the French minister, Cardinal du Bellay, and by Francis I. of France. Sleidan did not remain long, however, under royal patronage. Having secretly adopted the Lutheran doctrines, he was compelled to quit the service of the first Francis in 1542. Retiring to Strasburg, he was appointed by the Protestant princes historian of the league of Schmalkald, and subsequently he was made professor of law by the council of that town. In 1545 he was employed in negotiations with France and England. While residing in the latter country he married an Englishwoman. On his return to Strasburg, he was sent as a deputy in 1551 to the council of Trent. On the dissolution of this assembly in 1552, Sleidan returned to Strasburg, where he enjoyed a pension which had been settled on him some time previously, and engaged in various politico-religious negotiations. Sleidan is now chiefly remembered by his faithful and accurate work, which has been lauded more than once, both by friend and foe, and which was first published in 1555. It is written in a style of simple and elegant Latinity, and has been the source whence historians and churchmen have drawn the materials of their remarks on the Reformation in Germany since his time. The addition of a book found among Sleidan's papers, after his death, augments the work to twenty-six books in all, and comprises the period from 1517 till 1556. It bears the title of *Commentarii de Statu Religionis et Reipublicæ Carolo V.* The best edition is that of Böhm, Frankfurt, 3 vols., 1785–86. The work quickly appeared in German, Italian, French, and English. There have been two English versions of it, one in 1560 by John Daws, another in 1689 by G. Bohum. Sleidan's other works were his *De Quatuor Summis Imperiis*, 1556; Froissart's Chronicles in Latin, 1611; the Memoirs of Philip de Commines in Latin, 1548; and his *Opuscula*, which appeared in 1608. The death of his wife in 1555 plunged Sleidan into an abyss of melancholy, from which he was only delivered by death on the 31st December 1556.

SLESWICK. See Schleswig.

SLIDING-RULE, a mathematical instrument, used to work questions in gauging, measuring, and the like, without the use of compasses, merely by sliding the parts of the instrument one past another, the lines and divisions of which give the answer by inspection. This instrument is variously contrived and applied by different authors, particularly Everard, Coggeshall, Gunter, Hunt, and Partridge; but the most common and useful are those of Everard and Coggeshall.

SLIGO, a maritime county in the north-west of Ireland, and the province of Connaught, bounded on the north by the Atlantic Ocean, on the east by Leitrim, on the south-east by Roscommon, and on the south and west by Mayo. It extends from N. Lat. 53. 54. to 54. 28., and from W. Long. 8. 10. to 9. 10.; being 38 miles in its greatest length from north to south, between Mullaghmore Head and Lough Gara, and 41 in breadth from west to east, between Ardnaree and the junction of the three counties of Sligo, Roscommon, and Leitrim, and comprehending an area of 721 square miles, or 461,753 acres; of which 290,696 are arable, 151,723 uncultivated, 6,134 in plantations, 460 in towns, and 12,740 under water.

According to Ptolemy the geographer, this district was inhabited by the tribe of the Nagnatæ, whose chief city, Nagnata, is supposed to have been situated somewhere in the vicinity of the town of Sligo. It afterwards formed part of the kingdom of Connaught, one of the five into which the island was divided previously to the arrival of the English, in the reign of Henry II. Subsequently, it came into the possession of one of the family of the O'Conors, kings of Connaught, who was called O'Conor Sligo, to distinguish him from the other chieftains of the same family; and under him the heads of the septs of O'Bean, O'Doud, O'Gara, O'Hara, M'Donogh, and M'Firbis, were subordinate chieftains in their respective districts. After a protracted struggle between the natives and the English, it fell into the hands of the De Burgos, who, either by force or treaties, had made themselves masters of the greater part of the ancient kingdom of Connaught. When the province was made shire-ground by Elizabeth, in 1569,

Sligo. Sligo formed one of the seven counties into which it was divided; but so far from being thus rendered amenable to the jurisdiction of that queen, it became the theatre of several conflicts in the war against O'Heil, chieftain of Tyrone, in the latter part of Elizabeth's reign. The most remarkable of these was that with Sir Conyers Clifford, who, in attempting to pass into the county from Roscommon with a body of from 1500 to 2000 men, in order to relieve Belleek, was attacked in a defile of the Curlew Mountains by O'Roark, chieftain of Breffney, was himself killed, and his troops were driven back with considerable loss. During the civil wars of 1641, the Irish kept possession of the open country until nearly its close, when they were reduced to submission by the parliamentary forces under Ireton. In the subsequent war of 1688, the county was held by the forces of King James for some time, but ultimately yielded to the victorious arms of William III. The French force which landed at Killalla under General Humbert in 1798, had a severe skirmish at Coloony with the Limerick militia, commanded by Colonel Vereker, afterwards Viscount Gort, which ended in the retreat of the latter.

The county includes an extensive and irregular line of sea-coast along its northern border, in which are the bays of Classyvaun and Milkhaven in the north, and Brown Bay, which branches into the smaller and less frequented indentations of Drumcliff, Sligo, and Ballysadare Bays. Killala Bay, to the west of the county, belongs also to Mayo. The island of Innismurray, of which Viscount Palmerston is the proprietor, lies about five miles off the northern coast, being separated from the mainland by a passage dangerous, except in moderate weather, from the number of reefs of rocks under water. The island itself rises precipitously on the ocean side, but shelves gradually downwards on that of the land: there is but one practicable landing-place. The whole surface extends over 209 acres, of which about 120 are arable, affording pasturage to a few cattle and sheep. There is also some bog. The inhabitants depend chiefly on the fishery, which in most seasons is abundant. The place is specially remarkable for a small chapel or cell, celebrated for an image of its patron, St Molasse. Near the chapel is a singular relic, called the cursing-stone, so named from a superstitious opinion of its efficacy in punishing guilt if appealed to according to an established form. The island is also a favourite burial-place, and was formerly the seat of extensive illicit distillation.

Mountains. The land rises into mountains of considerable height in the northern extremity of the county. The principal of these are the singularly formed limestone elevation of Benbulben, 1722 feet high, and Knocknarea, near the town of Sligo, which, however, is only 1078 in height, but standing in remarkable contrast to the rugged gneiss mountains which lie around it. King's Mountain, 1965; Gullogherboy, 1430; and Truskmore, part of which is in Leitrim, 2113. In the west are the ranges of the Slieve, Gamph, and Ox Mountains, the highest points of which are 1321 and 1600 feet, respectively. In the east, Keshcorran and Carrowkeel rise to the heights of 1183 and 1062 feet. The Curlew Mountains, in the south-east, between Roscommon and Sligo, rise only to the height of 863 feet. The principal rivers are the Moy, which forms the western boundary, separating the county from Mayo, and emptying itself into Killala Bay; it is navigable to Ballina, six miles inland, for vessels of ten feet draught; the Tinned; the Easkey; the Ballybeg; the Dunneill; the Ballysadare river, with its branches the Owenmore, Owenbeg, and Arrow, or Unshin, and the Garogue, a short but rapid stream, rising in Lough Gill, and passing through Sligo town into the bay of the same name. All these rivers have their sources within the county. The lakes are numerous, and several of them large and highly picturesque. Lough Gill, the most northern, spreads over 3130 acres, besides a small portion in Leitrim; its western side is richly planted, and in it are ten islands, the largest of which are Church Island, 41 acres, and Cottage Island 13. The scenery on the shores of this lake is highly romantic and picturesque, more especially in the neighbourhood of Hazlewood, the residence of the Right Honourable John Wynne. Lough Arrow, in the east, 3010 acres, is of very irregular form, and contains several islands. Loch Gara, in the south-east, 3683 acres, is also studded with small islands. Lough Talt, in a basin of the Ox Mountains, surrounded by projecting cliffs, occupies 300 acres, and is 455 feet above sea-level; it is remarkable for its abundance of trout, which vary in shape and flavour in various parts of the lake. Lough Easkey, 337 acres, lies in the same mountain-range; Templehouse lake contains 356 acres; Cloonacleigha, 177. Smaller lakes are numerous in various parts of the county.

Geology. The carboniferous, or mountain limestone, including the lower limestone, calp or black shale series, and the upper limestone, forms the basis of by much the greater portion of the county. A small tract of the yellow sandstone shows itself in the extreme north, as also on the north and east of Lough Gara, whence it extends into Mayo. The old red sandstone appears in two masses near Lough Arrow, the southern and larger portion plunging deeply into the adjoining county of Leitrim. A very small portion of the granite formation, which lies between Lough Conn and Foxford, enters the county, giving place to a broad belt of trap porphyry, bounded by a narrow fringe of old red sandstone, and stretching in a north-eastern direction, along the line of the Ox Mountains to Ballysadare Bay; a mass of granite protrudes through the middle of this formation. To the south of the same bay, and west of Ballysadare town, is a small field of quartz rock. The sandstone in some tracts assumes an appearance which gave rise to the opinion that coal existed under it, but, on making the experiment, the hopes of the speculator were always disappointed. Iron was procured in large quantities, particularly at the base of the Ox Mountains, until the timber used as fuel for smelting was exhausted. Sulphate of copper and iron pyrites are frequently found in small pieces; and pure copper occasionally in the beds of some of the rivers. Manganese has also been found in various places, and clay suitable for coarse pottery near Lough Gill.

Climate. The climate, owing to the proximity of the sea and the lofty tracts of mountains with which the county is intersected, is moist, and the weather extremely variable, the atmospheric changes being so frequent and sudden as often to render the barometer an unsatisfactory test of the weather. The soil, in the mountainous districts, is a light sandy loam on a freestone bottom, interrupted by large patches of bog, and often overspread with a thin coat of turf-mould. In the low country it is rich and deep, resting on a substratum of limestone, and suitable to the growth of every kind of agricultural produce. In many parts, a superior stratum, called by the people lac-leigh, or the gray flag, is found incumbent on the limestone bottom. It is principally composed of silicious marl, in a state so compact as to be impenetrable to water; thus, by preventing the drainage of the surface, opposing what was for some time deemed an insurmountable obstacle to the successful culture of the land. But it was afterwards discovered, that deep trenching, so as to cut through the adhesive layer, not only served to carry off the water effectually, which now passed freely through the subjacent limestone gravel, but to add to the fertility of the soil; the marl, when broken up and mixed with the surface mould, proving a valuable compost. Timber was abundant, until destroyed by the consumption of it required for the iron-works, and by its lavish use for domestic and agricultural purposes, without any regard to the formation of a fresh supply. That the land is capable of furnishing plenty of this valuable article

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is evident from the manner in which young forest-trees of various kinds shoot up in the mountainous districts, and in the escars which traverse the county in various directions, checked in their growth only by want of due care to protect the young shoots from the depredations of cattle. But this defect in the picturesque and agricultural character of the surface is diminishing. The attention of the principal landholders has been directed to the increase of forest timber, and numerous plantations are to be seen round the mansions and villas of the gentry, particularly on the borders of the beautiful lakes which grace the landscape. The prevalence of western gales from the Atlantic forbids the full growth of trees near the shore, except the willow and sycamore. Arbutus of small size grows freely in most parts, as does the myrtle in the more favoured aspects. Many parts of the beach along the sea-shore are covered with a coraline sand, interspersed with numerous beds of oyster-shells of considerable extent. These beds are also found in some parts of the interior, at elevations of more than 50 feet above high-water mark.

Population.

The population, like that of every other county in Ireland, was for some time steadily on the increase, until the census of 1851 revealed the extent to which the population had been reduced by famine and emigration. The number of inhabitants at several periods was as follows:—

Year.	Authority.	No.	Year.	Authority.	No.
1760...	De Burgo	38,736	1831...	Parliamentary census...........	171,765
1792...	Beaufort............	60,000	1841...	ditto	180,886
1812...	Parliam. census...	119,265	1851...	ditto	128,510
1821	ditto ...	146,229			

The two latest of these statements exhibit the density of the population in 1841 as being 251 to the square mile, and in 1851, 178, showing a decrease of 73 inhabitants to each square mile in the course of a few years, the diminution not having commenced until the year 1845. According to the census taken by the commissioners of Public Instruction in 1834, the population was estimated at 174,400, of which number 17,900 were Protestants, and 156,500 Roman Catholics; the former being to the latter as one to nine nearly. The number of Presbyterians and other dissenters, who are included in the preceding statement of numbers among the Protestants, amounted to 560.

In the return of the commissioners of Education in 1824–6, the only one in which the difference of religious persuasion of the children receiving instruction in public schools is noted, the numbers of each of these are,—of the Established Church, 2558; Protestant dissenters, 200; and Roman Catholics, 7495. Of the total number of schools, 226, included in the same return, 130 were pay-schools, in which the teachers were remunerated by the pupils' fees, and 74 were supported, either wholly or partially, by voluntary subscriptions, and but 22 by grants of public money. The number of schools in the county, and of pupils attending them, in the week ending the 12th of April 1851 was:—

Schools.	No. of Schools.	Children.		
		Males.	Females.	Total.
National......................	77	1861	2130	3991
Church Education.........	35	525	876	1401
Diocesan	1	30	...	30
Endowed	3	69	23	92
Boarding	1	...	39	39
Private	43	727	480	1207
Parochial	3	170	7	177
Free............................	2	27	83	110
Industrial	4	5	101	106
Mission	16	121	659	780
Workhouse	2	270	280	550
Gaol............................	1	25	7	32
Total..................	188	3830	4685	8515

At the same period, 58 per cent. of the male, and 68 per cent. of the female, population, were unable to read or write.

Divisions.

The county is divided into the six baronies of Carbury, Coolavin, Corran, Leney, Tiraghrill, and Tyreragh, which are subdivided into thirty-nine parishes; of these, twenty-three are in the diocese of Tuam, and sixteen in that of Elphin. The county was represented in the Irish parliament by four members; two for the county and two for the borough of Sligo. By the Act of Union, the number was reduced to three, one being deducted from the borough. The Reform Act made no change in this respect. The constituency of the county is about 2500. The county is in the Connaught circuit; the assizes, and some of the sessions of the peace, are held in the town of Sligo, which contains the county court-house and prison. Sessions of the peace are also held at Ballymote and Easky, where there are likewise court-houses and bridewells. The county infirmary, and the district lunatic asylum, for this county and Leitrim, are in the county town.

Agriculture.

Most parts of the county afford ample scope for agricultural improvements, either in tillage or pasturage. Oats and potatoes are the principal crops on the tillage land. The culture of wheat was long unknown, the coldness and humidity of the climate having been deemed insuperable bars to its successful treatment, but it is now raised on the rich lowlands. Green crops, under the rotation system, are more attended to every year. The spade, in many of the mountain districts, still supplies the place of the plough. Fences of every kind are usually constructed, those of dry stones being most common, particularly in the more elevated districts, where the farmers adopt this mode of structure, as well to clear their fields of surface stones as to secure them from trespass. Sea-weed, collected on the shore, which, some years ago, had been manufactured into kelp, is now used as manure, and is in such repute that it is carried twenty miles up the country. The beds of oyster-shells, and the coraline sand, on some stretches of the beach, are also applied to the same purpose. Tillage farms are from five acres, and even lower, to two hundred or three hundred in size. Those used chiefly for pasturage are often of much greater extent, and were formerly held by a number of tenants in a species of partnership, according to which each had an exclusive portion of tillage ground, while a large tract of mountain or coarse bottom-land was depastured in common; but this system is altogether obsolete. Though the tillage system is much encouraged, it is still subordinate to that of pasturage, which is adopted in all parts of the county, and on every description of soil. The extent of land under each description of crop in the following years was:—

Description.	1847.	1859.
	Acres.	Acres.
Wheat	3,570	2,072
Oats	42,837	43,539
Barley, Bere, Rye, Beans, and Pease...	8,665	2,179
Potatoes	3,352	32,250
Turnips	5,825	3,518
Other green crops	703	1,341
Flax	77	247
Meadow and Clover	11,643	18,171
Total..................................	76,672	103,317

Horned cattle of the largest size are fattened in the rich lowland plains; young cattle are reared in the hilly and mountain districts; sheep also are kept in large flocks, particularly in the western baronies. Much butter is made, both in dairy farms and by small landholders. Swine, which are reared in great numbers, are looked upon as a

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very profitable source of income. Goats are not common. The native breed of horses has little to recommend it, unless when improved by crosses from those of the neighbouring counties, in which more attention is paid to them. The quantity of live stock in the county, at several periods, has been ascertained to be as follows:—

	1847.	1859.
Horses	7,824	9.232
Cattle	56,772	96,065
Sheep	24,201	47,463
Pigs	6,116	21,576

The bays abound with both round and flat fish. The herring visits the coast in large shoals, and the sun-fish and some species of whales are frequently seen in the offing. But this source of profitable industry is far from being rendered as productive as the natural capabilities of the place would warrant. The Sligo fishery district extends from Ballina Bridge to Mullaghmore, and in 1851 employed 475 registered vessels, and 2724 men and boys; but since that period the numbers are much reduced. Of the larger fish, cod, hake, haddock, skate, and turbot, are the most abundant. Sprats are taken in great quantities. The Lissadill oyster is much esteemed. This fish, with many others of the shell kind, as lobsters, crabs, scallops, &c., are found in many other parts of the coast. There are large and profitable salmon fisheries at Ballina, Sligo, and Ballysadare; and the numerous lakes and rivers supply the usual species of fresh-water fish in equal abundance. The increase of agricultural improvement of late years is mainly attributable to the facilities for export afforded by the ports of Sligo and Ballina, but more especially the former, it being the great mart of commerce for the whole county, except its western districts, which, for the same purpose, take advantage of their vicinity to the latter. The statements relative to the external trade will be found in the subsequent description of the town and port of Sligo. The inland trade, in consequence of the want of communication by inland navigation or railroads, has been confined to that of coarse cloths, woollens, and stockings from Connaught, and to the sale of linen, mostly for domestic use. The chief trade of this description is from Sligo town to Boyle, in Roscommon, and thence, by the Shannon and the two canals, to more distant counties. A more confined traffic is carried on with Coloony.

Manufactures.

The linen manufacture was introduced into the county so lately as the middle of the last century, when a number of weavers were located at Ballymore by Lord Shelburne. It continued to flourish for many years, but at length suffered, as in other parts, by the depression of the trade, and by the introduction of that of cotton. Coarse woollens are still made for domestic consumption. In the neighbourhood of the larger towns are several thriving tanneries, distilleries, and breweries; and the manufacture of flour has caused the erection of numerous mills, which prepare large quantities of grain, both for home consumption and export. The manufacture of kelp is nearly extinct.

There is a considerable number of resident gentry in the county in proportion to its size, and consequently many elegant mansions and well-planted demesnes, which contribute more and more every year to diminish the former denuded appearance of the landscape, arising from the improvident destruction of its ancient timber. The houses of the smaller farmers are plain but comfortable; but the cottages of the peasantry generally present indications of poverty. They are either of stone or mud, rudely thatched with straw or rushes. The food of the labouring classes are potatoes and oaten bread, with some milk and fish, and meat on extraordinary occasions. Fuel from the bogs is abundant. Coal, imported from Great Britain by the vessels which take in return cargoes of agricultural produce, is used in the larger towns, and by the respectable families in their vicinity; but the high price precludes its general use throughout the county. The garments of the men are chiefly of home-manufactured wool, and so were those of the women until the native fabrics were supplanted by cheap cottons. The Irish language was understood, in 1851, by 30 per cent. of the population, or 38,644 persons; of which number 10,584 could speak Irish only. The rustic customs and amusements resemble those of the other north-western counties, in which the language and habits introduced from Scotland are less prevalent than in the eastern parts of Ulster.

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Antiquities.

There are numerous relics of ancient structures. A round tower at Drumcliff, in Carbury barony, differs from all others in Ireland, in being of smaller size, and inferior architecture. Near the church where it stands, are two stone crosses. On Knocknaree Mountains are several cairns; and in the same mountains, a deep valley, called the Glen of Knocknaree, thickly planted and watered by several romantic falls, appears to have been formed by a violent organic shock, causing a fissure through the mountain; it is about three-quarters of a mile in length, thirty feet only in width, and its wall-like boundaries about forty feet in height. Some grottoes, hollowed out of the side of a hill near Carron, are of unknown antiquity. Near Sligo town is a cromlech, and a number of circular structures, popularly called giants' graves. Near Castleconnor, in Tyreragh barony, are several vaults of a square form, whether built for cemeteries or storehouses is uncertain. There are several remains of ancient castles in different parts of the county. That of Knocknamoyle, crowning an elevated hill near Skreen, is supposed to have existed before the arrival of the English; the others are thought to have been built since. Upwards of forty monastic buildings are noticed by antiquaries, the ruins of ten of which are still visible; eight others have been converted into parochial churches, but the remainder are known only by name, even the site of some of them being either doubtful or undiscoverable. At Temple House, six miles from Coloony, are the extensive ruins of a former residence of the Knights' Templars, who had a settlement there.

SLIGO, the assize town of the county, a considerable maritime town and parliamentary borough, first became a place of importance by the building of a castle there, in 1242, by Maurice Fitzgerald, Earl of Kildare. Its consequence was increased by the subsequent foundation, in 1252, of a Dominican monastery; but its progress was afterwards much impeded by fires, and by the hostilities produced by the struggles for superiority between the English and the natives. It was incorporated and invested with the privileges of a parliamentary borough in 1613, and in 1621 obtained a charter of the staple. In the early period of the war of 1641, it was taken, without opposition, by the Parliamentarians, under Sir Charles Coote, who was afterwards attacked by a force collected by the Roman Catholic archbishop of Tuam, which retreated in consequence of an alarm being spread that a large force was approaching to relieve the town. When retiring they were attacked by the Parliamentarian forces; the archbishop was killed, and on his person was found the important document, exposing the secret communications which took place between Charles I. and the Irish Catholics. Coote subsequently evacuated the town, which thence continued in the possession of the Royalists till the termination of the war. In 1688 it declared in favour of King James, was taken for King William by the Enniskilleners, who, in turn, were driven out by General Sarsfield; but the place ultimately surrendered to the Earl of Granard. The town is situated in a very beautiful neighbourhood, on both sides of the mouth of the Garogue, where it discharges itself into the bay. The river is crossed by two bridges. The streets are narrow, winding, and irregularly built. Its public buildings are—two Protestant

churches, two Roman Catholic chapels, a Dominican friary, Presbyterian, Independent, and Methodist meeting-houses. The existing remains of the ancient monastery of Sligo still exhibit a fine specimen of early English architecture. Near its high altar is the tomb of the O'Conor Sligo, embellished with effigies. The town contains the county infirmary, the county jail, the county court-house, a custom-house, the county lunatic asylum, the union workhouse, cavalry barracks for a hundred men, and constabulary barracks. The markets are held on Tuesday and Saturday. Fairs are held four times in the year. The corporation, styled "the Mayor, Free Burgesses, and Commonality of the Borough of Sligo," consists of six aldermen and eighteen councillors. The paving, lighting, and other departments of the municipal police, are under the direction of the town and harbour commissioners. Previously to the union, the borough returned two members to parliament; subsequently the number was reduced to one, the right of franchise being vested in the mayor and twenty-seven burgesses and freemen, till the passing of the reform act, when it was extended to the L.10 householders, and is now enjoyed by occupiers rated in the last poor-rate at L.8. The number of electors is about 350. The assizes and sessions of the peace for the county are held here in the court-house, a small but elegant modern building, and petty sessions are likewise held weekly. The county prison is commodious, well arranged, and under a good system of discipline.

Sligo Bay, in its more extended bearings, stretches from Rinoran Point to Aughris Head, at its opening, a distance of about six miles, and is divided into three inlets, the central, largest, and deepest of which terminates at the town of Sligo. The entrance of this branch is screened from the violence of the ocean waves by two small islands, Oyster Island and Coney Island. There are three lighthouses at the mouth of the harbour. Across its main entrance is a bar, with but ten feet depth at low water. Though the entrance of ships of deep draught is thus prevented, yet vessels of 300 tons can come up to the quays in the turn of spring-tides. The trade of Sligo increased very considerably between 1800 and 1840, but it has been stationary for the last twenty years. The number of vessels registered as belonging to the port, on 31st Dec. 1858, was—sailing vessels, 34; tonnage 4524: steam-vessels, 3; tonnage 269. The total number of vessels that entered the port (including their repeated voyages) during that year was 378 vessels, of 51,399 tons (13, with 1830 tons, being foreign); that left, 333 vessels, of 45,960 tons (3, with 555 tons, being foreign). Of those that entered, 214 sailing vessels, of 12,928 tons, and 122 steam-vessels, of 30,443 tons; and of those that left, 197 sailing vessels, of 11,685 tons, and 125 steam-vessels, of 30,981 tons, were in the coasting or cross-channel trade. The revenue of customs and excise duties at various periods was as follows:—*Customs*—1802, L.14,690; 1810, L.15,133; 1821, L.26,083; 1830, L.39,438; 1835, L.33,703; 1854, L.20,010; 1858, L.22,732. *Excise*—1828, L.39,484; 1835, L.33,507; 1854, L.22,879; 1855, L.38,129; 1856, L.52,487; 1857, L.61,692; 1858, L.74,967.

The population of Sligo town was, in 1851, 11,104. There is not in the county another town containing 2000 inhabitants. Part of Ballina, called Ardnaree, with 533 inhabitants, is in this county, but the town is mainly in the adjoining county of Mayo. (H. S—R.)

SLINGELANDT, Peter Van, was a pupil of the eminent Dutch painter, Gerard Douw, and was born at Leyden, in 1640. He is distinguished above nearly every artist of his time for the elaborate minuteness with which he goes into every detail and circumstance of the interiors which he has undertaken to paint. For example, his most celebrated picture, which contains the portraits of the Meerman family, and consists only of some 20 inches by 16, had no less than three years devoted to its execution. The beauty of the colouring, and the delicacy with which every detail is filled in, doubtless enchants the eye of the observer; but one is apt to reflect whether it would not be possible for an artist of genius to produce a much better picture in a much shorter time. It betrays a slavish adherence to matter of fact, to spend a month on a lady's ruff, or to copy, with the most abject care, every hair of a dog's, or of a cat's, back. Slingelandt's pictures are certainly gems, and none but the opulent can buy them. In the collections of the Earl of Ellesmere and of Sir Robert Peel, at the galleries of the Louvre, of Amsterdam, and of Dresden, the curious may compare the pictures of Douw and Slingelandt, when they will have an opportunity of judging how far a touch of genius can glorify a picture, and of what an infinity of touches are required by an artist of mere talent to give his painting the veriest semblance of an approximation to the production which he has set himself to emulate. Slingelandt executed some seventy pictures in all, generally of the interiors of houses, and pencilled with an accuracy that would delight the heart of a Pre-Raphaelite. He died in 1691, in his fifty-first year.

SLOANE, Sir Hans, eminently distinguished as a physician and a naturalist, was of Irish birth but of Scottish extraction, his father, Alexander Sloane, having been at the head of that Scottish colony which King James I. settled in the north of Ireland, where the son was born, at Killyleagh, in the county of Down, on the 16th of April 1660. The place of his birth, a small two-storied house, is still pointed out in a back street of the town. At a very early period, he displayed a strong inclination for natural history; and this propensity being encouraged by a suitable education, he employed those hours which young people generally lose by pursuing low and trifling amusements, in the study of nature, and contemplating her works. When about sixteen, he was attacked by a spitting of blood, which threatened to be attended with considerable danger, and which interrupted the regular course of his application for three years. He had, however, already learned enough of physic to know that a malady of this kind was not to be suddenly removed, and he prudently abstained from wine and other liquors that were likely to increase it. By strictly observing this severe regimen, which he in some measure continued ever afterwards, he was enabled to prolong his life beyond the ordinary bounds; being an example of the truth of his own favourite maxim, that sobriety, temperance, and moderation, are the best and most powerful preservatives that nature has granted to mankind. As soon as he recovered from this infirmity, he resolved to perfect himself in the different branches of physic, which was the profession he had made choice of; and with this view he repaired to London, where he hoped to receive that assistance which he could not find in his own country.

On his arrival in the metropolis, he entered himself as a pupil of Stafforth, an excellent chemist, bred under the illustrious Stahl; and by his instructions he gained a perfect knowledge of the composition and preparation of the different kinds of medicines then in use. At the same time, he studied botany at the garden at Chelsea, assiduously attended the public lectures of anatomy and physic, and in short neglected nothing that he thought likely to prove serviceable to him in his future practice. His principal merit, however, was his knowledge of natural history; and it was this part of his character which introduced him early to the acquaintance of Boyle and Ray, two of the most eminent naturalists of that age. His intimacy with these distinguished characters continued as long as they lived; and as he was careful to communicate to them every object of curiosity that attracted his attention, the observations which he occasionally made often excited their admiration and obtained their applause. After studying four years

in London with unremitting severity, Sloane determined to visit foreign countries for further improvement. With this view he set out for France in the company of two other students, and having crossed to Dieppe, proceeded to Paris. In the way thither they were entertained by Lemery the elder; and in return Sloane presented that eminent chemist with a specimen of four different kinds of phosphorus, of which, upon the credit of other writers, Lemery had treated in his book of chemistry, though he had never seen any of them. At Paris Sloane lived as he had done in London. He attended the hospitals, heard the lectures of Tournefort, De Verney, and other eminent masters; visited all the literati, who received him with particular marks of esteem; and employed himself wholly in study. From Paris he proceeded to Montpellier; and, being furnished with letters of recommendation from Tournefort to Chirac, then chancellor of that university, he found easy access, through his means, to all the learned men of the province, particularly to Magnol, whom he always accompanied in his botanical excursions in the environs of that city. Having here found an ample field for contemplation, which was entirely suited to his taste, he took leave of his two companions, whom a curiosity of a different kind led into Italy. After spending a whole year in collecting plants, he travelled through Languedoc with the same design; and passing through Toulouse and Bordeaux, returned to Paris, where he made a short stay. About the end of the year 1684 he set out for England, with an intention of settling there as a physician. On his arrival in London, he made it his first business to visit his two illustrious friends Ray and Boyle, in order to communicate to them the discoveries which he had made in his travels. The latter he found at home, but the former had retired to Essex; to which place Sloane transmitted a great variety of plants and seeds, which Ray has described in his *History of Plants*, and for which he makes a proper acknowledgment.

About this time Sloane became acquainted with Sydenham, who soon contracted so warm an affection for him that he took him into his house, and recommended him in the strongest manner to his patients. He had not been long in London before he was proposed by Dr Martin Lister as a candidate to be admitted a Fellow of the Royal Society, on the 26th of November 1684; and being approved, he was elected on the 21st of January following. In 1685 he communicated some curiosities to the Society; and in July the same year he was a candidate for the office of secretary, but without success, as he was obliged to give way to the superior interest of his competitor Dr Halley. On the 12th of April 1687, he was chosen a fellow of the College of Physicians in London; and on the 13th of July of the same year his friend and fellow-traveller Dr Tancred Robinson, having mentioned to the society the plant called "the star of the earth" as a remedy newly discovered for the bite of a mad dog, Dr Sloane acquainted them that this virtue of the plant was to be found in a book called De Grey's *Farriery;* and that he knew a man who had cured with it twenty couple of dogs. On the 12th of September following he embarked at Portsmouth for Jamaica with the Duke of Albemarle, who had been appointed governor of that island. The doctor attended his grace in quality of physician, and arrived at Jamaica on the 19th of December following. Here a new field was opened for fresh discoveries in natural productions; but the world would have been deprived of the fruits of them had not Sloane, by incredible application, converted, as we may say, his minutes into hours. The Duke of Albemarle died soon after he landed, yet he so improved his time in making collections of natural curiosities, that, though his whole stay in Jamaica was not above fifteen months, he brought together such a prodigious number of plants, that, on his return to England, Ray was astonished that one man could procure in one island, and in so short a space, so vast a variety. On his arrival in London, he applied himself to the practice of his profession, and soon became so eminent, that he was chosen physician to Christ's Hospital on the 17th October 1694; and this office he held till the year 1730, when, on account of his great age and infirmities, he found it necessary to resign. It is somewhat singular, and redounds much to the doctor's honour, that though he received the emoluments of his office punctually, because he would not lay down a precedent which might hurt his successors, yet he constantly applied the money to the relief of those who were the greatest objects of compassion in the hospital, that it might never be said he enriched himself by giving health to the poor. He had been elected secretary to the Royal Society on the 30th of November 1693; and upon this occasion he revived the publication of the *Philosophical Transactions*, which had for some time been neglected. He continued to be the editor of this work till the year 1712; and the volumes which appeared during that period are monuments of his industry and ingenuity, many of the pieces contained in them being written by himself. In the meantime he published *Catalogus Plantarum quæ in Insula Jamaica sponte proveniunt; seu Prodromi Historiæ Naturalis pars prima;* which he dedicated to the Royal Society and the College of Physicians. About the same time he formed the plan of a dispensary, where the poor might be furnished at prime cost with such medicines as their several maladies might require; and this he afterwards carried into execution, with the assistance of the president and other members of the College of Physicians. His eager thirst for natural knowledge seems to have been born with him, so that his cabinet of curiosities may be said to have commenced with his life. He was continually enriching and enlarging it; and the fame which, in the course of a few years, it had acquired, brought everything that was curious in art or nature to be first offered to him for purchase. These acquisitions, however, increased it but very slowly in comparison of the augmentation which it received in 1701 by the death of William Courten, a gentleman who had employed all his time, and the greater part of his fortune, in collecting rarities, and who bequeathed the whole to Dr Sloane, on condition of his paying certain debts and legacies with which he had charged it. These terms our author accepted, and he executed the will of the donor with the most scrupulous exactness; on which account some people have said, that he purchased Courten's curiosities at a dear rate.

In 1707, the first volume of Dr Sloane's *Natural History of Jamaica* appeared in folio, though the publication of the second was delayed till 1725. By this very useful as well as magnificent work, the materia medica was enriched with a great number of excellent drugs not before known. In 1708, the author was elected a foreign member of the Royal Academy of Sciences at Paris, in the room of Tschirnaus; an honour so much the greater as we were then at war with France, and the queen's express consent was necessary before he could accept it. In proportion as his credit rose among the learned, his practice increased among the people of rank. Queen Anne herself frequently consulted him. On the advancement of George I. to the throne, that prince, on the 3d of April 1716, created Sloane a baronet, an hereditary title of honour to which no English physician had before attained; and at the same time made him physician-general to the army, in which station he continued till 1727, when he was appointed physician in ordinary to George II. He attended the royal family till his death; and was particularly favoured by Queen Caroline, who placed the greatest confidence in his prescriptions. In the meantime, he had been unanimously chosen one of the elects of the College of Physicians on the 1st of June 1716, and he was elected president of the same body on the 30th of September 1719, an office which he held for

sixteen years. During that period he not only gave the highest proofs of his zeal and assiduity in the discharge of his duty, but, in 1721, made a present to that society of L.100, and so far remitted a very considerable debt which the corporation owed him as to accept it in such small sums as were least inconvenient to the state of their affairs. Sir Hans was no less liberal to other learned bodies. He had no sooner purchased the manor of Chelsea, than he gave the company of apothecaries the entire freehold of their botanical garden.[1] He gave besides several other considerable donations for the improvement of this garden, the situation of which, on the banks of the Thames, and in the neighbourhood of the capital, was such as to render it useful in two respects: first, by producing the most rare medicinal plants; and, secondly, by serving as an excellent school for young botanists, an advantage which he himself had derived from it in the early part of his life.

The death of Sir Isaac Newton, which happened in 1727, made way for the advancement of Sir Hans to the presidency of the Royal Society. He had been vice-president, and frequently sat in the chair for that great man; and by his long connection with this learned body he had contracted so strong an affection for it, that he made the Society a present of an hundred guineas, caused a curious bust of Charles II., its founder, to be erected in the great hall where it met, and, as is said, was very instrumental in procuring Sir Godfrey Copley's benefaction of a medal of the value of five guineas, to be annually given as an honorary mark of distinction to the person who should communicate the best experiments to the Society. On his being raised to the chair, Sir Hans applied himself wholly to the faithful discharge of the duties of the offices which he enjoyed. In these laudable occupations he employed his time, from 1727 to 1740, when, at the age of fourscore, he formed a resolution of retiring into private life. With this view, he resigned the presidency of the Royal Society much against the inclination of that respectable body, who chose Martin Folkes to succeed him, and in a public assembly thanked him for the great and eminent services which he had rendered them. In the month of January 1741, he began to remove his library, and his cabinet of rarities, from his house in Bloomsbury to that at Chelsea; and, on the 12th of March following, having settled all his affairs, he retired thither himself, to enjoy in peaceful tranquillity the remains of a well-spent life. He did not, however, bury himself in that solitude which excludes men from society. He received in Chelsea, as he had done in London, the visits of people of distinction, of learned foreigners, and of the royal family, who sometimes did him the honour to wait on him; but, what was still more to his praise, he never refused admittance or advice to rich or poor who came to consult him concerning their health. Not contented with this contracted method of doing good, he now, during his retreat, presented to the public such useful remedies as success had warranted, during the course of a long-continued practice. During the whole course of his life Sir Hans had lived with so much temperance as had preserved him from feeling the infirmities of old age; but in his ninetieth year be began to complain of pains, and to be sensible of a universal decay. He was often heard to say, that the approach of death brought no terrors along with it; that he had long expected the stroke; and that he was prepared to receive it whenever the Great Author of his being should think fit. After a short illness of three days, he died on the 11th of January 1752, in his ninety-second year, and was interred on the 18th at Chelsea, in the same vault with his lady, his remains being attended by the greatest concourse of people, of all ranks and conditions, that had ever before been seen on a like occasion.

Sir Hans being extremely solicitous lest his cabinet of curiosities, which he had taken so much pains to collect, should be again scattered at his death, and being at the same time unwilling that so large a portion of his fortune should be lost to his children, bequeathed it to the public, on condition that L.20,000 should be made good by parliament to his family. The sum, though large in appearance, was scarcely more than the intrinsic value of the gold and silver medals, the ores and precious stones that were found in it; for in his last will he declares, that the first cost of the whole amounted at least to L.50,000. Besides his library, consisting of more than fifty thousand volumes, three hundred and forty-seven of which were illustrated with cuts finely engraven and coloured from nature, there were three thousand five hundred and sixty manuscripts, and an infinite number of rare and curious works of every kind. The parliament accepted the legacy, and fulfilled the conditions, and from this ample collection the British Museum had its origin.

SLOBODSKOI, or Slobosk, a town of European Russia, capital of a circle in the government and 18 miles N.E. of Viatka, on the river Viatka. It contains 12 churches, including several cathedrals; 2 schools and 2 charitable institutions. The inhabitants are employed in iron-works; also in hunting and fishing, and in weaving and soap-making. A considerable trade is carried on in corn, tallow, and linen. Pop. (1850), 6032.

SLONIM, a town of European Russia, capital of a circle in the government and 67 miles S.E. of Grodno, on the Schtschara. It contains 7 churches, 2 schools, and large manufactories of cloth. The town is walled, and has an old castle. Pop. (1850), 8708.

SLOUGH, a village of England, Buckinghamshire, 20 miles W. of London. It has recently risen to some consequence, since it has been made a principal station on the Great Western Railway; a new church, a large railway hotel, and many private houses have been erected. It was here that Sir William Herschell erected his large telescope, and made some of his great discoveries. Pop. 1189.

SLUICE. See Navigation, Inland.

SLUTSK, a town of European Russia, on a river of the same name, capital of a circle in the government and 60 miles S. of Minsk. It is large and well built, but chiefly of wood; and contains three castles, 15 churches, a convent, several schools, and benevolent institutions. A considerable trade is carried on. Pop. (1851), 5174.

SMART, Christopher, now chiefly remembered by his prose translation of Horace, was born at Shipbourne, in Kent, on the 11th of April 1722. He received his education successively at Maidstone, at Durham, and at Pembroke Hall, Cambridge. He early gave evidence of possessing a power of versification; and on entering college he rose to immediate distinction as a classic, a rhymster, and a frequenter of taverns. Smart was chosen fellow of his college in 1745, and gained the Seatonian prize for five successive years, for poems composed on the Supreme Being. In 1752 he married Miss Carman, a relation of

[1] This garden was first established by the company in 1673; and having, after that period, been stocked by them with a great variety of plants for the improvement of botany, Sir Hans, in order to encourage so serviceable an undertaking, granted to the company the inheritance of it, being part of his estate and manor of Chelsea, on condition that it should be for ever preserved as a physic garden. As a proof of its being so maintained, he obliged the company, in consideration of the said grant, to present yearly to the Royal Society, in one of their weekly meetings, fifty specimens of plants that had been grown in the garden the preceding year, and which were all to be specifically distinct from each other, until the number of 2000 should be completed. This number was completed in the year 1761. In 1733 the company erected a marble statue of Sir Hans, executed by Rysbrack, which is placed upon a pedestal in the centre of the garden, with a Latin inscription expressing his donation, and the design and advantages of it.

Newberry the publisher, gave up his fellowship, and betook himself to London, to commence the career of author. He wrote a satire, called the *Hilliad*, against the notorious Sir John Hill, who had previously attacked him in a criticism of his poems. He was not deficient in those mental qualities which ensure success in the literary calling, but he was hopelessly addicted to drinking and other vices, which speedily wrecked his constitution. Harassed by disease, and plunged irrecoverably in poverty, he lost his reason, and was confined in a lunatic asylum for two years. During his intervals of sanity he executed prose translations of the Psalms, of Phædrus, and of Horace. He was in the receipt of L.50 a year out of the treasury, yet his confirmed habits as a spendthrift could not be broken through, and he died in great poverty in King's Bench prison, where he had been confined during the latter part of his life, on the 22d of May 1771. Poor Smart was not quite destitute of good qualities. He was generous and open-hearted, and was possessed of considerable sensibility. He was known after a debauch to pen fervid lines on his knees, so great was his contrition; but as usually happens, when the next temptation came, he had forgotten all his vows. He was the friend of Garrick, of Goldsmith, and of Johnson. He was the Edgar Allan Poe of the eighteenth century, though he fell considerably short of that ideal writer in all the higher qualities of his genius. A quarto edition of his poems was published in 1753, and a collected edition of them in 1791.

SMEATON, John, an eminent civil engineer, was born on the 18th of June 1724, at Austhorpe, near Leeds, in a house built by his grandfather, and where his family have resided ever since. The strength of his understanding and the originality of his genius appeared at an early age. His playthings were not the playthings of children, but the tools which men employ; and he appeared to have had greater entertainment in seeing the men in the neighbourhood work, and asking them questions, than in anything else. One day he was seen on the top of his father's barn, fixing up something like a wind-mill; another time, he attended some men fixing a pump at a neighbouring village, and observing them cut off a piece of bored pipe, he was so lucky as to procure it, and he actually made with it a working pump that raised water. These anecdotes referred to circumstances that happened while he was yet in petticoats, and most likely before he attained his sixth year. About his fourteenth or fifteenth year, he constructed for himself an engine for turning, and made several presents to his friends of boxes in ivory or wood very neatly turned. He forged his iron and steel, and melted his metal; he had tools of every sort for working in wood, ivory, and metals. He made a lathe, by which he cut a perpetual screw in brass, a thing little known at that day, which was the invention of Henry Hindley of York, with whom Smeaton soon became acquainted, and they spent many a night at Hindley's house till daylight, conversing on those subjects. Thus had Smeaton, by the strength of his genius and indefatigable industry, acquired, at the age of eighteen, an extensive set of tools, and the art of working in most of the mechanical trades, without the assistance of any master. A part of every day was generally occupied in forming some ingenious piece of mechanism. Smeaton's father was an attorney, and desirous of bringing him up to the same profession. Smeaton therefore came up to London in 1742, and attended the courts in Westminster Hall; but finding that the law did not suit the bent of his genius, he wrote a strong memorial on that subject to his father, whose good sense from that moment left the youth to pursue the bent of his genius in his own way.

In 1751 he began a course of experiments to try a machine of his invention to measure a ship's way at sea, and also made two voyages in company with Dr Knight to try it, and a compass of his own invention and making, which was rendered magnetical by Dr Knight's artificial magnets. The second voyage was made in the Fortune sloop of war, commanded at that time by Captain Alexander Campbell. In 1753 he was elected member of the Royal Society. The number of papers published in their *Transactions* will show the universality of his genius and knowledge. In 1759 he was honoured, by a unanimous vote, with their gold medal for his paper entitled "An Experimental Inquiry concerning the Natural Powers of Water and Wind to turn Mills, and other Machines depending on a circular motion." This paper, he says, was the result of experiments made on working models in the years 1752 and 1753, but not communicated to the Society till 1759; before which time he had an opportunity of putting the effect of these experiments into real practice, in a variety of cases, and for various purposes, so as to assure the Society he had found them to answer. In December 1755, the Eddystone lighthouse was burned down. Weston, the chief proprietor, and the others, being desirous of rebuilding it in the most substantial manner, inquired of the Earl of Macclesfield, then president of the Royal Society, whom he thought the most proper to rebuild it; and his lordship recommended Smeaton. He accordingly undertook the work, and he completed it in the summer of 1759. Of the preparation for this extraordinary work, of its commencement and progress, Smeaton has given an ample and interesting description in a splendid folio volume which was first published in 1791. The same volume contains the history of the different buildings which have been erected on the Eddystone rock. Though Smeaton completed the building of the Eddystone lighthouse in 1759, yet it appears he did not soon get into full business as a civil engineer; but in 1764, while in Yorkshire, he offered himself a candidate to be one of the receivers of the Derwentwater estate, and on the 31st of December in that year, he was appointed, at a full board of Greenwich hospital, in a manner highly flattering to himself, when other two persons, strongly recommended and powerfully supported, were candidates for the employment.

Smeaton having now got into full business as a civil engineer, performed many works of general utility. He made the Calder navigable; a work that required great skill and judgment, owing to the very impetuous floods in that river. He planned and attended the execution of the great canal in Scotland, joining the Firths of Forth and Clyde, for conveying the trade of the country either to the Atlantic or German Ocean; and having brought it to the place originally intended, he declined a handsome yearly salary, in order that he might attend to the multiplicity of his other business. The vast variety of mills which Smeaton constructed, so greatly to the satisfaction and advantage of the owners, will show the great use which he made of his experiments in 1752 and 1753; for he never trusted to theory in any case where he could have an opportunity to investigate it by experiment. He built a steam-engine at Austhorpe, and made experiments upon it, purposely to ascertain the power of Newcomen's steam-engine, which he greatly improved. About the year 1785 Smeaton's health began to decline; and he then took the resolution of endeavouring to avoid all the business he could, so that he might have leisure to publish an account of his inventions and works, which was certainly the first wish of his heart; for he has often been heard to say, that "he thought he could not render so much service to his country as by doing that." He got only his account of the Eddystone lighthouse completed, and some preparations to his intended *Treatise on Mills*. He could not resist the solicitations of his friends in various works; and Aubert, whom he greatly loved and respected, being chosen chairman of Ramsgate harbour, prevailed upon him to accept the place

of engineer. To their joint efforts the public is chiefly indebted for the improvements which have been made there, as fully appears in a report that Smeaton presented to the board of trustees in 1791, which they immediately published. Smeaton being at Austhorpe, walking in his garden on the 16th of September 1792, was struck with palsy, and died the 28th of October.

SMELLIE, William, a learned and ingenious printer, was born at Edinburgh in the year 1740. He received a fair education at a school in Duddingstone, from which, at the early age of twelve years, he was removed, and apprenticed for six years and a half, to Hamilton, Balfour, and Neill, printers to the university. To this occupation he applied himself with great assiduity, and devoted his evenings to the acquisition of knowledge. During his apprenticeship he was permitted to attend some of the university lectures. The Edinburgh Philosophical Society having offered a silver medal for the most accurate edition of a Latin classic, Smellie set and corrected an edition of Terence, which obtained this prize for his employers. His edition, which bears the date of 1758, but was actually printed during the preceding year, has been described as immaculate; but of the literal accuracy of this description we entertain some doubt. His apprenticeship was completed on the 1st of April 1759; and in the ensuing month of September, he agreed to transfer his services to the office of Murray and Cochrane. In this new situation, Smellie's employers allowed him three hours a day for the prosecution of his academical studies. He studied Latin, Greek, Hebrew, mathematics, logic, rhetoric, moral and natural philosophy. He besides attended all the medical courses, including the lectures on chemistry and botany. The Hebrew class he attended in the year 1758, with the immediate view of preparing himself to superintend the printing of Dr Robertson's *Hebrew Grammar*. In 1763, then in his twenty-third year, he married and settled down to his books. In 1760 he had become a member of the Newtonian society, a literary association chiefly composed of young men educated in the university, and many of whom subsequently rose to be men of influence in the country. A new association, of which he acted as secretary, was formed in the year 1778, under the denomination of the Newtonian Club. Most of the other members were connected with the medical profession, and five of them either then were, or afterwards became, medical professors in the university. In the list of these associates we find the names of Dugald Stewart and James Gregory. For the different branches of natural history Smellie had evinced an early predilection. To the study of botany he devoted so much attention, that in 1765 his "Dissertations on the Sexes of Plants" gained the gold medal given by Dr Hope. In this dissertation, which was inserted in the first edition of this *Encyclopædia*, he strenuously opposed the doctrines of Linnæus. The substance of it was incorporated in his *Philosophy of Natural History*, and his opinions were then controverted by Dr Rotheram, afterwards professor of natural philosophy at St Andrews. (Smellie's *Philosophy of Natural History*, vol. i., p. 245.)

On the 25th of March 1765 he commenced business as a printer, in conjunction with two brothers named Robert and William Auld, which was next year to be merged into the new company of Balfour, W. Auld, and Smellie, and subsequently into that of Balfour and Smellie. He was intimate with Lord Kames, and he incidentally mentions his supping with his lordship in company with Hume and other guests. He was likewise a guest at the learned suppers of Lord Monboddo; and he reckoned Lord Hailes, as well as Lord Gardenstone, among his friends.

Balfour and Smellie were appointed printers to the university. The chief advantage which attended this appointment was the profit of printing the dissertations written by candidates for medical degrees. Smellie likewise printed the theses written by candidates for admission to the Faculty of Advocates; and his knowledge of the Latin language was in both cases found very serviceable to the writers. He rendered material assistance to his friend Dr Buchan in the composition of his *Domestic Medicine*, published at Edinburgh in the year 1770, and which attained to an enormous popularity.

The first edition of the *Encyclopædia Britannica* consisted of only three volumes, which began to be printed in the year 1771. The principal articles were written, compiled, or devised by Smellie, and he prepared and superintended the entire publication. "As you have informed me," says a letter of Andrew Bell, the chief proprietor, "that there are fifteen capital sciences which you will undertake for, and write up the subdivisions and detached parts, conform[ably] to your plan, and likewise to prepare the whole work for the press, &c., &c., we hereby agree to allow you L.200 for your trouble." If his capital sciences had not exceeded the old number of seven, this remuneration could scarcely have been considered as extravagant. One of his original articles, contributed to this edition, was that on "Æther," which attracted a considerable degree of attention, and gave no small offence to Dr Cullen, whose theory was there exposed, though without any mention of his name. Of the second edition of the *Encyclopædia* Smellie was offered a share, apparently a third, conjoined with the charge of editorship. This offer he unfortunately declined, and thus lost the only golden opportunity that fortune ever presented to him. "At the death of Mr Macfarquhar, printer, in April 1793, the whole work became the property of Mr Bell. It is well known that Mr Macfarquhar left a handsome fortune to his family, all or mostly derived from the profits of the *Encyclopædia*; and that Mr Bell died in great affluence, besides possessing the entire property of that vast work, every shilling of which may be fairly stated as having grown from the labours of Mr Smellie in the original fabrication of the work, which is confessedly superior, and all of which he and his family might have shared in equally with Mr Bell and the other proprietor, if he had not been too fastidious in his notions, and perhaps too timid in his views of the risk which might have been incurred in the mercantile part of the speculation." (Kerr's *Memoirs of the Life, Writings, and Correspondence of William Smellie*, vol. i., p. 363, Edin. 1811, 2 vols. 8vo.)

Smellie afterwards embarked in a speculation which did not prove so lucrative. This was *The Edinburgh Magazine and Review*, which began in the month of October 1773, and extended over five volumes, closing with the number for August 1776. Of the Society of Antiquaries, instituted at Edinburgh in 1780, Smellie was an original member. In 1781 he was elected superintendent of the Museum of Natural History, which they proposed adding to their antiquarian cabinet. He afterwards published an *Account of the Institution and Progress of the Society of the Antiquaries of Scotland*, Edin. 1782, 4to. To this account he added a second part in 1784. He was elected to the office of secretary in 1793. This new institution excited the jealousy of some other learned bodies; but a royal charter was finally got ratified in the month of May 1783. At the request of the Society of Antiquaries he had, in 1781, digested the plan of a statistical account of all the parishes of Scotland. The circulation of this plan did not excite much industry; but, at no distant period, it was followed by an extensive and important work. As superintendent of the museum, he was authorized to deliver in their hall a course of lectures on natural history. "His object was to deliver lectures on the philosophy of natural history, which is a subject totally different from what a public professor is obliged to teach. A professor

must instruct his students in the technical and elementary part of the science; but the private lecturer was to confine himself to general views of the economy of nature." (Smellie's *Account of the Society of Antiquaries*, part ii., p. 24.) The professor of natural history, who certainly had reason to fear such a rival, was alarmed at what he considered as an encroachment on his province, and this plan of lectures was reluctantly abandoned. On the death of Dr Ramsay, in the year 1775, Smellie had offered himself as a candidate for the professorship of natural history, but it was bestowed upon another.

Smellie continued to prosecute his favourite study, and he published *Natural History, General and Particular, by the Count de Buffon*, translated into English, Edin. 1781, 8 vols. 8vo. The translator was honoured with the correspondence of Buffon, and likewise of Pennant. The firm of Balfour and Smellie having been dissolved, that of Creech and Smellie began business on the 14th of September 1782, and continued it till the close of the year 1789. After the termination of these different partnerships, he continued the business on his own account. His next publication was, *An Address to the People of Scotland on the Nature, Powers, and Privileges of Juries*, Edin. 1784, 8vo. This tract excited a considerable degree of attention; and it was quoted with much approbation by Lord Erskine in his famous speech in defence of Dr Shipley, dean of St Asaph. He published several other pamphlets, which chiefly related to local politics. But the most elaborate of his works is *The Philosophy of Natural History*, Edin. 1790, 4to. This is an ingenious book, written in a very pleasing style, and it accordingly experienced a favourable reception. It was reprinted at Dublin and Philadelphia. Lichtenstein published a German translation, to which some notes were added by C. A. W. Zimmermann. His plan, however, was not yet completed, and he immediately applied himself to the preparation of a second volume. He lived to bring it to a conclusion, though not to make any arrangement for its publication. During the last years of his life his health appears to have been infirm and precarious. After a long illness, he died on the 24th of June 1795, at the age of sixty-five. He left a widow, with four sons and four daughters; two sons and three daughters having died before their father.

Of his *Philosophy of Natural History*, the second volume was published by his son in the year 1799. Another posthumous work speedily followed, *Literary and Characteristical Lives of John Gregory, M.D., Henry Home, Lord Kames, David Hume, Esq., and Adam Smith, LL.D. To which are added a Dissertation on Public Spirit*, and *Three Essays*, Edinb. 1800, 8vo. His original plan comprehended the lives of other twenty-five men of literary eminence with whom he was personally acquainted.

Smellie appears to have been a man of excellent talents, and of extensive knowledge. His disposition was social, his habits were convivial, and he was distinguished by a sarcastic vein of wit and humour. Burns describes him as "a man positively of the first abilities and greatest strength of mind, as well as one of the best hearts and keenest wits, that he had ever met with." And in the following lines, which allude to a club called the Crochallan Fencibles, he has exhibited a graphic delineation of Smellie:—

"To Crochallan came
The old cock'd hat, the grey surtout, the same;
His bristling beard just rising in its might,
'Twas four long nights and days to shaving night;
His uncomb'd grizzly locks, wild staring, thatch'd
A head for thought profound and clear, unmatch'd;
Yet though his caustic wit was biting, rude,
His heart was warm, benevolent, and good."

SMELTING. See IRON.

SMIEINJORSK, or SMEYINOGORSK, in Siberia, a small district in the Altai Mountains, with a village of the same name, in the government of Tomsk. It contains mines of silver and copper, a silver smelting-house, and an hospital. Pop. (1850), 14,904.

SMITH, ADAM, author of the *Theory of Moral Sentiments* and the *Wealth of Nations*, and the most distinguished political economist of modern times, was born at Kirkcaldy, on the 5th of June 1723. His father, who held the situation of comptroller of customs in that town, died a few months before his birth; so that the charge of his early education devolved wholly on his mother, the daughter of Mr Douglas of Strathenry, in the county of Fife.

His constitution during infancy is said to have been extremely infirm and delicate, and required all the anxious attention of his mother, who treated him with greatest indulgence. This, however, had no unfavourable influence over his temper or dispositions; and he repaid the fond solicitude of his parent by every attention that filial gratitude and affection could dictate, during the long period of sixty years.

He received the rudiments of his education in the grammar school of Kirkcaldy. The weakness of his constitution prevented him from indulging in the amusements common to boys of his age. But Dugald Stewart states, that he was even then distinguished by his passion for books, and by the extraordinary powers of his memory; that he was much beloved by his schoolfellows, many of whom subsequently attained to great eminence; and that he was thus early remarkable for those habits which remained with him through life, of speaking to himself when alone, and of absence in company.

He continued at Kirkcaldy until 1737, when he was sent to the University of Glasgow, where he remained for three years. He then entered Balliol College, Oxford, as an exhibitioner on Snell's foundation; and continued for seven years to prosecute his studies at that celebrated seminary.

Mathematics and natural philosophy formed his favourite pursuits while at Glasgow. But, subsequently to his removal to Oxford, he seems to have principally devoted the time not consumed in the routine duty of the university to the study of the *belles lettres*, and of those moral and political sciences of which he was destined to become so great a master.

Smith does not seem to have felt any very peculiar respect for his English *alma mater*. The severe remarks in the *Wealth of Nations* on the system of education followed in Oxford and Cambridge were suggested by his own observations. He shows that it is reasonable to expect that the plan of appointing professors with handsome salaries, who are not permitted to receive fees from their pupils, should, in all ordinary cases, make them either wholly neglect the important duties of their office, or discharge them in a slovenly manner; and he refers to the example of Oxford, to prove the accuracy of this conclusion; "the greater part of the public professors of that seminary having, for these many years, given up altogether even the pretence of teaching."

While at Oxford, Smith frequently employed himself in translating, particularly from the French, in the view of improving his style; and he used often to express a favourable opinion of this sort of exercise. But he might have practised it with nearly equal advantage anywhere else. No doubt, however, he must have reaped considerable advantage from his residence at Oxford, by its contributing to improve and perfect his acquaintance with the niceties of the English language, and rendering him a greater proficient in classical learning, of which his knowledge was both extensive and accurate. But it is not, perhaps, very easy to discover what other obligations he could owe to it. What advantage could he derive in prosecuting his inquiries respecting the history of society, and

into "those principles which ought to run through and be the foundation of the laws of all nations," from living among those who were satisfied with what had been known on these subjects two thousand years ago? and who compelled the noble and aspiring youth of the country committed to their charge to draw the principal part of their information with respect to politics and philosophy from the politics and the logic of Aristotle?[1]

Something had occurred, while Smith was at Oxford, to excite the suspicions of his superiors with respect to the nature of his private pursuits; and the heads of his college, having entered his apartment without his being aware, unluckily found him engaged reading Hume's *Treatise of Human Nature*. The objectionable work was, of course, seized; the young philosopher being at the same time reprimanded.

He continued, subsequently to his return from Oxford in 1747, for nearly two years at Kirkcaldy, with his mother. He had been sent to Oxford that he might qualify himself for entering the Church of England. The ecclesiastical profession was not, however, agreeable to his taste. And, in opposition to the advice of his friends, he resolved to devote himself exclusively to literary pursuits.

In the latter part of the year 1748, Smith fixed his residence in Edinburgh, where he was prevailed upon by Lord Kames, and some of his other friends, to deliver, during that and the two following sessions, courses of lectures on rhetoric and *belles lettres*. These were well attended by an audience composed chiefly of students of law and theology. Among his pupils were Mr Wedderburn, afterwards Lord Loughborough; Mr William Johnstone, afterwards Sir William Pulteney Johnstone, Bart.;[2] Dr Blair, &c.; with all of whom he subsequently continued on the most intimate terms. It was at this period also that he laid the foundation of that friendship with David Hume which lasted, without the slightest interruption, till the death of the latter.

No part of these lectures has been published; but it would appear from the statement of Blair, who commenced his lectures on rhetoric and *belles lettres* in 1758, ten years after Smith's first course, that they had been reduced into a systematic shape. In a note to his eighteenth lecture, Blair mentions that he had borrowed several of the ideas respecting the general characters of style, particularly the plain and simple, and the characters of those English authors by whom they have been most successfully cultivated, from a manuscript treatise of Smith on rhetoric, of which the author had shown him a part.

It may be worthy of notice that Smith's was the first course of lectures on polite literature given in Scotland. It was followed by lectures on the same subject by Dr Watson, author of the *History of Philip II.* And a taste for such prelections being introduced, a chair of rhetoric was established by the crown in the University of Edinburgh in 1760, and endowed with a salary of L.70 a-year, to which Dr Blair was appointed as first professor. We may further add, in illustration of the progress of this interesting study, that Lord Kames' *Elements of Criticism* was originally published in 1762; Dr Campbell's excellent work on the *Philosophy of Rhetoric* in 1776; and Dr Blair's useful and admirable lectures in 1783. Such were the followers of Smith in this peculiar department of literature; and it is but seldom that an impulse given by one individual is so vigorously and successfully followed up.

Smith's increasing celebrity, and the strong recommendations of Lord Kames and other distinguished persons, procured for him, in 1751, the honour of being elected professor of logic in the University of Glasgow; and in the following year he was elevated to the chair of moral philosophy in the same university, vacant by the death of Mr Craigie, the immediate successor of the celebrated Dr Hutcheson, under whom Smith had formerly studied, and for whom he justly entertained the highest regard. Of the offices to which he might have been appointed, this was probably the most suitable to his peculiar talents, and afforded the best opportunity for employing them to the greatest advantage. It is not, therefore, surprising that he considered the thirteen years during which he continued in Glasgow as the happiest portion of his life. At the same time, it seems reasonable to conclude that his professional pursuits must have materially contributed to mature his speculations in morals and politics, and, consequently, to determine him to undertake the great works which have immortalised his name.

Mr Millar, author of the *Historical View of the English Government*,[3] and professor of law in the University of Glasgow, had the advantage of hearing Smith's course of lectures on moral philosophy, of which he has given the following account:—

"His course of lectures was divided into four parts. The first contained natural theology, in which he considered the proofs of the being and attributes of God, and those principles of the human mind upon which religion is founded. The second comprehended ethics, strictly so called, and consisted chiefly of the doctrines which he afterwards published in his *Theory of Moral Sentiments*. In the third part, he treated at more length of that branch of morality which relates to justice, and which, being susceptible of precise and accurate rules, is for that reason capable of a full and particular explanation.

"Upon this subject he followed the plan that seems to be suggested by Montesquieu; endeavouring to trace the gradual progress of jurisprudence, both public and private, from the rudest to the most refined ages, and to point out the effects of those arts which contribute to subsistence, and to the accumulation of property, in producing corresponding improvements or alterations in law and government. This important branch of his labours he also intended to give to the public; but his intention, which is mentioned in the conclusion of the *Theory of Moral Sentiments*, he did not live to fulfil.

"In the last part of his lectures he examined those political regulations which are founded, not upon the principle of *justice*, but that of *expediency*, and which are calculated to increase the riches, the power, and the prosperity of a state. Under this view, he considered the political institutions relating to commerce, to finances, to ecclesiastical and military establishments. What he delivered on these subjects contained the substance of the work he afterwards published under the title of *An Inquiry into the Nature and Causes of the Wealth of Nations*.

"There was no situation in which the abilities of Dr Smith appeared to greater advantage than as a professor. In delivering his lectures, he trusted almost entirely to extemporary elocution. His manner, though not graceful, was plain and unaffected; and, as he seemed to be always interested in the subject, he never failed to interest his hearers. Each discourse consisted commonly of several

[1] It is perhaps unnecessary to observe, that these remarks apply only to the state of education at Oxford at the period when it was attended by Smith. Latterly it has been very much improved, though the constitution of the university opposes formidable obstacles to the introduction of the best system.

[2] This gentleman, a younger son of Sir James Johnstone, Bart. of Westerhall, assumed the name of Pulteney on his marrying the Countess of Bath, the heiress to the property and honours of the famous parliamentary leader, Pulteney, first earl of Bath. He founded, in 1790, the chair of agriculture in the University of Edinburgh, and endowed it with a salary of L.50 a year.

[3] A work overrated when it first appeared, and now too much neglected.

distinct propositions, which he successfully endeavoured to prove and illustrate. These propositions, when announced in general terms, had, from their extent, not unfrequently something of the air of a paradox. In his attempts to explain them, he often appeared, at first, not to be sufficiently possessed of the subject, and spoke with some hesitation. As he advanced, however, the matter seemed to crowd upon him, his manner became warm and animated, and his expression easy and fluent. In points susceptible of controversy, you could easily discern that he secretly conceived an opposition to his opinions, and that he was led upon this account to support them with greater energy and vehemence. By the fulness and variety of his illustrations, the subject gradually swelled in his hands, and acquired a dimension which, without a tedious repetition of the same views, was calculated to seize the attention of his audience, and to afford them pleasure, as well as instruction, in following the same object through all the diversity of shades and aspects in which it was presented, and afterwards in tracing it backwards to that original proposition or general truth from which this beautiful train of speculation had proceeded.

"His reputation as a professor was accordingly raised very high, and a multitude of students from a great distance resorted to the university merely upon his account. Those branches of science which he taught became fashionable at this place, and his opinions were the chief topics of discussion in clubs and literary societies. Even the small peculiarities in his pronunciation or manner of speaking became frequently the objects of imitation."

Smith made his debût as an author, by contributing, anonymously, two articles to the *Edinburgh Review*, commenced in 1755, of which two numbers only were published. The first of these articles is a review of Johnson's *Dictionary*, and the second a letter to the editor, containing some observations on the literature of the different European countries. The latter is worth notice as evincing the attention paid by Smith to continental literature at a period when it was comparatively neglected in Scotland.

In 1759 Smith published his *Theory of Moral Sentiments*. He had been engaged for a very considerable period in the composition of this work, which is finished throughout with the greatest care. It is bottomed on the principle that *sympathy* forms the real foundation of morals; that we do not immediately approve or disapprove of an action on becoming acquainted with the intention of the agent and the consequences of what he has done, but that we previously enter, by means of that sympathetic affection which is natural to us, into the feelings of the agent and those to whom the action relates; that, having considered all the motives and passions by which the agent was actuated, we pronounce with respect to the *propriety* or *impropriety* of the action, according as we sympathise or not with him; while we pronounce, with respect to the *merit* or *demerit* of the action, according as we sympathise with the gratitude or resentment of those who were its objects, and that we necessarily judge of our own conduct by comparing it with such maxims and rules as we have deduced from observations previously made on the conduct of others.

"Whatever judgment," says Smith, "we form with respect to our own motives and actions, must always bear some secret reference either to what are, or to what, upon a certain condition, would be, or to what we imagine ought to be, the judgment of others. We endeavour to examine our own conduct as we imagine any other fair and impartial spectator would examine it. If, upon placing ourselves in his situation, we thoroughly enter into all the passions and motives which influenced it, we approve of it by sympathy with the approbation of this supposed equitable judge. If otherwise, we enter into his disapprobation, and condemn it."[1]

Several, and, as it is now generally admitted, some unanswerable objections have been urged against this very ingenious theory.[2] But whatever opinion may be entertained with regard to the truth of the leading principle which it involves, the *Theory of Moral Sentiments* is incomparably the best, or rather it is the only great ethical work in the English language. It everywhere evinces great ingenuity, subtilty, and depth of thought. These, however, are the least of its excellences. Its conclusions are all practical, just, and true. The different passions, affections, and characters of the different classes of men, are delineated with singular fidelity. What is proper and praiseworthy in them is carefully discriminated from what is improper and blameworthy. The disturbing influences of fortune and of custom over our estimates of merit and demerit are skilfully appreciated; and the soundest maxims for the regulation of our conduct under every variety of circumstances are everywhere met with, and set in so clear a light that they are impressed even on the most careless readers. The style unaffected, copious, and, though sometimes redundant, always eloquent, is worthy of the subject. The richness of its colouring relieves the dryness of some of the more abstract discussions, while it gives additional force and embellishment to the powerful recommendations of generous, upright, and virtuous conduct, which are profusely scattered throughout the work, and are obviously the author's favourite topics.

The accounts which Smith has given in his last volume of the principal systems of moral philosophy are infinitely superior to anything of the kind that had previously appeared; and are said by an excellent judge, M. Cousin,[3] to be imbued with the true spirit of philosophical history. The account of the "Stoical Philosophy" deserves especial notice. It is a beautiful exposition of a difficult subject, and is as correct in its statements as it is felicitous in its language.

It may be worth while, perhaps, to observe, that Dr Gillies has affirmed, in a note to his translation of Aristotle's ethics and politics,[4] that Smith was indebted for the principle of his theory to a statement of Polybius, in his *General History* (Book vi., ex. 1). But though the passage referred to be a remarkable one, it is doubtful whether it ever attracted the notice of Smith; and though it had, there is an immeasurable difference between a brief statement, or hint, like that in question, and the well digested system expounded in the *Theory of Moral Sentiments*. The principle of sympathy had, indeed, been always well known, not to Polybius only, but to everybody. It was remarked nearly two thousand years ago:—

> "Ut ridentibus arrident, ita flentibus adflent,
> Humani vultus: Si vis me flere, dolendum est,
> Primum ipsi tibi; tunc tua me infortunia lædent."
> HOR. *Ars Poetica*, l. 101.

Smith's peculiar merit does not lie in his having made sympathy the keystone of his system, for that is its cardinal defect, but it lies, as Stewart has justly stated, in his having availed himself of that principle to give a systematical view of all the principal doctrines and discussions embraced in the science of ethics, and in the beauty of his illustrations.

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1 *Theory of Moral Sentiments*, part iii., chap. 1.

2 Brown's *Lectures*, iv., pp. 77–116, edit. 1824; Stewart's *Active and Moral Powers*, i., pp. 308–316, and note C; Mackintosh *On the Progress of Ethical Philosophy*, by Whewell, pp. 232–242; *Cousin Cours de l'Histoire de la Philosophie Moderne*, iv., pp. 192–278, ed. 1846; *Dictionnaire des Sciences Philosophiques*, vi., p. 661, art. "Smith," &c.

3 *Cours de l'Histoire de la Philosophie Moderne*, iv., 249, ed. 1846.

4 Third edition, i., 302.

And considered in this point of view, the *Theory of Moral Sentiments* is a highly original work.

Having published the substance of so important a part of his lectures, Smith was enabled to make considerable retrenchments from the ethical part of his course, and to give a proportional extension to the disquisitions on jurisprudence and political economy. He had long been in the habit of embodying the results of his studies and investigations with respect to both these departments of political science, but particularly the latter, in his lectures. And it appears from a statement which he drew up in 1755, to vindicate his claims to certain political and literary opinions, that he had been in the habit of teaching from the time he obtained a chair in the University of Glasgow, and even when at Edinburgh, the same enlarged and liberal doctrines with respect to the freedom of industry, and the injurious influence of restraints and regulations, which he afterwards so fully established in the *Wealth of Nations*. His residence in a large commercial and manufacturing city, like Glasgow, gave him a considerable advantage in the prosecution of his favourite studies, by affording means of easily obtaining that correct practical information on many points, which cannot be found in books, and by enabling him to compare his theoretical doctrines with the experimental conclusions of his mercantile friends. Notwithstanding the alleged disinclination of men of business to listen to speculative opinions, and the opposition of his leading principles to the old maxims of trade, he was able, before leaving the university, to rank some eminent merchants among his proselytes.

The publication of the *Theory of Moral Sentiments* brought a vast accession of reputation to Smith; and placed him, in the estimation of all who were qualified to form an opinion on such a subject, in the first rank of moralists and of able and eloquent writers.

In 1762 the Senatus Academicus of the University of Glasgow unanimously conferred on him the honorary degree of Doctor of Laws,[1] in testimony, as it is expressed in the minutes of the meeting, of their respect for his universally acknowledged talents, and of the advantage that had resulted to the university from the ability with which he had for many years expounded the principles of jurisprudence. But the most important effect of his increasing celebrity, in so far at least as respected himself, was his receiving in 1763 an invitation from Mr Charles Townshend, who had married the widow of the Earl of Dalkeith, to attend her ladyship's son, the young Duke of Buccleuch, on his travels; and the advantageous terms that were offered, combined with his strong desire to visit the Continent, induced him to accept the offer, and to resign his chair at Glasgow. "With the connection which he was led to form in consequence of this change in his situation," says Stewart, "he had reason to be satisfied in an uncommon degree, and he always spoke of it with pleasure and gratitude. To the public it was not perhaps a change equally fortunate; as it interrupted that studious leisure for which nature seems to have destined him, and in which alone he could have hoped to accomplish those literary projects which had flattered the ambition of his youthful genius."

Smith set out for France in company with his noble pupil in March 1764. They remained only a few days at Paris on their first visit to that capital, but proceeded to Toulouse, where they continued for about eighteen months. This being a considerable city, and at that time the seat of a parliament, the society in it may be presumed to have been a good deal superior to that of most country towns; and Smith no doubt availed himself of it, and of the leisure he then enjoyed, to perfect and extend his knowledge of the literature, internal policy, and state of France. He has told us that he was not disposed to place much confidence in the facts and reasonings of political arithmeticians; and it is evident from his rarely making statements on the authority of others, and from his occasionally referring to circumstances connected with Toulouse, Geneva, and other places which he visited, that he was chiefly indebted to his own observation and inquiries for his extensive information in regard to the institutions, habits, and condition of the French people.[2]

After leaving Toulouse, Smith and his noble pupil proceeded to Geneva, where they resided two months. They returned to Paris at Christmas, 1765, and remained there for nearly a year. During the whole of this period, Smith lived on an intimate footing with the best society in that city, to which his friendship with Hume greatly facilitated his introduction. Turgot, afterwards comptroller-general of finance, D'Alembert, Helvetius, Marmontel, the Abbé Morellet,[3] the Duke of la Rochefoucault, Count Sarsfield, Buffon, the Baron D'Holbach, Madame Riccoboni, Mademoiselle de L'Espinasse, &c., were of the number of his acquaintances; and some of them he continued ever after to reckon among his friends. He was also on familiar terms with Quesnay, the author of the economical theory; and there is every reason to think that he derived considerable advantage from his intercourse with that able and excellent person, than whom none was better qualified to strike out original and ingenious views. So sensible, indeed, was Smith of his merits as a man and a philosopher, that he intended, had he not been prevented by Quesnay's death, to have left a lasting testimony of the high place which he held in his estimation by dedicating to him the *Wealth of Nations*.

In October 1766, the Duke of Buccleuch, accompanied by Smith, returned to London. The latter soon after removed to his old residence at Kirkcaldy, where he remained, with little interruption, for about ten years, habitually occupied in study, and in the elaboration of his great work. This, however, was not a task but a labour of love, *labor ipse voluptas*. In a letter to Hume, written in 1767, he says, "My business here is study, in which I have been deeply engaged for about a month past. My amusements are, long and solitary walks by the sea-side. You may judge how I spend my time. I feel myself, however, extremely happy, comfortable, and contented. I never was, perhaps, more so in my life. You will give me great comfort by

[1] Smith did not assume this distinction in private life, but contented himself with printing it on the titles of his works. He had, in truth, little or no respect for academical honours, which he has characterised in very depreciatory terms.

[2] It has always appeared to us as a singular and not easily explained fact, that notwithstanding their familiar acquaintance with the state of France, we do not find either in Hume or Smith any anticipation, how faint soever, of the tremendous convulsion of which that country was, at no distant period, the theatre. And yet it had given numerous, and those not obscure, indications of its approach. It is curious, that what had thus escaped the observation of the two most eminent philosophers of the age should have been clearly discerned and pointed out by Smollett. See his *Travels*, ii., p. 197, ed. 1766.

[3] The paragraph which follows is extracted from the *Mémoires* of the Abbé Morellet, published in 1821. "J'avais connu Smith dans un voyage qu'il avait fait en France, vers 1762; il parlait fort mal notre langue; mais sa *Théorie des Sentimens Moraux*, publiée en 1759, m'avait donné une grande idée de sa sagacité et de sa profondeur. Et véritablement je le regarde encore aujourd'hui comme un des hommes qui a fait les observations et les analyses les plus complètes dans toutes les questions qu'il a traitées. M. Turgot, qui aimait ainsi que moi la métaphysique, estimait beaucoup son talent. Nous le vîmes plusieurs fois; il fut présenté chez Helvétius: nous parlâmes théorie commerciale, banque, credit public, et de plusieurs points du grand ouvrage qu'il méditait. Il me fit présent d'un fort joli portefeuille anglais de poche, qui était à son usage, et dont je me suis servi vingt ans." (Tome i., p. 237.)

writing to me now and then, and letting me know what is passing among my friends in London." And so, with a few short intervals, he went on, till, in 1776, an æra that will be for ever memorable in the history of political philosophy, the *Inquiry into the Nature and Causes of the Wealth of Nations* was given to the world. We have elsewhere examined most part of the leading theories and conclusions advanced in this famous work. (See Introduction to Article POLITICAL ECONOMY.) At present, it is enough to observe, that despite its imperfections in a scientific point of view, the objections that have been made, and not without justice, to its arrangement, and the many changes that have taken place since its publication in the policy and condition of nations, its celebrity is in no degree diminished. It is not in truth a book for one country or one age, but for all countries and all ages; and will always be regarded as a noble monument of profound thinking, various learning, and persevering research, applied to purposes of the highest interest and importance.

Little needs be said in regard to the originality of the theories advanced by Smith. We have shown, in the article referred to, that some of the most important doctrines embodied in the *Wealth of Nations*, had been distinctly announced, and that traces, more or less faint, of the remainder may be found in various works published previously to its appearance. But this has little or nothing to do with the peculiar merits of Smith; and in no respect invalidates his claim to be considered as the real founder of the science of political economy. Some of its *disjecta membra* had, indeed, been discovered, with indications of the others. But their importance, whether in a practical or scientific point of view, and their dependence on each other, were all but wholly unknown. They formed an undigested mass, without order or any sort of rational connection; what was sound and true being frequently (as in the theory of the economists) closely linked to what was false and contradictory Smith was the enchanter who educed order out of this chaos—

"E tenebris tantis tam clarum extollere lumen
Qui primus potuisti, inlustrans commoda vitæ."

And in such complicated and difficult subjects, a higher degree of merit belongs to the party who first establishes the truth of a new doctrine, and traces its consequences and limitations, than to him who may previously have stumbled upon it by accident. and dismissed it as if it were valueless. He did not, like the greater number of his predecessors, build his conclusions on metaphysical abstractions, or on the partial and distorted statements of interested or prejudiced parties, but on a careful review and analysis of the more prominent circumstances connected with the progress of society from antiquity down to his own times. And none will be surprised that, in taking, for the first time, so wide a survey, he sometimes overlooked a principle, or was deceived in regard to its influence or operation, and that, in consequence, some parts of his book are defective or erroneous. This, however, is but rarely the case. He had none of that impetuous rashness which, while it satisfies itself with hasty and superficial investigations, pushes with unhesitating confidence every theory, however narrow or ill-founded, to an extreme. On the contrary, he was slow and circumspect. And without seeking to establish new doctrines, was influenced by a sincere desire to trace and discover the natural and sound principles of public economy, however obscured by sophistry or encumbered by error, and to exhibit what he believed would be found to be their practical working, if allowed to come into free operation. In pursuing his laborious inquiries, his caution and his unequalled sagacity never forsook him. And the real wonder is, that a work involving so many abstruse researches and conflicting considerations as that of Smith, should have so few blemishes, and be so nearly perfect as we find it to be. It contains a greater number of useful and readily available truths than are to be found in any other publication; and it pointed out and smoothed the path by following which subsequent inquirers have been able to perfect much which its author left incomplete, to rectify the mistakes into which he fell, and to make many new and important discoveries. Whether, indeed, we refer to the soundness of its leading doctrines, the liberality and universal applicability of its practical conclusions, or the powerful and beneficial influence it has had on the progress of economical science, and on the policy and conduct of nations, the *Wealth of Nations* must be placed in the foremost rank of those works which have helped to liberalise, enlighten, and enrich mankind.

By showing that the real and lasting interests of nations are always best promoted by cultivating a fair and friendly intercourse with their neighbours, and that the jealousies and fears that were formerly entertained of the advance of others in wealth and civilisation, are as unfounded as they are malevolent and base, the *Wealth of Nations* has contributed, in no ordinary degree, to weaken national antipathies, and to lessen the chances of war. Its influence in this respect has been well illustrated by Mr Buckle, who does not hesitate to affirm, that "Adam Smith contributed more, by the publication of this single work, towards the happiness of man, than has been effected by the united abilities of all the statesmen and legislators of whom history has preserved an authentic account."[1]

Hume, who was then labouring under his last illness, addressed a congratulatory letter to Smith on the publication of the *Wealth of Nations*. And it is a curious fact, that he pointed out in that letter what is the principal defect of the work, viz., the erroneous view which it gives of the nature and causes of rent. He says, "I cannot think that the rent of farms makes any part of the price of produce." It is not known whether Hume had directly arrived at this conclusion, or had derived it at second hand, from the writings or conversation of Dr Anderson,[2] by whom it had been already established. But it is singular, seeing that his attention had been directed to the subject by one he so greatly esteemed, that Smith did not submit his statements in regard to rent to a more searching and careful analysis. Had he done this, he would most probably have adopted the views of Anderson and Hume, and materially improved his work.[3]

Smith survived the publication of the *Wealth of Nations* fifteen years. He had the satisfaction to see it translated into all the languages of Europe; to hear his opinions quoted in the House of Commons; to be consulted by the minister; and to observe that the principles he had expounded

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[1] *History of Civilization*, vol. i., p. 197, 2d ed. The following characteristic eulogy of Smith proceeds from a very high quarter, but one whence, perhaps, it would hardly be expected. "By the bye, the excise instructions you mentioned were not in the bundle, but 'tis no matter. Marshall in his Yorkshire and particularly that extraordinary man, Smith, in his *Wealth of Nations*, find my leisure employment enough. I could not have given any mere *man* credit for half the intelligence Mr Smith discovers in his book. I would covet much to have his ideas respecting the present state of some quarters of the world that are, or have been, the scenes of considerable revolutions since his book was written." (Letter of Robert Burns to Mr Graham of Fintry, 13th May 1789, in the Supplement to the 4th volume (p. 329) of Chambers' *Life of Burns*.)

[2] See a notice of Anderson, and of his *Exposition of the Theory of Rent*, in the art. POLITICAL ECONOMY.

[3] In the copy of the letter now referred to, given by Stewart in his *Life of Smith*, the important paragraph relating to rent is omitted. Another paragraph is also omitted, in which Hume expressed his belief that the statement in regard to the seignorage charged on coins in France was not well founded. And in that case too he was quite right.

were beginning to produce a material change in the public opinion, and in the councils of this and other countries. And he must have enjoyed the full conviction that the progress of events would ensure their ultimate triumph, by showing that they were productive of signal advantage, not only to the general mass of mankind, but to the inhabitants of every country which should have good sense enough to adopt them.

Hume died soon after the *Wealth of Nations* made its appearance. Smith, with whom he had lived on the most intimate terms, was most solicitous in his attentions to his illustrious friend during his illness; and gave an interesting account of the circumstances connected with his death, and a sketch of his character, in a letter addressed to Mr Strahan, of London, which was soon after published as a supplement to Hume's autobiography. In it he says that he considered that his deceased friend "had approached as nearly to the idea of a perfectly wise and virtuous man, as, perhaps, the nature of human frailty will permit." This unqualified eulogium having given offence to many who dissented from Hume's opinions in regard to religion, was much found fault with. Dr Horne, bishop of Norwich, the most distinguished of those by whom it was censured, attacked Smith, in an anonymous pamphlet, with considerable asperity; and unwarrantably ascribed to him, for he had no sure grounds to go upon, the same sceptical tenets that had been entertained by Hume.[1] But he took no notice of this effusion; and wisely declined entering upon a controversy which could have no useful result.[2]

Smith resided principally in London during the two years immediately subsequent to the publication of the *Wealth of Nations*, enjoying the society of some of the most distinguished persons in the metropolis. In his conversation, though never in his writings, his judgments of men and things were often precipitate, dogmatical, and erroneous. But he was always ready, on being better informed, to review and amend his inconsiderate decisions.[3] And his friends, while they not unfrequently dissented from his opinions, were pleased with his straightforwardness, want of pretension, and intellectual ability.

In 1778 he was appointed, through the spontaneous application of his old pupil and friend, the Duke of Buccleuch, a commissioner of customs for Scotland.[4] In consequence, he removed to Edinburgh, where he continued afterwards to reside, possessed of an income more than equal to his wants, and in the society of his most esteemed friends. He was accompanied to his new residence by his mother, then in extreme old age, and by his cousin, Miss Douglas, who superintended the domestic arrangements and economy of his family.

But though highly creditable to the nobleman by whose intervention it was procured, his appointment to the customs[5] was little in harmony with the tastes of Smith, while it seriously interrupted or terminated those pursuits in which he might have continued to render invaluable services. The philosopher who had, for the first time, fully explored and laid open the true sources of national wealth and prosperity, deserved a different if not a higher reward. There were thousands of persons who could have performed the duties of a commissioner of customs quite as well as Smith, or perhaps better; but there was not one, besides himself, who could give that "account of the general principles of law and government, and of the different revolutions they have undergone in the different ages and periods of society,"[6] which it was his intention to give. And he would most probably have fulfilled this intention had not the well-earned bounty of the public been clogged by the performance of petty routine duties which engrossed the greater part of his time, and left him little or no leisure for study.

Smith paid several visits to London after his appointment to the customs. And we are told by Mr Paterson that on the last of these occasions he dined at Wimbledon with Mr Dundas, afterwards Lord Melville, and that Mr Pitt, Lord Grenville, and Mr Addington were of the party. Smith happening to come late, the company had already sat down to dinner. On his entering the room, they stood up; and when he begged of them to be seated, they answered, "No, we must stand till you are seated, for we are your scholars!" This was a flattering compliment; and in so far true, that the distinguished guests, Mr Pitt and Lord Grenville, were really what they professed to be, pupils of Smith.

We may, perhaps, be permitted farther to observe, that in the matter now referred to, or in his general, though not very intimate acquaintance with economical subjects, Mr Pitt had a material advantage over his great rival, Mr Fox. The latter admitted that he had never read the *Wealth of Nations*, and that "there was something in those subjects which passed his comprehension."[7] But, however well-founded it might be, no parliamentary leader would now venture to make such a confession. To his ignorance of the sound principles of national intercourse, we may, perhaps, mainly ascribe the determined opposition made by Fox to Pitt's proposals for modifying and in part rescinding the restrictions, which a jealous and short-sighted policy

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1 Had the bishop looked ever so cursorily into the *Theory of Moral Sentiments*, he would have seen that there was a material difference between Smith's theological opinions and those of Hume.

2 It has been stated over and over again, and among other places, in an article in the *Quarterly Review*, written by Sir Walter Scott, and in the *Edinburgh Review*, in an article by Jeffrey (vol. lxxiii., p. 51), that having met in Glasgow, Dr Johnson attacked Smith in the most outrageous manner for having written this notice of Hume, and that Smith retorted in terms no less rude and offensive. But though apparently well vouched, it is certain that no such unphilosophical *rencontre* did, or in fact could take place; and for this plain reason, that Johnson visited Glasgow in 1773, and that Hume did not die till 1776. Johnson and Smith did meet in London, and did not, to use Johnson's phrase, "take to each other;" but there is not a vestige of ground for supposing that any scene similar to that referred to above ever took place between them. See further Boswell's *Life of Johnson*, by Croker, 1 vol. 8vo, p. 393, &c.

3 Robertson calls them "prompt and vigorous." See Gibbon's *Miscellaneous Works*, vol. ii., p. 255, 8vo ed.

4 On receiving this appointment, Smith expressed his wish to resign the annuity of L.300 a year which had been settled upon him by the Duke's trustees at the time when he resigned his professorship to accompany his grace on his travels. But it is hardly necessary to add that this offer was at once declined, and that Smith continued to enjoy the annuity till his death. We are indebted for this fact and for others to the notice of Smith in Kay's *Collection of Portraits*, edited by Mr James Paterson. It is, like the rest of the work, carefully compiled, and contains authentic information not to be elsewhere met with.

5 Lord Brougham, in his *Life of Smith*, is extremely indignant at this proceeding, which he seems to regard in nearly the same light with the making of Burns an exciseman at a salary of L.70 a year! But however unsuitable to his tastes and talents, it is absurd to compare this recognition of Smith's services with the mean occupation and beggarly pittance awarded to Burns. The learned lord says that such a thing as Smith's appointment could not happen again; but this is by no means clear, at least if he mean that nothing so paltry will be again offered to any distinguished individual. When he censured Lord North's government for having made Smith a commissioner of customs, his lordship might have recollected that he had himself been a conspicuous member of a government which took no notice of Malthus, and rewarded the lengthened and faithful services, the various learning, and splendid talents of Mackintosh, by a seat at a board from which he might be dismissed at any moment, and where he had neither influence nor consideration.

6 See the concluding paragraph of the *Theory of Moral Sentiments*.

7 Butler's *Reminiscences*, vol. i., p. 173.

had imposed on the trade with Ireland, and to the comparatively liberal commercial treaty negotiated with France in 1786. But there can be no doubt that party considerations had also a good deal to do with these discreditable displays. The reader will not be surprised to learn that this conduct on the part of Fox greatly lessened the high estimation in which he had been previously held by Smith.

In 1787 Smith was elected Lord Rector of the University of Glasgow. On this occasion he addressed a letter to that learned body, which strikingly evinces the high sense he felt of this honour, and his regard for those from whom it emanated. "No perferment," says he, "could have given me so much real satisfaction. No man can owe greater obligations to a society than I do to the University of Glasgow. They educated me; they sent me to Oxford. Soon after my return to Scotland, they elected me one of their own members; and afterwards preferred me to another office, to which the abilities and virtues of the never-to-be-forgotten Dr Hutcheson had given a superior degree of illustration. The period of thirteen years, which I spent as a member of that society, I remember as by far the most useful, and therefore as by far the happiest and most honourable, period of my life; and now, after three-and-twenty years' absence, to be remembered in so very agreeable a manner by my old friends and protectors, gives me a heart-felt joy which I cannot easily express to you.'

His constitution, which had at no time been robust, began early to give way; and his decline was accelerated by the grief which he felt on account of the death of his mother, in 1784, and of Miss Douglas, in 1788. He survived the latter only about two years, having died on the 17th July 1790. His last illness, which was occasioned by a chronic obstruction of the bowels, was both tedious and painful. He bore it with the greatest fortitude; and had all the consolation that could be derived from the attention of his friends, and from their sympathy and that of his fellow-citizens.

In a letter written by Mr Smellie, to a friend in London, about three weeks before Smith's death, we find the following statement:—"Poor Smith! We must soon lose him; and the moment in which he departs will give a heartfelt pang to thousands. His spirits are flat, and I am afraid the exertions he sometimes makes to please his friends do him no good. His intellects, as well as his senses, are clear and distinct. He wishes to be cheerful, but Nature is omnipotent. His body is extremely emaciated, because his stomach cannot admit of sufficient nourishment; but, like a man, he is perfectly patient and resigned."[1]

Smith was no speculative moralist, no pseudo-liberal, no eulogist of virtues which he failed to practise. He had the utmost contempt, which he never hesitated to express in the most decided manner, for whatever was insincere, mean, or malignant. His integrity and truthfulness were unimpeached and unimpeachable. Unsuspecting and warm in his affections, he was most anxious, on all occasions, to promote the interests of his friends; and his generosity was limited only by his means. He was in the habit of allotting a considerable part of his income to offices of secret charity. Stewart mentions that he had been made acquainted with some very affecting instances of his beneficence. "They were all," he observes, "on a scale much beyond what might have been expected from his fortune; and were accompanied with circumstances equally honourable to the delicacy of his feelings and the liberality of his heart." This was no doubt the cause that the property which he left at his death was not such as might have been expected from his income, and the moderate, though gentlemanlike, scale of his household expenditure.

Smith was deeply versed in the history and philosophy of antiquity. His acquaintance with English, French, and Italian literature was, also, intimate and critical; and it might be said of him, as it was said of his countryman Buchanan, that he was *omni liberali eruditione non leviter tinctus, sed penitus imbutus.* He had a strong relish for the beauties of poetry, Homer, Virgil, Tasso, and Ariosto, being among his chief favourites. But his studies and speculations were directed more to what was useful and important, than to what was elegant and entertaining. And he looked with a scrutinising eye into the history of the rise, progress, and decline of nations, and of the revolutions of art, science, and taste, that he might thence deduce the principles and practical results embodied in his works. He never separated the *honestum* from the *utile.* And his principles and theories were valuable only in his estimation as they contributed to promote the freedom, the virtue, and the wellbeing of mankind.

He acquired an extensive,[2] well-selected, and valuable collection of books, which he prized very highly, in most departments of philosophy, literature, and science. It was bequeathed, along with his other property, to his cousin, David Douglas, Esq., who eventually became a judge of the Court of Session in Scotland, under the courtesy title of Lord Reston. At the death of the latter, the library was equally divided between his two daughters and co-heiresses, and is still in their possession.[3]

Notwithstanding the apparent flow and artlessness of his style, and his great experience in composition, Smith stated, not long before his death, that he continued to compose as slowly, and with as great difficulty, as at first. He did not write with his own hand, but generally walked up and down his apartment, dictating to an amanuensis,[4] a habit which may in part, perhaps, account for that repetition and diffuseness of style which is so observable in both his works, but especially in the *Wealth of Nations.* He regarded the works of Middleton as affording the best specimens of English composition; and he was accustomed to recommend the careful study of his *Life of Cicero* to all who wished to write easily, perspicuously, and in correct English.

The want of notes, and the fewness of references to authorities, may be mentioned as a peculiarity of Smith's writings; and one in which they differ very widely from those of his contemporaries, Hume and Robertson, especially the latter. Stewart says, that "Smith considered every species of note as a blemish or imperfection, indicating either an idle accumulation of superfluous particulars, or a want of skill and comprehension in the general design."[5] Although, however, it must be admitted that Robertson in his Histories of Charles V. and America, has embodied in notes a large amount of interesting matter which might have been advantageously incorporated with the text, Smith has cer-

[1] Letter, 27th June 1790; Kerr's *Life of Smellie*, p. 205.

[2] Probably about 5000 volumes.

[3] Smellie, in his account of Smith, says, "The first time I happened to be in his library, observing me looking at the books with some degree of curiosity, and perhaps surprise, for most of the volumes were elegantly, and some of them superbly bound, 'You must have remarked,' said he, 'that *I am a beau in nothing but my books.*'" (Smellie's *Lives*, p. 296.) We have seen the books, and we doubt whether their condition warrants the account given of them by Smellie. They seem to have been neatly, and in some instances elegantly bound; but we saw few or none of which the binding could, with much propriety, be said to have been superb. But, independently of their condition, they are a most interesting collection; and it were much to be wished that they were preserved entire in some public institution.

[4] Stewart states that all Hume's works were written with his own hand; and that the last volumes of his *History* were printed from the original copy, with only a few marginal corrections.

[5] *Account of the Life and Writings of Robertson*, p. 142.

tainly carried the opposite practice to an extreme. It is impossible, indeed, to lay down any precise rules on a subject of this sort, or to say positively when notes or references had better be made or omitted. But their total or nearly total omission seems to be quite as objectionable as their excess. At all events, there does not appear to be much room for doubting that the arrangement of the *Wealth of Nations* would have gained materially in clearness and simplicity, had the author adopted, in part at least, the plan of Robertson, and thrown some of the numerous digressions by which the thread of the investigation is interrupted into the form of notes or supplementary chapters. And there are many occasions when a reference to the facts or authorities on which an argument is founded would have given it additional strength, and been satisfactory to the reader.

Smith had early resolved that such only of his manuscripts as were, in his own estimation, fit for publication should ever see the light. And the resolution to which he had thus unfortunately come was carried into effect a few days before his death, when all his papers were committed to the flames, excepting parts of essays, intended to illustrate the principles that lead and direct philosophical inquiries, which he left to his friends to publish or not as they thought proper. The contents of the manuscripts that were destroyed are not exactly known; but they certainly comprised the course of lectures on rhetoric and belles lettres delivered at Edinburgh in 1748, and the lectures on jurisprudence and natural religion, which formed a most important part of the course of moral philosophy delivered at Glasgow. The loss of the latter must ever be a subject of deep regret, and is, in truth, one of the most serious which philosophy has to deplore. We are ignorant of the motives which determined Smith to enforce their destruction. Stewart surmises that it was not so much on account of any apprehended injury to his literary reputation from the publication of such unfinished works, as from an anxiety lest the progress of truth should be retarded by the statement of doctrines of which the proofs were not fully developed; but this is doubtful.

The following observations on the private character and habits of Smith proceed from the pen of Dugald Stewart, who knew him well, and who was the last survivor of that galaxy of illustrious men who shed, during the latter portion of last century, so imperishable a glory over the literature of Scotland. "The more delicate and characteristical features of his mind," Stewart observes, "it is perhaps impossible to trace. That there were many peculiarities, both in his manners and in his intellectual habits, was manifest to the most superficial observer; but although, to those who knew him, these peculiarities detracted nothing from the respect which his abilities commanded; and, although to his intimate friends they added an inexpressible charm to his conversation, while they displayed, in the most interesting light, the artless simplicity of his heart, yet it would require a very skilful pencil to present them to the public eye. He was certainly not fitted for the general commerce of the world, or for the business of active life. The comprehensive speculations with which he had been occupied from his youth, and the variety of materials which his own invention continually supplied to his thoughts, rendered him habitually inattentive to familiar objects, and to common occurrences; and he frequently exhibited instances of absence, which had scarcely been surpassed by the fancy of La Bruyere.[1] Even in company he was apt to be engrossed with his studies; and appeared at times, by the motion of his lips, as well as by his looks and gestures, to be in the fervour of composition. I have often, however, been struck, at the distance of years, with his accurate memory of the most trifling particulars; and am inclined to believe, from this and some other circumstances, that he possessed a power, not perhaps uncommon among absent men, of recollecting, in consequence of subsequent efforts of reflection, many occurrences which, at the time when they happened, did not seem to have sensibly attracted his notice.

"To the defect now mentioned it was probably owing, in part, that he did not fall in easily with the common dialogue of conversation, and that he was somewhat apt to convey his own ideas in the form of a lecture. When he did so, however, it never proceeded from a wish to engross the discourse, or to gratify his vanity. His own inclination disposed him so strongly to enjoy in silence the gaiety of those around him, that his friends were often led to concert little schemes, in order to engage him in the discussions most likely to interest him. Nor do I think I shall be accused of going too far when I say, that he was scarcely ever known to start a new topic himself, or to appear unprepared upon those topics that were introduced by others. Indeed, his conversation was never more amusing than when he gave a loose to his genius upon the very few branches of knowledge of which he only possessed the outlines.[2]

"The opinions he formed of men, upon slight acquaintance, were frequently erroneous; but the tendency of his nature inclined him much more to blind partiality than to ill-founded prejudice. The enlarged views of human affairs, on which his mind habitually dwelt, left him neither time nor inclination to study, in detail, the uninteresting peculiarities of ordinary characters; and accordingly, though intimately acquainted with the capacities of the intellect and the workings of the heart, and accustomed in his theories to mark, with the most delicate hand, the nicest shades, both of genius and of the passions, yet, in judging of individuals, it sometimes happened that his estimates were, in a surprising degree, wide of the truth.

"The opinions, too, which in the thoughtlessness and confidence of his social hours he was accustomed to hazard on books, and on questions of speculation, were not uniformly such as might have been expected from the superiority of his understanding, and the singular consistency of his philosophical principles. They were liable to be influenced by accidental circumstances, and by the humour of the moment; and, when retailed by those who only saw him occasionally, suggested false and contradictory ideas of his real sentiments. On these, however, as on most other occasions, there was always much truth, as well as ingenuity in his remarks; and if the different opinions which, at different times, he pronounced upon the same subject had been all combined together, so as to modify and limit

[1] Some instances of this sort, and of his peculiarities in other respects, have been specified in an article in the *Quarterly Review*; but of these some have been shown to be quite apocryphal (*ante*, p. 342), and they are all too evidently caricatured to warrant any confidence being placed in them.

[2] According to Boswell, Smith once told Sir Joshua Reynolds "that he made it a rule, when in company, never to talk of what he understood." (*Boswell's Johnson*, by Croker, 8vo, p. 662.) But, if ever made, this must have been a mere jocular assertion, and doubtless was so understood by Reynolds. Boswell, however, takes it in its literal sense, and explains it by saying that it proceeded from Smith having "book-making much in his thoughts," and being "chary of what might be turned to account in that way." But though sufficiently characteristic of Boswell, nothing can be more opposed than this statement to all that is known of Smith. It may be safely affirmed that no great author ever less deserved to be twitted with book-making than he did. And the notion that his conversation was influenced by a regard to his prospective interests in that rather humble occupation, is so inexpressibly mean and absurd, that one is surprised at its having occurred even to Boswell.

each other, they would probably have afforded materials for a decision, equally comprehensive and just. But, in the society of his friends, he had no disposition to form those qualified conclusions that we admire in his writings; and he generally contented himself with a bold and masterly sketch of the object, from the first point of view in which his temper or his fancy presented it. Something of the same kind might be remarked when he attempted, in the flow of his spirits, to delineate those characters which, from long intimacy, he might have been supposed to understand thoroughly. The picture was always lively and expressive, and commonly bore a strong and amusing resemblance to the original, when viewed under one particular aspect; but seldom, perhaps, conveyed a just and complete conception of it in all its dimensions and proportions. In a word, it was the fault of his unpremeditated judgment to be too systematical and too much in extremes.

"But, in whatever way these trifling peculiarities in his manners may be explained, there can be no doubt that they were intimately connected with the genuine artlessness of his mind. In this amiable quality he often recalled to his friends the accounts that were given of good La Fontaine; a quality which in him derived a peculiar grace from the singularity of its combination with those powers of reason and of eloquence, which, in his political and moral writings, have long engaged the admiration of Europe.

"In his external form and appearance there was nothing uncommon. When perfectly at ease, and when warmed with conversation, his gestures were animated, and not ungraceful; and, in the society of those he loved, his features were often brightened with a smile of inexpressible benignity. In the company of strangers his tendency to absence, and perhaps still more his consciousness of this tendency, rendered his manner somewhat embarrassed—an effect which was probably not a little heightened by those speculative ideas of propriety which his recluse habits tended at once to perfect in his conception, and to diminish his power of realising. He never sat for his picture; but the medallion of Tassie conveys an exact idea of his profile, and of the general expression of his countenance."[1]

Thus far Stewart. Smellie says, "In his deportment, when walking, there were some singularities. His head had a gentle motion from side to side; and his body, at every step, had a kind of rolling or vermicular motion, as if he meant to alter his direction, or even to turn back. In the street, or elsewhere, he always carried his cane on his shoulder as a soldier does his musket. These may be considered as slight shades, but, in a picture, slight shades are often highly characteristic." (*Lives*, p. 296.)

We may further add, that Smith was about the middle size, well made, and stout, though not fat or corpulent. His countenance, which was manly and agreeable, inclined more to the Saxon than the Celtic caste, and was well lighted up by his large, expressive, grey eyes. His disposition was social in the extreme, especially in his own house, and in the company of his early friends. His Sunday suppers were long celebrated in Edinburgh circles.

The following is a list of the published works of Smith:—

1. Two articles in the *Edinburgh Review* for 1755, being (1) a Review of "Johnson's English Dictionary;" and (2) "A Letter to the Editors."

2. *Theory of Moral Sentiments.* The first edition of this work was published in 8vo, early in 1759. The sixth edition was published a short time before the author's death. It contains several additions, most of which were executed during his last illness.

3. *Considerations concerning the first Formation of Languages, and the different Genius of Original and Compounded Languages.*

This essay was originally subjoined to the first edition of the *Moral Sentiments.* It is an ingenious and pretty successful attempt to explain the formation and progress of language, by means of that species of investigation to which Dugald Stewart has given the appropriate name of *Theoretical* or *Conjectural History;* and which consists in endeavouring to trace the progress and vicissitudes of any art or science, partly from such historical facts as have reference to it, and, where facts are wanting, from inferences derived from considering what would be the most natural and probable conduct of mankind under the circumstances supposed.

4. *An Inquiry into the Nature and Causes of the Wealth of Nations.* The first edition was published at London in 1776, in two volumes 4to. The fourth edition, which was the last published by the author, appeared, in three vols. 8vo, in 1786.

5. His posthumous works, or those which he exempted from the general destruction of his manuscripts, and which were published by his friends, Doctors Black and Hutton. These gentlemen, in an advertisement prefixed to the publication, state that, when the papers which Dr Smith had left in their hands were examined, "the greater number appeared to be parts of a plan he had once formed for giving a connected history of the liberal sciences and elegant arts." "It is long," they add, "since he found it necessary to abandon that plan, as far too extensive; and these parts of it lay beside him neglected until his death. The reader will find in them that happy connection, that full and accurate expression, and that clear illustration, which are conspicuous in the rest of his works; and though it is difficult to add much to the great fame he so justly acquired by his other writings, these will be read with satisfaction and pleasure." The papers in question comprise:—I. Fragments of a great work "On the Principles which lead and direct Philosophical Inquiries, illustrated—(1) by the History of Astronomy; (2) by the History of the Ancient Physics; and (3) by the History of the Ancient Logics and Metaphysics." II. An essay entitled, "Of the Nature of that Imitation which takes place in what are called the Imitative Arts." III. A short tract, "Of the Affinity between certain English and Italian Verses." IV. A disquisition, "Of the External Senses."

Of the historical dissertations, the first only, on the *History of Astronomy,* seems to be nearly complete. They are all written on the plan of the dissertation on the *Formation of Languages,* being partly theoretical, and partly founded on fact. In the essay on the *History of Astronomy,* after premising some speculations with respect to the effects of unexpectedness and surprise, and of wonder and novelty, the author proceeds to give a brief outline of the different astronomical systems, from the earliest ages down to that of Newton.

The fragments that remain of the other two historical essays are much less complete, and do not possess the interest of the latter.

Smith contends, in the essay on the *Imitative Arts,* that the pleasure derived from them depends principally upon the difficulty of the imitation, or, as he has expressed it, "upon our wonder at seeing an object of one kind represent so well an object of a very different kind, and upon our admiration of the art which surmounts so happily that disparity which nature had established between them." On this principle he explained the preference so generally

[1] Along with the medallion referred to, Tassie executed for Smith medallions of his friends—Dr Black, the chemist, Dr Hutton, the geologist, Dr Reid of Glasgow, and Mr Lumisden, probably the author of the valuable work on the Antiquities of Rome. These interesting relics are now in the possession of Dr Bannerman.

given in tragedy to blank verse over prose; and Stewart mentions that, for the same reason, he was inclined to prefer rhyme in tragedy to blank verse, and that he extended the same principle to comedy;[1] and even went so far as to regret that the graphic delineations of real life and manners, exhibited on the English stage, had not been subjected to the fetters of rhyme, and executed in the manner of the French. But these conclusions were entirely consistent with his general views as to taste in composition. He was a firm adherent of the classical school. The principal tragedies of Corneille, Racine, and Voltaire, the comedies of Moliere, and the verses of Boileau, Pope, and Gray, had, in his estimation, reached the highest degree of excellence.

The short essay, *Of the Affinity between certain English and Italian Verses*, is curious rather than valuable. It however, illustrates the variety of the author's literary pursuits.

The disquisition with respect to the *External Senses* is of considerable extent; and is a valuable contribution to the science of which it treats. (J. R. M.)

Smith, *Edmund*, or Neale, for such was his father's name, an English poet, who gained some reputation in Dr Johnson's time for the elegance of his poetic genius, was born at Handley, in Westmoreland, in 1668. He was educated at Westminster and Oxford, where he took his degree of M.A. on the 8th of July 1696. Giving high promise both at school and college of his future eminence, his friends watched his progress with the liveliest interest. As so frequently happens with young men of genius, he got into irregular habits, and pestered the authorities of his college by his tavern brawls and general riotous behaviour. The Oxford dignitaries showed great forbearance to the young scapegrace, but without effect. In his life of Smith, Dr Johnson has recorded that he was silently expelled on December 20, 1705; but a writer in the *Gentleman's Magazine*, for September 1822, contradicts this statement. At all events he came shortly afterwards to London, where he was favourably introduced to the theatre by Addison and Prior. His drama of *Phædra and Hippolitus* was acted for the first time on the 21st of April 1707, but while it pleased the critics with the fine elegance of its classical mythology, the public, for whose amusement it was designed, unfortunately thought little, and cared less, for the beauties of mere classical allusion, and it was allowed to fall into oblivion before it had been enacted four times. Smith was too proud, or too indolent, or too shy to ensure its success by the regular band of applauders, and he found, to his mortification, that it was incapable of standing by its naked excellence. His Oxford ode on the death of Pocock, the orientalist, was reckoned, by Dr Johnson, the best lyrical composition of any that had appeared among modern writers. "Captain Rag," for such was the name he bore at Oxford, continued to please his friends by his varied knowledge and by the brilliancy of his conversation; but continued also to disgust them by the depth of his potations. It was said of Smith's friend, Phillips, the poet, "that he was never good company till he was drunk;" but it was said of Smith himself, that he was never good company "but while he was sober." He was, however, in his lucid moments a ready and exact critic, who had the faculty of seeing into the merits or demerits of a production at a glance. His casual censures or praises dropped in conversation, were, like those of the elder Scaliger, thought worthy of preservation by his friends. He had a great opinion of his own merits, and like most vain men, he did not escape the scorn and contempt of those who were much his inferiors. He died in the month of July 1710, of too large a doze of medicine, which he had taken in boastful contempt of the cautions of the apothecary. He was buried at Hartham, in Wiltshire. Oldisworth has left a highly laudatory notice of Smith, and Dr Johnson has assigned him a niche in his gallery of the poets.

Smith, *Sir James Edward*, the purchaser of the collections and library of Linnæus, and the founder of the Linnæan Society, was born at Norwich, on the 2d December 1759. His father was a man of cultivated mind, and being in prosperous circumstances was capable of affording his son an excellent education. Young Smith early inherited the taste for flowers peculiar to natives of Norwich, supposed to have been introduced into the place by the Flemish weavers who took refuge in England from the tyranny of the Spaniards. He proceeded to Edinburgh in 1781, where he obtained the gold medal for the best botanical collection. Accidentally hearing that Linnæus's collection was to be disposed of, he prevailed upon his father to advance the sum of L.1088, 5s., which made him the possessor of that splendid museum. Smith settled in London, with the intention of practising his profession. He subsequently made a tour on the continent, obtained an M.D. at Leyden, and published the result of his travels on his return to London. In 1788 he founded the Linnæan Society, and was chosen its first president. In 1792 he was employed to teach botany to Queen Charlotte and the Princesses; in 1796 he removed to Norwich; and in 1814 he was knighted as institutor and president of the Linnæan Society. The most popular of his works are his *English Botany*, in 36 vols., 1792–1807; *Biographical Memoirs of several Norwich Botanists*, 1803; *Flora Britannica*, 3 vols., 1800–1804; the *English Flora*, 4 vols.; *Flora Græca*, from Dr Sibthorpe's Materials, 1808; and *Floræ Græcæ Prodromus*, 1808. He was likewise author of the botanical articles and of the botanical biography in Rees's *Cyclopædia*, from the letter C. (See his *Memoir* by his widow, 2 vols., 1833.)

Smith, *James* and *Horace*, the authors of the *Rejected Addresses*, were the sons of Robert Smith, Solicitor to the Board of Ordnance. James was born in London, on the 10th of February 1775, and Horace was born in the same place, on the 31st December 1779. James Smith was educated under the Rev. Mr Burford, at Chigwell in Essex, was articled to his father on completing his education, was subsequently taken into partnership with him, and ultimately succeeded to his father's business. Horace, after receiving a similar education, became a stockbroker, acquired a fortune, and retired to Brighton. James, who lived and died single, was the author of several pieces in prose and verse, entirely of a comical description, which were collected after his death by his brother, and published under the title of *Memoirs, Letters, and Comic Miscellanies*, 2 vols., 1840. Besides contributing to various periodicals, he likewise wrote many of the amusing trifles for the "At Home" of the elder Mathews, and that comedian used to say of him, that he was the only man in London who could write good nonsense. After spending much of his time in society, for which both the Smiths were well suited, being men of fine appearance and possessing good conversational powers, he was ultimately confined to his house with gout. He died on the 24th December 1839, in the sixty-fifth year of his age.

Horace Smith contributed short pieces to various periodicals, among which may be mentioned his papers in the *New Monthly Magazine*, then edited by Campbell the poet. He was likewise author of some twenty three-volume novels,

[1] Boswell mentions, that having told Johnson how much Smith preferred rhyme to blank verse, Johnson said, "Sir, I was once in company with Smith, and we did not take to each other; but had I known that he loved rhyme as much as you tell me he does, I should have hugged him." (*Boswell's Johnson*, by Croker, p. 146.)

Smith, John Pye.

which were little known beyond the circulating libraries, if we except his *Brambletye House*, which was better received by the public. He died on the 12th of July 1849.

The work by which the brothers Smith are now best known, and by which they will long be remembered, is the *Rejected Addresses, or the New Theatrum Poetarum*, first published in 1812, and which has gone through upwards of twenty editions. The idea having been suggested by Mr Ward, secretary to the Drury Lane theatre, six weeks before the address was to be spoken, the brothers Smith eagerly set to work, and completed their delightful little volume within the required time. James supplied the imitations of Wordsworth, Southey, Coleridge, Crabbe, and Cobbett, and numbers 14, 16, 18, 19, and 20. The Byron was a joint effusion, James writing the first stanza, and Horace the remainder. Horace Smith supplied the rest of the volume. The copyright was purchased by Mr Murray, after the book had run through sixteen editions, for L.131, although he originally declined giving L.20 for it.

Smith, *John Pye*, an eminent dissenting divine, was born at Sheffield on the 25th day of May 1774. His father, John Smith, was a bookseller of some note in that town; and there is every reason to believe that young Smith was chiefly indebted for his early education to the books in his father's shop. At an early age he manifested great fondness for reading, and frequently when sent on errands he would be seen poring over a book by the roadside, sometimes even forgetting what he was sent to do. Some note-books, written between his twelfth and sixteenth year, show his reading at that early age to have been of an extensive and miscellaneous character. However objectionable this mode of education may be in general, we believe that in Smith's case it was not without its advantages. It not only gave him a taste for extensive and varied reading, but it also fostered that freedom of thought, and fearlessness in the search of truth, that afterwards specially characterised him.

It was in his sixteenth year that the doctrines of Christianity took hold on his heart, and gave that direction to his thoughts and studies that eventually led to his devoting himself to the ministry. In the first place, however, he was in 1790 apprenticed to his father, and served for five years. During this period his readings partook more of a theological character, and his writings manifest a high and growing spirit of Christianity. In 1796, while Mr James Montgomery, the proprietor and editor of the *Sheffield Iris*, was undergoing imprisonment for his alleged libel, the editorial duties of that paper were entrusted to Mr Smith, and were satisfactorily discharged by him from February to August. In September of the same year he entered the Independent Academy at Rotherham, with a view to the ministry; and at that time he is said to have been not only a superior linguist, but to have been also skilled in natural history, anatomy, and several branches of medicine. During the four years that he remained there, his active mind was not content with mastering the regular studies of the place, but likewise carried him into other departments of learning; so that among his fellow-students he was distinguished as well by the variety of his attainments as by the comparative ease with which he imbibed all kinds of useful knowledge. Such was his scholarship that, on completing his curriculum at Rotherham, he was chosen Resident Classical Tutor at Homerton College, and then was formed a connection which existed for the long period of fifty years, till Homerton was merged in New College. In 1801 he married a lady, who unfortunately was a very unsuitable companion for one of his character and circumstances, but with whose weaknesses he uncomplainingly bore for more than thirty years. It is the more necessary to mention this, as it interfered in many ways with his usefulness, depriving him of his times for study, and shutting him up from social intercourse with his students and others. It also led to his resigning his resident tutorship in 1807. In 1803 he opened the hall of the academy for public worship, and next year some of his stated hearers formed themselves into a church, and invited him to become their pastor. He was accordingly ordained on the 11th of April 1804, and retained the pastoral oversight of this congregation for almost forty-six years. Towards the close of 1810 his hearers had so increased that it became necessary to provide a larger place of worship, and accordingly they removed to the Old Gravel Pit Meeting House, and from this time Dr Smith had two regular services on Sunday, and two on week days, till the appointment of his colleague in 1846.

Smith, John Pye.

In 1804 appeared his "Letters to the Rev. Thomas Belsham (a Unitarian), on some important subjects of Theological Discussion," the first work that established his reputation, and led to his receiving, in 1807, the degree of D.D. from Yale College, Newhaven, Connecticut. On the commencement of the *Eclectic Review* Mr Smith became a contributor, and continued to furnish it with occasional articles for forty years. In 1806, a vacancy having occurred in the theological tutorship, Mr Smith was requested to occupy that chair, and a new classical tutor was appointed. In 1818 appeared the first volume of his largest work, *The Scripture Testimony to the Messiah*, the second and concluding volume of which was published in 1821. A second edition, in 3 volumes, appeared in 1829; a third in 1837; and a fourth, in 2 volumes, in 1847. The second edition was much improved and enlarged, especially by the fruits of his greatly extended researches in German literature, and each succeeding edition was enriched by the results of his continued labours. Such was the high character of this work, that though by a Dissenter, it received the high honour of being admitted as an authority in the English universities. In 1835 he received the diploma of LL.D. from Marischal College, Aberdeen. Dr Smith's other great work, *On the Relation between the Holy Scriptures and some parts of Geological Science*, appeared in 1839, being eight lectures delivered for the congregational library in that year. This work was also, by the author, carried through four editions, each greatly improved and extended, and led to his being admitted a Fellow of the Royal Society in 1840. Dr Smith was the author of a number of other works, which we have not enumerated,—as a list of them will be found appended to his *Memoirs* by Medway. In 1843, after more than ten years of widowhood, Dr Smith again married, and this time his choice fell upon one well suited to comfort and solace him in his declining years. He was now requested to again accept the office of resident tutor, which he cheerfully did, and continued to fill till the breaking up of the establishment in 1850. On retiring from active duty in last mentioned year, his friends and admirers testified their esteem for him by raising a sum of L.2600, the interest to provide an annuity for him while he lived, and afterwards to form divinity scholarships in connection with New College, which were to bear his name. The testimonial was presented to him at a public breakfast of the 8th of January 1851, and on the 5th of the succeeding month his spirit quietly left its mortal tenement, in the seventy-seventh year of his age. For nearly the whole of his public life Dr Smith was afflicted with deafness, which increased so much that at length it was only with difficulty that he could be made to receive any communications by the ear.

Dr Smith's was an active and vigorous, rather than a high cast of intellect. Its power lay more in the arranging and systematising of facts, than in the discovering or exploring of them. It had little of what is called originality, but was marked by great power of imbibing and assimilating

all kinds of knowledge. This, coupled with his great industry and singular perseverance, which continued undiminished down to near the close of his life, earned the encomium passed upon him by his colleague, Dr William Smith, that "there are few men in the present day who have embraced a greater sphere of knowledge, or mastered a greater number of subjects."

But it is in his moral and religious nature that we meet with the most distinguishing features of his character. He was eminently a sincere and true man—sincere in his beliefs, true to his convictions. However much one may be inclined to differ from him on certain points, yet no one can doubt the sincerity with which he held them. His sincerity made him ever ready to do battle for what he believed to be the truth, and not the less ready to yield whenever he saw that his opinions were untenable—never maintaining a controversy merely for the sake of argument. His sanguine nature led him to throw himself heart and soul into whatever was before him, so that what many are content to hold loosely as matters of opinion, became to him matters of belief and principles of action. His whole powers seemed to be actuated and regulated by a high moral sense of duty, so that acts seemingly the most trifling were to him matters of conscience; and even a verbal error appeared to offend his moral feelings. High as was his standard of duty, he acted up to it to a degree that is rarely to be met with. "He lived," says his biographer, "in strict conformity, both as to letter and spirit, with his rules for others," to an extent that "was often matter of surprise and admiration while he was with us." Such was the strength of this principle within him, that towards his death, when his other powers are declining, it comes into painful prominence. He had for many years abstained from spirituous liquors, holding it to be "a duty which we owe to God and to our fellow-creatures, to bear a practical testimony against this usage;" and when, a few weeks before his death, a medical friend recommended his taking a little brandy, he emphatically said "Never;" and turning to his wife, added, "My dear, I charge you, if such remedy be proposed when I am incompetent to refuse, let me die rather than swallow the liquid." His piety was an eminently active and living principle, stimulating and directing his ardent desire in the pursuit of knowledge, as well as sanctifying his whole life and conduct. He took a lively interest in politics, especially in such questions as were more immediately connected with the social interests of the nation; and he was an active supporter of the peace society. His *Memoirs*, by Mr John Medway, appeared in 1853.

SMITH, *John Thomas*, keeper of the prints and drawings in the British Museum, was the son of Nathaniel Smith, formerly a sculptor, and afterwards a printseller, who had been an early friend of the artist Nollekens, was born on the 23d of June 1766. The younger Smith was engaged in his youth in the studio of Nollekens, and afterwards became a pupil of the eminent engraver, John Keyse Sherwin. He commenced the publication of his *Antiquities of London and its Environs*, illustrated by 96 plates, in 1791, and completed it in 1800. His next work was *Remarks on Rural Scenery*, 1797, and which was illustrated by 20 etchings. His *Antiquities of Westminster* was illustrated by 246 engravings, many of them consisting of representations of objects and of curious paintings, no longer in existence. Sixty-two additional plates were published in 1809, without any letterpress, forming volume second of the *Antiquities*. In 1815 appeared his best work, the *Ancient Topography of London*. It was illustrated by 32 boldly etched plates, accompanied by descriptions of the buildings represented. Smith received his appointment at the British Museum in 1816, and next year appeared his *Vagabondiana, or Anecdotes of Mendicant Wanderers through the Streets of London*, illustrated with 30 portraits, and an introduction by Francis Douce. The last literary production of Smith was more amusing than honourable. This was a book on *Nollekens and his Times*, which was published in 1828, and though it attained to a considerable popularity, it was obviously the production of a disappointed man. Smith had been appointed an executor to Nollekens, and was mortified at not being made a legatee. He unfortunately wrote under the excitement of feeling occasioned by this circumstance, and took advantage of his intimate acquaintance with Nollekens and his affairs in dragging before the public much that was never intended for publicity. Smith had a considerable share of humour in his composition, as a small paragraph written by him in the album of his friend Upcott still testifies. "I can boast," he says, "of seven events, some of which great men would be proud of. I received a kiss, when a boy, from the beautiful Mrs Robinson; was patted on the head by Dr Johnson; have frequently held Sir Joshua Reynold's spectacles; partook of a pot of porter with an elephant; saved Lady Hamilton from falling when the melancholy news arrived of Lord Nelson's death; three times conversed with King George III.; and was shut up in a room with Mr Kean's lion." Smith died in his sixty-seventh year, on the 8th of March 1833. (See *Gentleman's Magazine* for 1833.)

SMITH, *Joseph*. See MORMONISM.

SMITH, *Sydney*, one of the wittiest and wisest churchmen which England has known during the present century, was born at Woodford, in Essex, in 1771. His father, who was a clever, sagacious man, with very odd ways, after wandering all over the world, at last settled down at Bishop's Lydiard, in Somerset. His mother was of French extraction, and Smith was accustomed to attribute not a little of his constitutional gaiety to this infusion of foreign blood. In after years, Sydney was fond of representing, in his peculiar way, that the "Smiths never had any arms, and have invariably sealed their letters with their thumbs;" and was fond of repeating the answer of Junot to the old noblesse when boasting of their ancestry, "Ah, ma foi! je n'en sais rien; moi je suis mon ancêtre." Sydney was the second of four boisterous, overbearing, intellectual young athletes, as old Smith calls them, who, according to an original view of their father's, were sent to different schools, to weed out of them the strong personal rivalry which existed at home. Robert, or "Bobus," as he was called, had the good fortune to be sent to Eton, where he established for himself that character for learning and intellectual power which so greatly distinguished him in after years; while Sydney was admitted to the foundation at Winchester. In spite of "hunger and neglect," he soon rose to be captain of the school, and to be foremost in every frolic. The Winchester boys were glad when it became the captain's turn to set out for Oxford; for "one could never get any prizes where those Smiths were." A touch of sorrow mingled with their joy, however, as they looked on that bright manly face for the last time. To have been still possessed of his gay leadership in all their mad pranks, they would gladly have foregone all the prizes. After a visit of six months to Normandy, he entered New College, Oxford, in 1780, and was chosen a fellow ten years afterwards. He had to contend with the sharp pinchings of poverty during his university career, which was perhaps better for his head than it was for his heart. At all events, he, who afterwards became one of the most social spirits in all England, lived in those days much out of society. His own inclination led him to the bar, but his father's finances had been so much drained by equipping his other sons for the world, that Sydney was prevailed upon to enter the church. With a shrug he complied with his father's wishes, although, with such shining talents as he

possessed, he would doubtless have attained a much greater pre-eminence in connection with the legal profession, than a man of his liberality would be able to gain in connection with the English Church. Smith accordingly became a curate of the Church of England, in a small village in the midst of Salisbury Plain. Of all places in the world, this was the very last for a man who, like Sydney Smith, possessed such powers of wit and conversation. Yet he contrived to show to his people, that "in the midst of worldly misery, he had the heart of a gentleman, the spirit of a Christian, and the kindness of a pastor." The squire was the only person he could speak to in the place, and he stormed his affections so completely, that in two years he appointed him tutor to his son. He accordingly bade good-bye to Nether-Avon, and, in 1797, started for Edinburgh with his young charge. The political state of the continent of Europe at that time compelled the annual tourists and others to find out some more fitting place for their sojourn, and Edinburgh was selected as the most fashionable and the most cultivated city open to Englishmen in the later years of the eighteenth century. The northern metropolis at that day presented one of the brightest galaxies of talent of any city in the world. There were Jeffrey, Horner, Playfair, Walter Scott, Dugald Stewart, Brougham, Allen, Thomas Brown, Murray, Leyden, Lord Webb Seymour, Lord Woodhouselee, Alison, Sir James Hall, and many others, whose lights are now well-nigh all gone out. Society, besides, was on the easiest and most agreeable footing in Edinburgh at the time; its inhabitants were simple, and its hospitality was of the most generous kind. Sydney Smith could hardly have happened better had he made a personal selection, than to be thrown upon the generosity and talent of Edinburgh half a century ago. The peculiarities and foibles of the Scotch struck his English eye as exceedingly ludicrous. He says, in his exaggerating way, that "it requires a surgical operation to get a joke well into a Scotch understanding." Smith must have been well skilled in that delicate art by the time he left Edinburgh, for he practised it daily, and took lessons likewise in the theory of medicine as then taught in the university. Edinburgh was at that day so much given over to metaphysics, that he says its fair citizens were accustomed to make love metaphysically. During his residence in Edinburgh he married an English lady, and set a-going with Jeffrey and Brougham the *Edinburgh Review.* "Towards the end of my residence in Edinburgh," says Smith, "Brougham, Jeffrey, and myself happened to meet in the eighth or ninth storey or flat in Buccleuch Place, the then elevated residence of Mr Jeffrey. I proposed that we should set up a *Review.* This was acceded to with acclamation; I was appointed editor, and remained long enough in Edinburgh to edit the first number of the *Review.* The motto I proposed for the *Review* was, *Tenui musam meditamur avena* (we cultivate literature on a little oatmeal); but this was too near the truth to be admitted, so we took our present grave motto from Publius Syrus, of whom none of us had, I am sure, read a single line; and so began what has since turned out to be a very important and able journal. When I left Edinburgh it fell into the stronger hands of Lord Jeffrey and Brougham, and reached the highest point of popularity and success." It is impossible here to exhibit even in the briefest manner the enormous influence of that journal in letting in the light upon crazy institutions, in sweeping away those barriers to progress which ignorance and bigotry had raised, and in promoting the general cause of toleration and philanthropy, both in literature and in politics. It is not saying too much to assert that a large share of the success which attended the early life of that adventurous publication was due to the Rev. Sydney Smith. He was always proud of his connection with it, and in those days, to be an Edinburgh Reviewer and a Churchman was judged nearly as incompatible as to be a justice of the peace and a pick-pocket in one person. Common justice and common sense were the two poles, so to speak, between which all his faculties moved. His flashing wit, his sturdy understanding, his airy fancy, his kindly benevolence, and the exuberant luxury of his talk, all found play between the springs of sense and rectitude. In his writings he seems to have had no youth. He was much too great a wit to fall into the blundering extravagance peculiar to young writers. While his articles gained in staidness and in wisdom, they lost not a spark of that brilliance which wit and sense had originally lent them. Leaving Edinburgh in 1804, he carried south with him to London perhaps the largest stock of animal spirits then possessed by any individual in England. He became an earnest and rousing preacher at the Foundling Hospital; delivered clever, witty lectures, on what he chose to call "Moral Philosophy," at the Royal Institution; became famous as a "diner out;" and more famous still as a contributor to the savage northern *Review.*

On the triumph of the Whigs in 1806, Lord Erskine presented Smith with the living of Foston-le-Clay in Yorkshire. In the summer of 1807 appeared the celebrated *Letters of Peter Plymley* on the subject of the Roman Catholics, which burst over England like a thunder-cloud. They lay on every table; they were discussed by every coterie which design or chance had brought together; their periodical publication was eagerly anticipated; the curiosity of the public had become irrepressible; but the secret of their authorship could not be cleared up. There were doubtless cultivated individuals who knew Sydney Smith who harboured secret suspicions, assured as they were that no man in England could convey so much sound sense and unanswerable argument on the vehicle of irresistible wit and pleasantry, except the obscure preacher at the Foundling Hospital. But such men were content to hold their tongues until the correspondent of "my dear Abraham" was disposed to disclose himself.

Smith having removed his family to Yorkshire, began the work of his pastorate in right earnest. The prospect of the place on his arrival was of the most forbidding character; yet the gaiety of his disposition had life and heat in it capable of warming a county. In the first place, the parsonage-house was the meanest hovel, in which there had not been a resident clergyman for 150 years, and the church bore the nearest resemblance to a barn. Add to this, that the ground was so impassable that any ordinary foot sunk in it beyond reach of recovery, and Mrs Smith actually lost her shoe on her first attempting to walk on Yorkshire soil. In the second place, his rustic flock were so unaccustomed to the sights of civilised life, that the half of the parish would turn out to witness a four-wheeled carriage, or a gentleman in a superfine coat. If such was the outside of these Yorkshire folks, one may faintly guess what sort of furniture adorned the interior of them. His attention to medicine here stood him in good stead. He preached, doctored, lectured, talked, and joked to the Yorkshiremen, till they would have laid down their lives for him. He designed, built, and completed one of the ugliest parsonage-houses that ever eye had looked on; but it had the rare advantage of being one of the most commodious houses one could choose to live in. Nothing could be plainer than his table. He never affected to be what he was not. He strove to inculcate upon his family throughout life his favourite motto, "Avoid shame, but do not seek glory; nothing so expensive as glory." He studied literally in the midst of his family; and the talking and music, that would have distracted another mind, only seemed to lend him renewed stimulus. Through love of his society the learned and the wealthy made pilgrimages to Foston-le-Clay. Among these were Sir Samuel Romilly,

Sir James Mackintosh, Lord Jeffrey, the Earl of Carlisle, Mr Horner, Lord and Lady Holland, Dr Marcet, and his distinguished brother Bobus.[1]

In 1828 Smith was promoted, by Lord Lyndhurst's patronage, to be canon of Bristol, and rector of Combe-Florey, a lovely little spot near Taunton. Amid the joy of this sudden change of prospect and of scene he had the unspeakable sorrow to lose his eldest son, Douglas, by death. He had to begin his old trade of architect over again at Combe-Florey; but with his increased experience and means, he succeeded much better in pleasing the taste of his friends than he had done before on his parsonage-house in Yorkshire. He now resigned his connection with the *Edinburgh Review*, esteeming it more becoming a dignitary of the church to attach his name to whatever he might write. Ten years afterwards he collected and published the greater part of his contributions to that periodical. His fame greatly increased after his removal to Bristol; and in 1832 he was appointed canon of St Paul's, the last preferment he was destined to receive. Writing to Lord Holland, he says, "I have entirely lost all wish to be a bishop," and dissuades him from making any friendly attempts in his favour. He would assuredly have been the wittiest bishop on record, and not one of the least wise, but a man whom his friend, Lord Macaulay, could characterize as "the greatest master of ridicule who has appeared among us since Swift," was a dangerous subject to bear the ermine of the church. He was not the approved, "grave, elderly man, full of Greek," &c., whom his lively fancy was accustomed to depict as the "real bishop."

In 1834 Lord Holland received the hand of Smith's daughter, who, in the character of Lady Holland, has, in 1855, furnished the public with so interesting a biography of her father. He now removed his residence to London, where he purchased a house in Green Street, Mayfair. There is a fine glimpse into the generous and pathetic side of Smith's nature afforded by his employment of the living of Edmonton, which he might in justice have appropriated, or given over to a relation or a friend. He writes to his wife, "I went over yesterday to the Tates at Edmonton. The family consists of three delicate daughters, an aunt, the old lady, and her son, then curate of Edmonton; the old lady was in bed. I found there a physician, an old friend of Tate's, attending them from friendship, who had come from London for that purpose. They were in daily expectation of being turned out from house and curacy. I began by inquiring the character of their servant; then turned the conversation upon their affairs, and expressed a hope the chapter might ultimately do something for them. I then said, 'It is my duty to state to you (they were all assembled) that I have given away the living of Edmonton, and have written to our chapter clerk this morning to mention the person to whom I have given it; and I must also tell you, that I am sure he will appoint his curate (a general silence and dejection). It is a very odd coincidence,' I added, 'that the gentleman I have selected is a namesake of this family; his name is Tate. Have you any relations?' 'No, we have not.' 'And, by a more singular coincidence, his name is Thomas Tate; in short, there is no use in mincing the matter, you are vicar of Edmonton.' They all burst into tears. It flung me also into a great agitation of tears, and I wept and groaned for a long time. Then I rose, and said, I thought it was very likely to end in their keeping a buggy; at which we all laughed as violently. The poor old lady, who was sleeping in a garret, because she could not bear to enter into the room lately inhabited by her husband, sent for me, and kissed me, sobbing with a thousand emotions. The charitable physician wept too. I never passed so remarkable a morning, nor was so deeply impressed with the sufferings of human life, and never felt more thoroughly the happiness of doing good" (*Life*, by Lady Holland, vol. i., p. 290). What can a man do after a king? One need not be ashamed to laugh and weep in such company. This must suffice for Smith's wisdom. Another illustration of his wit, which was as multifarious as the forms of an evening cloud, and we have done. "Some one mentioned that a young Scotchman, who had been lately in the neighbourhood, was about to marry an Irish widow, double his age, and of considerable dimensions. 'Going to marry her!' he exclaimed, bursting out laughing; 'going to marry her! impossible! you mean a part of her; he could not marry her all himself. It would be a case, not of bigamy, but trigamy; the neighbourhood or the magistrates should interfere. There is enough of her to furnish wives for a whole parish. One man marry her! it is monstrous. You might people a colony with her; or, perhaps, take your morning's walk round her, always provided there were frequent resting-places, and you were in rude health. I once was rash enough to try walking round her before breakfast, but only got half-way, and gave it up exhausted. Or you might read the riot act and disperse her; in short, you might do anything with her but marry her.'" This affords a good specimen of the spirit of subtle, fanciful exaggeration which ran through many of Smith's jokes. One may fancy what sort of an opponent he would have made had he been inclined to controversy. It is singular, however, how very few enemies his wit and sarcasm, of which he was so eminent a master, ever were the means of making him. It must be clear to every one, that nothing but the unfailing kindliness of his disposition, his generosity, his pathos, his sympathy with his fellow-men under every phasis of suffering, and under every aspect of enjoyment, could have kept him so far out of the way of error. He was subjected to no ordinary temptation in being endowed with a faculty of such singular brilliancy, and of such equivocal consequences to its possessor. Sydney Smith laid claim to no more than practical common sense; and his intellect, while very acute, was not of the most searching kind. He possessed, however, an unfailing stock of the richest and choicest language, which would flow out from the fountain of his mind as spontaneously as water from a spring. He was always intrepid in his inquiry into alleged abuses, and fearless in his exposure of all kinds of clerical misrule. His letters to the States of North America regarding the payment of old debts contracted by them, written a short time before his death, is as full of pungent satire, of gay humour, and of strong sense, as anything he wrote in his more vigorous years. He died of water in the chest, consequent upon disease of the heart, on the 22d February 1845. He was buried in the family cemetery of Kensall Green. His widow and his son inherited the greater portion of his property. His works, consisting of sermons, lectures, essays, and pamphlets, were published in 3 vols. in 1839. His *Sketches of Moral Philosophy* were republished in 1850; and there has been since published a small edition of the *Letters of Peter Plymley*, with selections from his Essays and Speeches, but without a date. (See *Memoirs of Rev. Sydney Smith*, by his daughter, Lady Holland, and Mrs Austin, 2 vols. 8vo, 1855.) (J. D—S.)

SMITH, *Sir Thomas*, was born at Walden, in Essex, in the year 1512. At fourteen he was sent to Queen's College, Cambridge, where he distinguished himself so much that he was made Henry the Eighth's scholar, together with John Cheke. He was chosen a fellow of his college in 1531, and appointed two years afterwards to read the public Greek lecture. The common mode of reading

[1] We observe, from a statement in Rogers' *Table Talk*, lately published, that Rogers was accustomed to regard Bobus Smith and Sir James Mackintosh as the most accomplished metaphysicians then in England.

Greek at that time was very faulty, the same sound being given to the letters and diphthongs, ι, η, υ, ει, οι, υι. Smith and Cheke had been for some time sensible that this pronunciation was wrong; and after a good deal of consultation and research, they agreed to introduce that mode of reading which prevails at present. Smith was lecturing on Aristotle *De Republica*, in Greek. At first he dropped a word or two at intervals in the new pronunciation, and sometimes he would stop as if he had committed a mistake, and correct himself. No notice was taken of this for two or three days; but as he repeated it more frequently, his audience began to wonder at the unusual sounds, and at last some of his friends mentioned to him what they had remarked. He owned that something was in agitation, but that it was not yet sufficiently digested to be made public. They entreated him earnestly to discover his project. He did so, and in a short time great numbers resorted to him for information. The new pronunciation was adopted with enthusiasm, and soon became universal at Cambridge. It was afterwards opposed by Bishop Gardiner, the Chancellor; but its superiority to the old mode was so visible that in a few years it spread over all England.

In 1539 he travelled into foreign countries, and studied for some time in the universities of France and Italy. At Padua he took the degree of LL.D. On his return, he was admitted *ad eundem* at Cambridge, and was appointed regius professor of the civil law. He was useful in promoting the reformation of religion as well as of learning. Having gone into the family of the Duke of Somerset the protector, during the minority of Edward the Sixth, he was employed by that nobleman in public affairs; and in 1548 he was made secretary of state, and received the honour of knighthood. While Somerset continued in office, he was sent as ambassador, first to Brussels, and afterwards to France. Upon the accession of Mary he lost all his places, but was fortunate enough to preserve the friendship of Gardiner and Bonner. He was exempted from persecution, and was allowed, probably by their influence, a pension of L.100. During Elizabeth's reign he was employed in public affairs, and was thrice sent to France in the capacity of an ambassador. He died in the year 1577.

Sir Thomas Smith was a man of excellent talents, united with solid and variegated learning. He obtained a respectable place among the scholars of the age by the publication of his epistle to the bishop of Winchester, *De recta et emendata Linguæ Græcæ Pronunciatione*, Lutetiae, 1568, 4to. The same volume includes his dialogue, *De recta et emendata Linguæ Anglicanæ Scriptione*. But the work by which he is best known, in modern times, is entitled *De Republica Anglorum: the Maner of Gouernment or policie of the Realme of England*, Lond. 1583, 4to. Of this treatise, which was translated into Latin, there are many editions.

SMITH, *William*, was known amongst geologists by the designation of "The Father of English Geology;" and familiarly amongst his acquaintances, in order to distinguish him from others of the same name, as "Stratum Smith." He will be more generally remembered as the framer and author of the first complete geological map of England and Wales, and as the discoverer of the principle of the identification of strata by their included organic remains, which has now passed into the elements of the science. He was born at Churchill, in Oxfordshire, on March 23, 1769,—the same year in which Cuvier saw the light. Deprived of his father, who was an ingenious mechanic, before he was eight years old, he depended upon his father's eldest brother, who was but little pleased with his nephew's love of collecting "pundribs" (*terebratulæ*), and "pound-stones" or "quoit-stones" (large *echinites*, frequently employed as a pound-weight by dairywomen); and had no sympathy with his propensity to carve sun-dials on the soft brown "oven-stone" of his neighbourhood. Circumstances led to his becoming a mineral surveyor and civil engineer. In the former capacity he traversed the oolitic lands of Oxfordshire and Gloucestershire, the lias clays and red marls of Warwickshire, and other districts of geological interest; in all of which he noticed the varieties of strata and soils. In 1791 he surveyed an estate in Somersetshire, and walked to it, and far round it, to observe the strata. In 1793 he executed the surveys and completed the levellings for the line of a proposed canal, in the course of which he confirmed a previous supposition, that the strata lying above the coal were not horizontal, but inclined in one direction—to the eastward—so as to terminate successively at the surface, and to resemble, on a large scale, the ordinary disposition of the slices of bread and butter on a breakfast plate—an illustration to which he was frequently accustomed to resort in all societies and on all occasions.

On being appointed engineer to the Somerset Coal Canal in 1794, he was deputed to make a tour of observation with relation to inland navigation. During this tour, which occupied nearly two months, and extended over 900 miles, he carefully examined the geological structure of the country passed over, and corroborated his preconceived generalization of a settled order of succession in the several strata, a continuity of range at the surface, and a general declination eastward. Five years subsequently he prepared a tabular view of the "Order of the Strata, and their imbedded Organic Remains, in the neighbourhood of Bath, examined and proved prior to 1799." From this period up to 1812, he was engaged in completing and arranging the data for his large *Geological Map of England and Wales, with part of Scotland*, and he now commenced this publication. In 1815 the entire map was published, and was contained in fifteen large sheets, engraved on a scale of 5 miles to 1 inch. Its size was 8 feet 9 inches high, by 6 feet 2 inches wide. When this map is regarded as the result of the nearly unassisted labours of one man, not favoured by education or special tuition, it must ever remain as a signal proof of what genius and perseverance can accomplish, even although it may now be in a great measure superseded. The large map was reduced to one of an elementary form and size in 1819; and from this date to 1822 separate county geological maps were prepared by Mr Smith, and published in successive years; the whole constituting "A New Geological Atlas of England and Wales; on which are delineated by colours the Courses and Width of the Strata, which occasions the varieties of soil; calculated to elucidate the Agriculture of each County, and to shew the situation of the best materials for Building, making of Roads, the constructing of Canals, and pointing out those places where Coal and other valuable materials are likely to be found." This series included an excellent four-sheet map of Yorkshire.

It was in January 1831 that the Geological Society of London, by their Council, resolved unanimously to confer on Mr Smith the first Wollaston Medal. At the meeting of the British Association, held in Oxford, June 1832, the above medal was put into Mr Smith's possession; and the writer well remembers the simple and almost boyish glee with which the receiver exhibited his medal to every one with whom he came into contact, exclaiming many times in a morning, "Have you seen my medal?" and then producing it A fuller and more substantial honour was conferred upon him by the Government, at the united request of English geologists, in the shape of a life-pension of L.100 per annum. The last public distinction with which he was honoured was the unexpected diploma of LL.D., conferred upon him by Trinity College, Dublin, at the meeting of the British Association in that city in 1835. At such meetings he was always, if possible, present, and always heartily welcomed and honoured. To see him in an arm-

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chair near the president of the geological section was to see him in his glory. He was now in his 67th year.

In 1838 he was appointed one of the Government Commissioners engaged to examine various building-stones, and to select the best for the new Houses of Parliament. Dr Smith's previous knowledge was here of signal benefit. The last years of his life were spent at Hackness (of which he made a good geological map), near Scarborough, and in the latter town. In these places the writer frequently visited him, and was impressed with his originality, devotion to geology, simplicity of character, and self-satisfied industry in observing minute phenomena. Dr Smith accumulated great numbers of geological memoranda in loose papers, which were never published. His usually robust health failed him in 1839, and on August 28th of that year he died. He once said he was born on the oolite, and should wish to be buried on it; and so he was, at Northampton. His nephew, Professor John Phillips, has penned an interesting memoir of his uncle. Of Dr Smith we may finally remark, that he laid deep and broad the foundations upon which others are now erecting an elegant and richly-sculptured temple of science. (J. R. L.)

Definition.

SMOKE. The question is often asked, What is smoke? Dr Lardner answers, "That when coals are thrown on to a furnace a smoke will arise, which, passing into the flues over the burning coal, will be ignited,"—a definition which, as Mr Wye Williams has pointed out, would compel us to consider the gas we burn in our houses as smoke; otherwise, the word is employed for the whole of the products which rise from burning fuel; or sometimes, as when we speak of the *consumption* of smoke and the *prevention* of smoke, we mean only the visible products of combustion. At the time when the use of pit-coal became general, but before the properties of combustible gases were well understood, all visible vapours rising from heated bodies were denominated smoke; hence the terms red smoke, black smoke, and white smoke; and more recently parliamentary smoke, a term for that thin transparent smoke through which objects could be seen, and derived from a local act of parliament, compelling millowners to construct their furnaces so as to consume their smoke, or, as we should now more accurately say, prevent its production.

It will be well if for scientific purposes the meaning of the term can be restricted and defined. When a combustible undergoes ignition, its elements, separated from their original combinations, unite with oxygen, and pass off as usually invisible gases. For these new gaseous combinations, the term products of combustion is fittest. If, however, the supply of oxygen be deficient, or the temperature of combustion lowered by the presence of a colder body, the combustion will be imperfect, and a part of the combustible will pass off in a finely divided, but generally visible form. Usage has tended to the restriction of the term smoke to the visible products of imperfect combustion, or unconsumed fuel disengaged in a minutely-divided condition from a gaseous combination. We have therefore the expressions—

Combustible; for the fuel, usually free carbon, or a combination of hydrogen and carbon, or sulphur.

Supporter of combustion; oxygen.

Products of combustion; the resulting combinations of oxygen with the combustible.

Smoke; the visible product of imperfect combustion, arising from deficiency of heat or deficiency of oxygen, and is usually free carbon, liberated in the combustion of hydro-carbons, which deposits itself on coal surfaces as soot.

Ash; the inorganic residuum of some kinds of fuel.

Perfect and imperfect combustion of coal.

To take an instance, and observe the process:—With ordinary coal, the oxygen it contains passes off with a corresponding quantity of hydrogen, as water, with little or no heating effect. The free carbon burns yielding carbonic acid, which in turn, in some cases, combines with another atom of carbon, and, if there be a deficiency of oxygen, passes off without producing a due heating effect. The hydrogen of the hydro-carbons forms steam, liberating the carbon which has the less affinity for oxygen. If, however, the supply of oxygen be ample, the carbon in its nascent condition combines with it very readily, and forms invisible carbonic acid; but if the supply of oxygen be deficient, it is seized by the hydrogen, and the carbon condenses into a black cloud of smoke, which is then much less facile of combustion. Hence we speak of the prevention of smoke rather than of its combustion, because the true process is the supply of an adequate quantity of air, which, combining with the carbon in the condition in which it is most susceptible, prevents the formation of smoke. Practically, however, in furnaces this can be only imperfectly attained, and after admitting as nearly as possible a due quantity of air in the most effective manner, we must be content to consume it by double furnaces and similar means, so far as that is possible.

At the more early period of our history, there were few chimneys in England; but we read that in Henry VIII.'s reign most gentlemen's houses had at least one chimney. At that time pit-coal began to be used in private houses; and there is extant among the records of Elizabeth's reign, a motion to the effect, "That many dyers, brewers, smiths, and other artificers of London, having of late taken to the use of pit-coal for their fires, instead of wood, which filled the air with noxious vapour and smoke, very prejudicial to the health, especially of persons coming from the country, a law might pass to prohibit the use of such fuel (at least during the session of parliament) by those artificers." From this it will be seen what a serious nuisance smoke was then considered; and much as its abatement is desired at the present time, it is yet fortunate that the inhabitants of London got over their prejudices, and considered the advantages of pit-coal very greatly to outweigh its defects.

Legislation on the subject.

The subject of the prevention of smoke has assumed very considerable importance, from the numerous local acts by which it is now rendered compulsory upon mill-owners and others who employ furnaces; and in many of the larger towns the nuisance, if not got rid of, has been considerably lessened by legislative measures. The subject is still one of great difficulty and perplexity, to which the incredible number of patent grates and furnaces will bear testimony; and the engineering profession is not yet agreed upon the best forms for our furnaces and stoves, so as to secure the largest effect from a given quantity of fuel, and at the same time abate to the greatest extent the nuisance of smoke. The difficulties do not arise from our ignorance of the constitution of fuel, or of the laws of combustion, but from practical obstacles, such as necessarily arise from the variable production of gaseous and other volatile products, and the want of system and regularity which attends the management of a furnace. Habits of economy, and attention to a few simple rules, have not been sufficiently enforced, and it is obvious that much may yet be done in establishing and carrying out a well-organized plan of operations. If this were accomplished, and the management of steam-engine furnaces consigned to men properly trained for their respective duties, many of these difficulties would vanish, and the atmosphere of our towns become more pure, whilst the owners of mills would be compensated by the saving of fuel which such a system would secure.

Composition of fuel.

Of the various kinds of fuel and their elementary analysis, sufficient has already been said under the head IRON-MAKING, and elsewhere. For our present purpose very accurate analysis is not essential, the following values of those constituents of fuel which contribute to the heating effect will be sufficient:—

Smoke.

	Percentage by weight of Carbon.	Hydrogen.[1]
Charcoal	87·0	2·0
Lignite	63·0	1·0
Peat	60·0	2·5
Coal, average of 36 samples from Wales	83·7	4·3
„ „ 18 „ Newcastle	82·1	4·6
„ „ 28 „ Lancashire	77·9	4·1
„ „ 8 „ Scotland	78·5	4·4
„ „ 7 „ Derbyshire	79·7	3·6
„ Anthracite	91·5	3·2

To find from this table the quantity of oxygen necessary for the combustion of 1 lb. of each kind of fuel, we must remember that each equivalent of hydrogen requires one of oxygen; oxygen is eight times as heavy as hydrogen, and therefore one pound of hydrogen will require eight of oxygen. Similarly each pound of carbon will require $1\frac{1}{3}$ lb. of oxygen for its conversion into carbonic oxide, and $2\frac{2}{3}$ for its conversion into carbonic acid.

Oxygen and air necessary for combustion.

Hence we get for the quantities of oxygen and corresponding weight of air required for the combustion of 1 lb. of each of the above fuel:—

Description.	Pounds of Oxygen to 1 lb. of fuel.	Pounds of air to 1 lb. of fuel.	Cubic feet of air to 1 lb. of fuel, at 60° F.
Charcoal	2·48	11·16	145·8
Lignite	1·76	7·92	103·4
Peat	1·80	8·10	105·8
Coal, Welsh	2·57	11·56	151·0
„ Newcastle	2.55	11·47	149·8
„ Lancashire	2·08	9·36	122·3
„ Scotch	2·09	9·40	122·8
„ Derbyshire	2·41	10·84	141·6
Anthracite	2·69	12·10	158·0
Coke	2·40	10·80	141·1

Hence we may consider that 12 pounds or 150 cubic feet of atmospheric air are on the average required for the combustion of each pound of fuel. In practice, however, we cannot expect the whole of the entering air to be so economised, and it is necessary to admit from $1\frac{1}{2}$ to 2 or more times the theoretical quantity of air necessary for combustion, and although the proportions have not been accurately ascertained, a larger surplus of air is required for bituminous coal than for coke, and less with excited than with slow combustion.

Heat liberated by combustion.

All bodies in chemically combining liberate heat, as in decomposing, they absorb it. The quantity of heat liberated has generally been estimated in pounds of water raised in temperature, or more recently by Mr Rankine, Mr Thomson, and those who have developed the dynamical theory of heat, as *thermal units*, or that amount of heat necessary to raise the temperature of 1 lb. of water 1 degree Fahrenheit. The most reliable experiments appear to give the following values for the heat liberated by combustion:—

	In pounds of water heated from 32° to 212° Fahr.	In thermal units.
1 lb. hydrogen, combining with oxygen	344·6	62,032
1 „ carbon combining with one equivalent of oxygen	24·4	4,400
1 „ carbon combining with two equivalents of oxygen	80·0	14,500

Hence, from these numbers, we may determine the heat which would be liberated by the combustion of each of the previous descriptions of fuel, of which we know the chemical composition:—

Fuel.	In Pounds of water heated from 32° to 212° Fahr.	In thermal units.
1 lb. charcoal	76·49	13855
„ lignite	53·8	9755
„ peat charcoal	56·6	11250
„ coal, Welsh	81·7	14802
„ „ Newcastle	81·5	14670
„ „ Lancashire	76·4	13755
„ „ Scotch	77·9	14027
„ „ Derbyshire	76·1	13705
„ coke	72·0	12960
„ anthracite	84·2	15156

With these values we may compare the following experimental determinations on similar fuels:—

Fuel.	Pounds of water heated, from 32° to 212°	Authority.
Charcoal	68	Berthier.
„	75·7	Winkler.
Peat	18·1 to 35·0	Berthier.
Peat charcoal	40·1 to 58·9	„
Lignite	37 to 57	„
Caking-coal	53 to 72	„
Dowlais and Newcastle coal	70 to 72	„
Coke	50·3 to 65·6	„
Anthracite	70·3	„

Plans for the Prevention of Smoke in ordinary Grates.

Domestic fires.

The first and most general plan which has been proposed for the prevention of smoke in ordinary grates, for domestic purposes, is the introduction of fresh fuel below instead of above that undergoing combustion; a plan which, when carried out by suitable mechanical arrangements, is sound in principle, and advantageous in practice. In 1785 James Watt took out the earliest patent for the prevention of smoke in furnaces on this principle, but as his patent applies to boiler-furnaces, it will be recurred to hereafter.

Mr Cutler, in 1815, took out a patent for a fire-place to be supplied with fuel from below. A metal chamber below the grate is filled with fuel, which, as it burns away at the top, is supplied by raising the bottom of the fuel-box, or chamber, by a system of pullies and chains. Other patentees have sought to diminish the difficulty of raising the whole day's consumption, by introducing the fuel horizontally from behind; and a third party have sought to employ a feeding-shovel, which is filled with fuel, and then thrust under the fire along the bottom grating; in this position its contents are forced beneath the burning fuel by a piston worked through the handle.

Dr Arnott's grate.

Dr Arnott's stove, which has formed the basis of the greater number of smoke-consuming grates, is constructed on the principle of Cutler's. The fuel-box is placed immediately beneath the grate, and a movable bottom is raised when the fire is to be replenished by means of the poker used as a lever. The aperture of the chimney is contracted by brickwork, or by a metallic hood lined with tile, somewhat in the shape of an inverted funnel, and a valve or damper, with a conspicuous handle moving over a graduated plate, is placed on the throat of the chimney, that the draught may be regulated with the greatest nicety. A channel communicating with the external air is introduced under the hearth, to diffuse into the room, and about the fire, a supply of air which becomes tempered in passing through the air-channel and under the fender.

In a patent founded on Arnott's stove (Tillett, 1846), it was proposed that the fire-grate should slide back into a

[1] This column does not give the total percentage of hydrogen, but only that portion which appears to contribute to the heating effect.

Smoke.

recess, to admit a fresh supply of fuel into the box. In another (Jeakes, 1854), the very convenient modification has been adopted of making the curtain or front of the fuel-box and grate-bars to descend, instead of raising the coal. By this arrangement a fresh portion of coal is secured for combustion between the open bars, whilst some of the objections to the mechanical arrangements necessary for raising a considerable weight of coal are obviated.

Supplementary fire.

Mr Bachoffner has proposed a somewhat different plan—viz., the use of a small supplementary grate for burning coke, anthracite, or other now-bituminous fuel, and which can be raised or lowered at pleasure. The ordinary coal having been supplied to a common grate, this supplementary fire is lowered upon it, and the smoke consumed as it passes through.

Rotatory grates.

Rotatory grates have been employed in some cases, the grate being made to turn on an axis, so that on fresh fuel being supplied, the grate is inverted, and the smoke compelled to pass through the clear fire. In the earliest patent on this principle the grate was a revolving cylinder, divided longitudinally by gratings into three compartments; these were filled in succession with fresh fuel, and the grate revolved each time, so that the clear fire might be brought to the top. This plan was first patented in 1818 by Spencer, and with very slight modification, has been several times patented since. Though possessing many merits, the enclosure of the fire in a cylindrical grate creates a prejudice against its use, and the isolation of the grate would seem to prevent the conduction of the heat, and its distribution, over a large radiating metallic surface.[1]

Prevention of smoke by a downward current.

A downward current of air, instead of a supply of fuel from below, has been proposed in some patents for the prevention of smoke in fire-grates. Thus, in a patent by Mr Williamson, in 1855, the back of the fire is an open grating of iron or fire-clay, hind which is a flue communicating with the chimney. To this flue there is a perpendicular valve or register, which forms the back of the fire-place, over which is a horizontal flap or register. When the register of the flue is thrown back, the draught passes direct into the chimney; when the register is vertical, and the flue thrown open, the draught is downwards through the fire and back of the grate, into the flue behind. In this system the prejudices against a change in the form of grate are removed, and a nearly smokeless fire secured without any modification of the ordinary mode of firing. A partial alleviation of the smoke nuisance has also been secured in the plan of Mr Stevens, by deflecting the heated air rising from the grate downward, on the burning surface of the fuel.

General considerations.

In all these plans for the prevention of smoke in ordinary house-fires, it being always assumed that there is a copious supply of air, the principle is to secure a large increase of the temperature of the smoke at the point where the hydrocarbons, &c., distil from the fresh fuel so as to insure their perfect consumption as soon as formed. We have seen that the more perfect plans provide for this purpose, either (1.) a supply of fresh fuel from beneath, so that the upward draught carries the gaseous products directly through the clear burning fuel at top, with the further advantage of producing them slowly and uniformly; or (2.) a downward draught, which effects the same purpose. When these plans are conjoined with an adequate provision for the supply of air from the external atmosphere, they appear calculated to insure the almost complete prevention of smoke, with a decrease of dirt, and a great economy of fuel. That Arnott grates have sometimes failed is probably to be attributed to mismanagement or prejudice on the part of attendants, and it is beyond question that an increasing number of them are in use, with a considerable saving of fuel. They possess the further advantage of burning coal of any size, as it cakes before it is brought into use, and they remain alight almost without attention.

Plans for the Prevention of Smoke in Stationary and Marine-Boiler furnaces.

We may leave out of consideration those plans in which the smoke and products of combustion required to be forced through water, in order to dispel them, as inapplicable and founded on false principles.

Plans for the Prevention of Smoke depending upon Double Furnaces, with alternate Firing.

Double furnaces. Fairbairn's double-flued boiler.

Double furnaces for the prevention of smoke, patented by Mr Losh, were in use as early as 1815, and in various ways have been employed since. At first a diaphram or mid-feather was employed running the length of the grate-bars; and afterwards the plan of two cylindrical flues, within the same boiler, was introduced by Mr W. Fairbairn of Manchester, where a local act for the suppression of smoke has been long in operation. The boiler adopted by him is shown in figs. 1, 2, and 3, and is a mean between the Cornish single-flue and the tubular boiler. It is perfectly cylindrical, and contains two circular flues *a,a*, varying from 2 feet 6 inches to 2 feet 9 inches in diameter, extending throughout its length. Towards the front end the flues receive the grate-bars, hearth-plates, &c.; beyond these is built a brick bridge, over which the products of combustion are deflected. After passing through the boiler, the two flues unite; and after again making a circuit outside and under the boiler, pass to the chimney. These two flues enable the stoker to feed the furnaces alternately, and so maintain a more uniform generation of steam than would

Fig. 1.
Longitudinal Section.

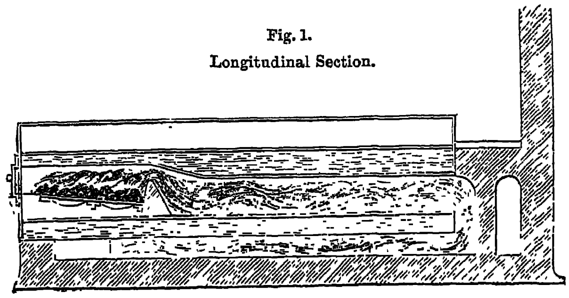
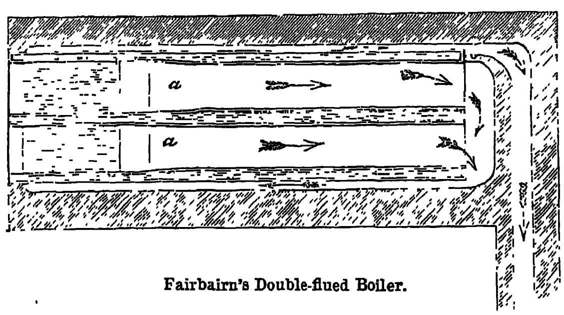


Fig. 2.
Horizontal Section.



Fairbairn's Double-flued Boiler.

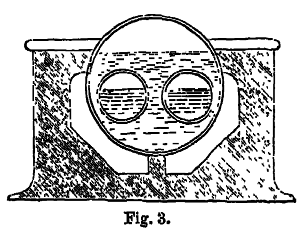


Fig. 3.
Transverse Section.

[1] The curious in this subject may compare patents 1818, No. 4316; 1825, No. 5257; 1854, Nos. 613, 1617, 1221; 1855, No. 646.

be possible with a single flue; and the flame passing from the one flue assists in the consumption of the gases generated in the other. Another form of boiler on the same principle, erected at the works of Messrs Salt of Saltaire, will be found described under the head STEAM-ENGINE.

Mr Fairbairn has long been of opinion, that this simple system of alternate firing, when conjoined with the three requisites of the generation of steam with economy, viz., plenty of capacity in the boiler, sufficient admission of air, and, what is quite as necessary, very careful and attentive stoking, will secure, without any costly apparatus, the prevention of smoke, so far as that is possible, with any given description of coal. Attempts have been made to save fuel, and effect perfect combustion, under boilers of a capacity insufficient to raise and maintain the required pressure of steam without forcing the fire. Now, it should be distinctly understood, that it is next to impossible to burn smoke, or effect perfect combustion where the fires have to be forced; the consideration of capacity should never be lost sight of in our attempts at boiler improvement, and the consequent prevention of smoke.

Armstrong's furnace.

Mr Robert Armstrong constructs what he calls the universal argand furnace upon the same principle, but by a different arrangement. The fire-bars are laid in three rows, the first next the door, horizontal; the second sloping downwards towards the third, which is horizontal, but at a lower level than the first. A double bearing bar between the first and second rows, permits a stream of air to enter the furnace at that point. In charging, a thin layer of coal is laid on next the door, and maintained in active combustion; behind and up to the bridge the coal is thrown in as thickly as possible; thus the flame from the thin stratum in front mingling with the air rushing in at the double bearing bar, acts like a torch in effecting the gaseous products distilling from the thick layer of coal behind. From time to time the ignited embers from which the flame has been expelled are raked forwards, and fresh coal is thrown on behind. Very little smoke is evolved from this species of furnace, and it differs but little in form from those ordinarily employed.

There is, however, this advantage peculiar to two furnaces combined, viz., that the air required for combustion must to some extent vary in quantity in a single furnace; we cannot determine the time at which the maximum would be required, nor that at which the minimum would be sufficient, nor what amount of surplus is necessary, but that the quantity varies according to the state of the fire, the time of feeding, and the attention of the stoker seems to be beyond question. Now, a double furnace tends to equalise the supply; the two fires fed alternately will not require a maximum or a minimum supply of air at precisely the same time, and when the two currents of gaseous products mingle, the surplus of one furnace will supply the deficiencies of the other. In this way the tendency is to compensate the supply and demand, and to prevent waste from too great or too small an admission of air.

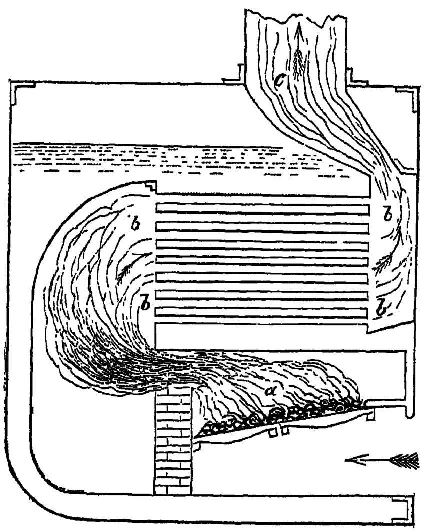


Fig. 4.

Marine boilers.

In marine boilers the system of double furnaces is to a large extent employed, and when sufficient air is admitted, and proper care and attention bestowed on the furnaces, smoke may to a large extent be prevented. Fig. 4 shows the general form of a marine tubular boiler of the ordinary construction. *a*, the furnace; *b b b b*, a series of small tubes, through which, in a finely divided state, the products of combustion pass; *c*, the uptake, in which the products of two or more furnaces mingle as they pass to the chimney.

Plans for the Prevention of Smoke depending on Mechanical contrivances for feeding the furnace and distributing the fuel.

Watt's patent.

Of this class is the earliest patent for smoke prevention, taken out by James Watt in 1785. By this plan the fire is supplied from above downwards, by a reservoir of fuel in contact with the burning mass, the combustion of which is supported by a strong lateral current of air, passing direct through the fire into a flue on the other side, aided by a slight downward current beside or through the fuel, which last descends by its own gravity as it is consumed by the fire. For the purpose of intercepting and completing the combustion of any of the gaseous products, a clear and separate fire is maintained near the entrance into the flues, so that the products of the first fire being subjected to the intense heat of the second, and mingled with atmospheric air, may be most effectually consumed.

Apart from the external reservoir, we owe to Watt the dead-plate often adopted in stationary boilers. The fire-bars and dead-plate at the furnace-doors being rather more than usually inclined, to facilitate the advance of the fuel.

The fresh coal is thrown on to the dead-plate, where it gradually cokes, the more volatile constituents distilling over, and being consumed by the bright fire beyond. The coked fuel is then pushed forwards on to the bars, and a new supply of coal introduced on the dead-plate. This plan, so far as it goes, seems right in principle and effective in practice, and where the combustion is slow and the supply of air properly proportioned, obviates as effectually as more complicated contrivances the consumption of the smoke.

The succeeding patentees of the principle of mechanical feeding as a substitute for hand-labour, have followed two different arrangements. Some have made the grate itself to carry forward the fuel, either (1.), by revolving horizontally, or (2.), by rolling forward longitudinally over fixed wheels, or (3.), by the rising and falling of the alternate bars, causing the thrusting forward of the fuel. Others have left the grate-bars stationary, and have used fans revolving either (1.) horizontally, or (2.) vertically, to distribute the fuel, or (3.) have depended in part on manual labour for that purpose.

Brunton's revolving grate.

In 1819 Brunton patented a furnace of a circular form, with a grate revolving horizontally, and having the fuel supplied from above by an external hopper. The circular grate is supported on a vertical axis, and has on its periphery a rim moving in sand, to prevent the entrance of air. The feeder is similar to the hopper of a corn-mill, excepting that the bottom is oblong; the coal falls through an opening, the width of which is adjusted by a vertical shutter, according to the size of the coal, and the supply

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is maintained by an inclined plate, to which a reciprocating motion is given by machinery. Mr Brunton proposes that the grate should revolve once in six minutes, to ensure a uniform spreading of the coal in a constantly renewed thin layer over the whole area of the grate.

In 1822, Brunton also patented what he terms the peristaltic furnace, in which the distribution of the coal is effected by the movement of the grate-bars. Each alternate bar is attached at the end next the furnace-door to an eccentric motion, by which it is raised above the level of the stationary bars, pushed forward a small distance, and then allowed to return and fall below the mean level. In this way, at every stroke the coal is shifted forwards a short distance from the door towards the bridge-end of the furnace, the bars being inclined at the rate of 1 in 7 to facilitate its progress. Near the door, the air-spaces between the bars are reduced as much as is consistent with their motion, so as to form a sort of dead-plate on which the coals may coke. The fuel is supplied at the upper end by a feeder as above.

Juckes' furnace.

Perhaps the most complete apparatus on the plan we are considering is that of Mr Juckes; but unfortunately it is, like those of Brunton, objectionable on the score of complication and liability to derangement. In this plan, as shown in fig. 5, endless chains supply the place of the ordinary

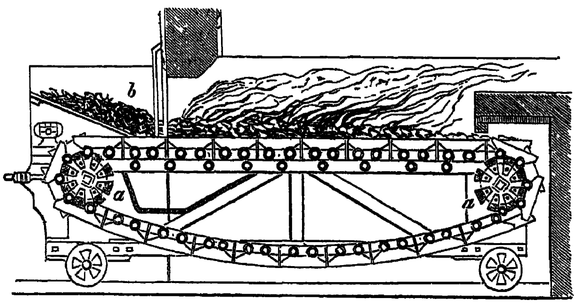

Fig. 5.
Juckes' Patent Furnace.

fire-bars, and revolve over two fixed rollers, *a a*. These rollers are kept in slow revolution, carrying the chains along with them. The coals are thrown on the inclined plate, *b*, at the mouth of the furnace, and fall gradually upon the moving grate-bar surface, on which, as they coke, they are carried along towards the back of the furnace. Thus the combustion is maintained by a slow and uniform supply of fuel, which gradually heats and parts with its gases, as it is drawn forwards through the furnace; whilst the whole of the products of combustion, after mingling with air, have to pass through the hottest part of the furnace.

Stanley's patent.

Of the plans for the distribution of the coal over stationary grate-bars by revolving fans, we may notice first that of Stanley in 1822. The coal is placed in a hopper external to the furnace, whence it falls on two fluted rollers, in passing between which it is reduced to a small size, and equalized in quantity. Below the rollers is placed a fan, with three vanes revolving vertically opposite the entrance to the furnace, and somewhat above the bars. This fan makes 200 revolutions per minute for a grate 5 feet 6 inches in length, and a greater number for a larger distance proportionally. The rollers above are worked from the fan axis by intermediate worms and wheels, so as to make but 1 revolution to 784 revolutions of the fan; hence the coal, falling in slow shower, is struck by the vanes of the fan, revolving with great rapidity, and projected forwards into the furnace, where it spreads uniformly over the surface of the burning fuel.

Stanley and Walmsley's patent.

In 1834, Stanley and Walmsley patented a plan, in which the crushed coal fell upon a horizontal revolving plate or fan projecting into the furnace, and thence was scattered over the bars by centrifugal action. At the same time the bars were intended to rock, as described above, but by a different arrangement, and a syphon tube and float were attached for regulating the feed according to the pressure of steam in the boiler. There is no doubt that the uniform distribution of the coal, in small but unintermitting quantities, over the whole surface of the fire, so far as it is secured by the above systems, must be to a large extent advantageous in the prevention of smoke and economy of fuel; but the complication and expense of the apparatus have hitherto prevented their general use, although for several years before the question of the smoke nuisance was taken up by the public, Stanley's feeding machines were extensively employed. They do appear to effect the uniform distribution of the coal more perfectly than when it is trusted to hand-labour, and where used they have permitted an inferior quality of coal to be substituted for that previously required.

Mechanical feeders for marine boilers.

Mr Bourne and other engineers look to the application of mechanical apparatus for feeding as likely to prove of signal importance in marine boilers. They suggest that, with their aid, two tiers of furnaces might be employed, and the present very reduced area of grate-bar surface in marine boilers increased, and that the feeding would be more efficiently performed, especially in stormy weather, when the difficulty and labour of stoking night and day are very considerable.

Plans for the Prevention of Smoke depending upon increased admission of air.

Under this section we have to consider a large series of plans, some of which have gained a wide notoriety, and attained a considerable measure of success in their application. The earliest plans consisted of a simple additional opening at the bridge, by which a stream of air mingled with the gaseous products when at their highest temperature. A later plan was the introduction of a large plate, pierced with holes, by which it was conceived that a greater diffusion of the air in more finely divided streams was obtained. Then the necessity of a variable instead of a constant admission of air was advocated, and plans were introduced for augmenting the supply of oxygen at the time of feeding, and slowly diminishing it afterwards. Another class of inventors have sought, not to increase the aperture for air simply, but to increase the draught by exhausting-fans, or to induce excited combustion; and some have sought to effect this more completely, and at the same time to utilise the waste heat of the chimney, by attempts to imitate the hot blast of iron-furnaces introduced by Mr Neilson.

General considerations on the admission of air.

Numerous attempts have been made to abate the nuisance of smoke by the admission of air through split bridges, or through the furnace-doors. These have been more or less successful as the boilers have been of less or greater capacity. No one plan has, however, proved its superiority so strikingly as to justify an adhesion to it rather than to any other plan; nor has any project attained such a preference in general estimation as to have secured its application in a preponderating majority of cases.

Mr C. Wye Williams, the apostle of "nature" and "the chemical point of view," was one of the earliest, as he has been one of the most pertinacious and consistent, advocates of the introduction of a large volume of ordinary cold air into the furnace; and if he has not solved all the difficulties of the subject, we have at least to thank him for the labour he has expended in proving the necessity for air as one of the prime conditions of economy in the use of fuel, and success in the prevention of smoke. Probably Mr Williams has underrated the necessity for space in the furnace, and has unduly ridiculed those plans in which the consumption of smoke is sought by an increase of its temperature; that

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is, by passing it over or amongst incandescent fuel; but it is certain that those plans, even if they effect the consumption of visible smoke, will be most wasteful of fuel if the conditions on which Mr Williams insists are not at the same time complied with. If the supply of air be deficient, a large quantity of carbonic oxide must be formed—the carbonic acid decomposing and forming, after taking up an additional atom of carbon, a double volume of carbonic oxide, and passing off invisibly. Where this takes place there must be an equivalent loss of heat, the carbonic oxide carrying off 10,100 thermal units per pound of carbon, which a sufficient supply of oxygen would have liberated.

To the impossibility of regulating the supply of air, so that, on the one hand, there may be no carbonic oxide formed, and, on the other, that no unnecessary waste of heat be occasioned by the gases passing into the chimney, is probably to be attributed the fact, that in practice much economy of fuel from smoke-burning is not generally attained, although in carefully conducted experiments as much as 20 to 30 per cent. has sometimes been saved.

Split bridges.

The earliest attempts at the introduction of an increased supply of air were by "split bridges," or openings from the external air through the bridge, behind the grate-bars. These were first used by Mr Wakefield and Mr Parkes in 1820—the former feeding thinly and carefully, and diffusing the air at the bridge by several apertures; the latter throwing in large quantities of coal next the door, the gases from which becoming intensely heated as they passed over the incandescent fuel behind, were ignited as they mingled with the air rushing in at the bridge.

Constant and variable admission.

Two different principles have guided the later patentees of methods for the admission of air. Mr Wye Williams, and those who have followed his views, have contended for a uniform supply, whatever be the condition of the furnace. Another party, of whom we may instance Mr Syme Prideaux, contend for a variable supply, greatest when the fuel is first thrown on, and lessening gradually as the coal becomes coked and burns clear. Mr Williams relies upon frequent firing, by which he thinks the needs of the furnace will be equalised and made uniform; whilst Mr Prideaux urges that, during the first violent distillation from the fresh coal, there is a need for a larger quantity of air than at any other time.

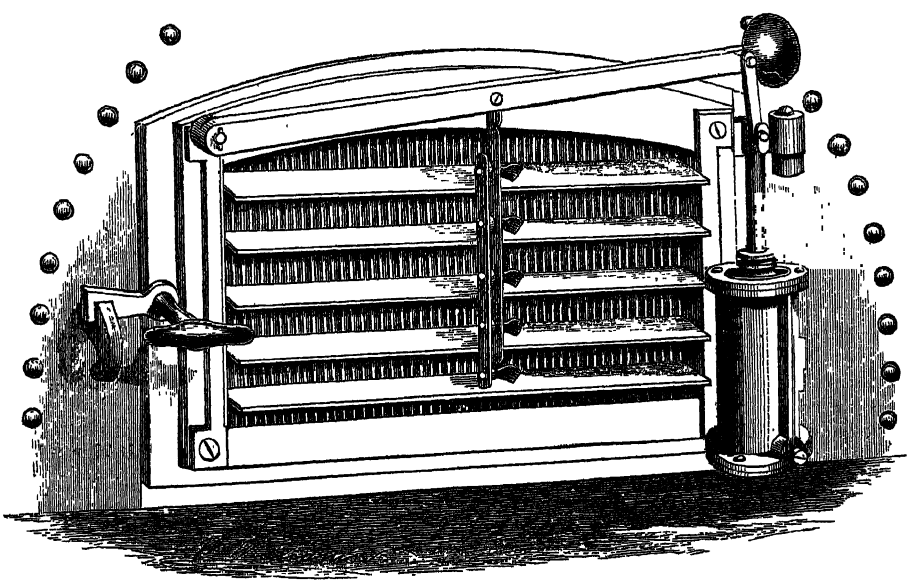

Fig. 6.

Mr Williams's diffusion plate.

Mr Williams lays the greatest possible stress upon the mechanical division of the air, by causing it to enter the furnace, not in a single stream, but through what he terms a diffusion-plate, or perforated partition. There is probably some advantage in this mode of admission, which is also adopted by Mr Prideaux, but it is probably not the whole secret of smoke prevention. When we consider the laws of the diffusion of gases, it can scarcely be credited that a thin perforated plate should divide a current of air into streams remaining separate at any considerable distance from the apertures, or make so enormous a difference in the decompositions going on in the furnace, as Mr Williams seems to contend. Nevertheless, we owe much to Mr Williams for his advocacy of a convenient mode of introducing air at the point where it is necessary for perfecting the combustion of the gases; and there is no doubt that the use of his simple perforated plate, giving a large increase of aperture for the admission of air, and placed behind the bridge, so as to supply pure air at the point where the stream of gases enters the furnace at its highest temperature, will in many cases much reduce the production of smoke, and in experimental trials has realized an important saving of fuel.

Mr Williams makes the area of aperture in the diffusion-plate equal to $\frac{1}{36}$th of the area of the grate, supposing 25 lb. of coal to be burned per square foot per hour.

Mr Prideaux's furnace-door.

Mr Syme Prideaux, who contends for a variable supply of air, constructs the door of his furnaces with metal venetians (fig. 6), which are opened by a lever when fresh coal is introduced. The other end of the lever is connected with a piston working in a cylinder, which fills with water when the piston is raised and the venetians opened. This water then slowly escapes through a small orifice, the area of which can be regulated at pleasure with the greatest nicety; and as the cylinder empties, the piston falls, and the openings in the furnace-door are closed. Thus an opening of $\frac{1}{12}$th the area of the fire-grate is provided with an arrangement by which, when fresh coal is thrown on, the whole area may be opened and a maximum supply of air allowed to pass; then, without any attention from the stoker, this surplus opening gradually closes at a regulated rate, and by the time the coal is coked the whole of the air has to pass through the furnace-bars. Mr Prideaux further provides a series of vertical plates at the back of the furnace-door, by which he thinks the air is somewhat heated before entering the furnace. Lately Mr Prideaux has adopted a mechanical arrangement somewhat different from the piston and cylinder, which is self-acting on the opening of the door. The invention in its essential features remains, however, the same.

Fan, blast, and heated air.

In 1822 and 1823 patents were taken out for applying a blast to boiler-furnaces, either for forcing air in at the bridge, or by exhausting it at the chimney.

Other inventors, as Hall in 1836 and Coad in 1835, have sought to save a portion of the waste heat, and also to prevent smoke by heating the air before it enters the furnace, in opposition to the views of Mr Wye Williams, who considers the colder air to be preferred. They effect their purpose by causing the air to enter through a series of pipes placed in the flue or chimney, and heated by the waste products of combustion. If

their plans were successful they would at least remove the principal objection which has been urged against Mr Williams's system—viz., that the cold currents which he introduces, striking against the boiler bottom, cause unequal contraction and loosen the rivets. But they have given no data for judging of the amount of heat attained by the air, which would appear to be very inconsiderable.

Système Beaufumé.

Abroad an entirely new system has been introduced, under the name, " Système Beaufumé," and is said, on good authority, to possess very great advantages, both as regards economy and entire prevention of smoke. The process has already been described under the head Iron-Making, to which process it is peculiarly applicable. The combination of the fuel takes place in a closed brick retort, surrounded by a water-chamber, supplied by a fan with a very deficient amount of air; in fact, only sufficient for the production of carbonic oxide gas, and the volatilization of the hydrocarbons. The gases thus produced are conveyed in pipes to the combustion-chamber, where, by the introduction of air, they are completely burned.

On the Prevention of Smoke in Locomotive Boilers.

The locomotive boiler requires a separate consideration, from the peculiarity of the conditions under which it generates steam, and the necessity for special modification of the contrivances for the prevention of its smoke.

The stringent enactments by which smoke upon railways has been prevented hitherto have practically operated to prevent the use of any fuel except coke, with which, in the ordinary locomotive furnace, there is no difficulty. Of late, however, the great demand for coal, and its consequent high price, together with the expense of the operation of coking, have induced several experiments to be made, with a view of employing the coal in the raw state, so as to avoid the waste necessarily attendant upon the coking process.

Mr Beattie's plan.

On the London and South Western Railway, Mr Joseph Beattie has introduced a system of combining the use of coal and coke, by means of an auxiliary fire-box or furnace. This auxiliary furnace is attached to the back of the ordinary fire-box, at a little below the level of the foot-plate, and is surrounded by a water-space similar to and communicating with the water-space of the ordinary fire-box. The flame and combustible gases thrown off by the coal pass into the coke fire-box through a series of small tubes, and, to promote combustion, they strike against and are diffused by a fire-tile curved bridge, forming a sort of combustion-chamber. The coal and coke fire-boxes are provided with separate ash-pans and close-fitting dampers, whereby the draught to each can be regulated with the greatest nicety, independently of one another. The damper to the coke fire-box is generally kept nearly closed, and is only opened about 1½ inch, with trains of 20 to 24 carriages; but the damper of the coal fire-box is generally kept quite open to admit the full draught, by which means the coal-fire being excited to the utmost, the gases and flame pass into the coke-fire, and with them air in a heated state; the high temperature of the coke-fire is maintained, and more perfect combustion is the result. The combustion of the smoke is completely effected, and a considerable economy of cost obtained. Mr Beattie combines with this plan an arrangement for heating the feed-water, so as to economize the waste heat of the exhaust-steam as it passes into the atmosphere.

Mr Jenkins's coal-burning locomotives.

Mr William Jenkins has patented a plan for the use of coal in locomotives, depending entirely upon the introduction, through a series of tubes in the fire-box, of a larger supply of air. These tubes answer as stays, and are placed on the tube-plate side, so as to admit air to the fuel above the fire-bars; the outside ends have a valve arrangement to regulate the quantity of air to be passed through them, or entirely shut it off; and in combining with these arrangements a partition of iron or other suitable material passing across the fire-box, the object of which is to prevent the air admitted through the tube-stays from passing directly to the flue-tubes of the boiler, this partition acting to cause the air admitted to mix with the combustible gases and ignite them, thus consuming the smoke. To obviate the smoke when the engine is standing, Mr Jenkins employs a steam-jet in the chimney, which can be turned on at pleasure, to supply the place of the blast from the cylinders.

Fig. 7 represents a longitudinal section of an ordinary fire-box, with Mr Jenkins's arrangements for burning coal.

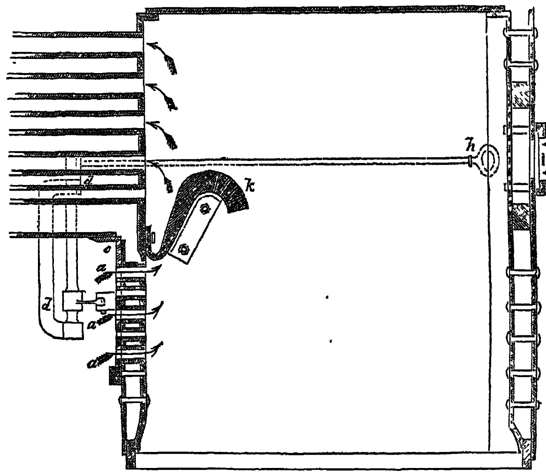

Fig. 7.

The principal apertures for air are shown at *a a a*, as arranged in rows across the tube-plate to the number of eighty or more; these apertures are formed by short tubes, which take the place of the ordinary fire-box stays. A plate *c c*, perforated with holes corresponding to those in the fire-box, is fitted on the outside, so as to slide in grooves. This plate is so arranged, that in one position it completely closes the air-apertures; but it may be drawn back by the levers *d d*, and handle indicated at *h*, and any requisite amount of opening allowed for the admission of air. The partition *k* across the fire-box is supposed to be of iron, and is perforated with holes, the purpose of which is to distribute the air admitted through the tube-stays in numerous jets, so as to secure its commingling with the combustible gases. This partition is screwed to the tube-plate, and rests at the ends or flanches secured to the sides of the fire-box. There are also somewhat similar arrangements in the fire-door *m*, by which, if necessary, an increased supply of air can be admitted.

This system is partially in use on the Great Northern Railway, on the Lancashire and Yorkshire, and on several other lines in this and foreign countries, and appears to act with great efficiency and economy. The Lancashire and Yorkshire Railway has dispensed with the use of coke altogether, at an estimated saving of L.27,000 per annum.

	lbs.
The average consumption of coke per mile run in 1856, was	33·12
The consumption of coal in 1859 was..........................	30·79
Saving..............................	2·33

showing an absolute saving in weight, apart from that arising from the expense and loss of the coking process. The plan possesses the further merit of great simplicity, and it requires no modification of the ordinary arrangements of a locomotive engine. In fact, it may be applied to old stock at an expense of L.6 or L.7 a piece.

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The following comparison of the cost of running on the Lancashire and Yorkshire Railway has been furnished me by Mr Jenkins:—

	Average Consumption per mile run.			Cost per mile run.			Price per ton.
	Goods.	Passengers.	Total.	Goods.	Passengers.	Total.	
	lb.	lb.	lb.	d.	d.	d.	s.
Month ending Sept. 17, 1857—Coke...	40·12	25·89	33·40	2·58	1·66	2·14	12
Month ending Sept. 16, 1858—Coal...	37·17	23·75	30·72	1·19	0·76	0·98	6

Mr D. K. Clark's locomotive furnace.

Mr D. K. Clark has proposed a system of coal-burning in locomotives, which does not widely differ from that of Mr Jenkins. He agrees with him in believing that a plan, to be successful, must be simple in design, facile in execution, applicable to existing stock, and easy to manage. His apparatus is external to the fire-box, and therefore not exposed to heat, and is controlled by a single stop-cock. Air is admitted above the fuel by one or more rows of tubes similar to those of Mr Jenkin's patent, inserted in the walls of the fire-box, and jets of steam are projected through the tubes from nozzles $\frac{1}{16}$th inch in diameter, in small steam-pipes, placed outside the fire-box. The jets of steam are used principally when the engine is standing, with the aid of a light draught from a ring-jet in the chimney to prevent the smoke, and they may be shut off when not required. The supply of air through the tubes may be further regulated by dampers. The grate-bars are placed close together, with narrow air-spaces, and the ash-pan and damper are tightly fitted. This system is said to be working with success on the Great North of Scotland Railway, and on the North London Railway.

On the Taff Vale Railway, Mr Tomlinson has also substituted coal for coke in the ordinary engines; the principal novelty of his plan being the introduction of a layer of broken fire-brick upon the grate-bars, to protect them from injury from the burning fuel.

It is alleged that smoke arising from domestic fires and steam-engine chimneys cannot be entirely prevented; but at least it has been shown that two-thirds of the immense volume of smoke which ordinarily pours into the atmosphere from steam-boilers may be prevented, and the atmosphere of our towns rendered much more clear and salubrious, where attempts are made to abate the nuisance. The local acts of large towns, such as Manchester, Glasgow, Liverpool, Leeds, &c., have enabled the authorities to inflict penalties on offenders of this kind, and have proved that dense smoke may be almost entirely removed with proper care and attention to the mode of firing, supply of air, &c., and that with economy in the consumption of fuel. It therefore follows that it is a duty that the owners of steam-engines should employ the proper means to relieve the public from an evil which admits of remedy.

On the River Thames, above London Bridge, the nuisance of smoke from the funnels of the small steamers became intolerable, until Lord Palmerston obtained an act to compel the working of their engines without smoke. Under this act the nuisance has been almost entirely removed; and it is to be regretted that it does not extend to the steamers below the bridge. Some persons maintain that the improvement is to be attributed to the use of Welsh smokeless coal; but, so far as the public are concerned, this question is of little moment, seeing that the evil is prevented. Be this as it may, it has been shown that the discharge of dense volumes of smoke *can be prevented.* If done once, it can be again; and, in order to abate the nuisance, the local authorities should have power to enforce a similar law in every case where it can be done without injury to individuals or to our industrial interests.

Smoke-sail || Smolensk.

Local acts for the abatement of the nuisance of smoke are not of a stringent character; the penalty seldom exceeds a fine of 40s. It is probably desirable that it should not throw any impediment in the way of our commercial or manufacturing progress, as any legal interference with the industrial interests of the community is to be deprecated and avoided. Yet, since it has been proved that a more efficient process of combustion can be secured, even in the case of bituminous coal, so as to obviate the nuisance of smoke, and, at the same time, to be a positive advantage to the consumer, there is no hardship in compelling the adoption of the requisite means for that purpose, when it will confer so great a boon on the rest of the community.

It is on this ground that we advocate the enforcement of local acts of Parliament; and we believe that they have contributed much to the comfort of the inhabitants of large manufacturing towns where steam-engines are employed, and where, in general, a reckless expenditure of fuel is indulged in, with no useful result at all, unless enveloping the surrounding district in a dense canopy of smoke is to be considered as such.

It is now many years since tall chimneys were erected for the purpose of abating this nuisance; but these erections are only to be regarded as transferring the nuisance to greater distances, where the unburned carbonaceous matter is deposited in large flakes, to the annoyance of a larger circle of inhabitants, and more serious injury to vegetable life. These are considerations of much importance to the public; and we hope that the time is not far distant when we may calculate upon a more improved system of consumption of our mineral deposits. We are bound to urge on the public the necessity of adhering to a sounder and more economical principle of action than has hitherto been generally adopted.

The reader may consult Charles Wye Williams, *On the Combustion of Coal and the Prevention of Smoke*, 1841; and *Prize Essay on the Prevention of Smoke*, 1854; T. Syme Prideaux, *Rudimentary Treatise on Fuel*, 1853; Fairbairn, *Useful Information for Engineers*, 1857; Bourne and Armstrong, *On the Modern Practice of Boiler Engineering*, 1856; *Report of Commissioners appointed to Inquire into the Warming and Ventilation of Dwellings*, 1857. (W. F.)

SMOKE-SAIL is a small sail hoisted against the foremast of a ship, when she rides head to wind, to allow the smoke of the galley to ascend, and to prevent its falling back on the quarter-deck.

SMOLENSK, a government of European Russia, lying between N. Lat. 53. 12. and 56. 30.; E. Long. 31. 50. and 36. 40.; bounded on the N. by the governments of Pskov and Twer, E. by that of Moscow, S.E. and S. by those of Kaluga, Orel, and Tchernigov, and W. by those of Mohilev and Vitebsk. Its extreme length from N. to S. is 235 miles; its breadth, 180; its area, 21,671 square miles. The surface consists generally of a lofty plain, the northern part of which is traversed by a ridge of low hills, the Volchonski forest, separating the rivers that flow into the Baltic from those that flow into the Black Sea. In other places the plain is undulating, or interrupted only by low hills. Several rivers of considerable size have their sources in this government. Among these are the Dnieper, with its affluents the Sosha and Desna, two small tributaries of the Volga, and the Ugra, an affluent of the Oka. The Düna forms the boundary between Smolensk and Pskov, and receives several small streams from the government. Smolensk contains a great number of lakes, some of considerable size, and many morasses. On account of the elevation of the land, the climate is somewhat cold, especially in the winter, when the weather is very severe, and frost continues till a late period. The temperature of the summer, on the other hand, is equally extreme, and fosters

Smolensk.

a luxuriant vegetation. The weather is regular, and the air salubrious. Extensive and valuable forests furnish the most part of the wealth of this region; and the soil is generally fertile and well cultivated. Rye is the kind of corn most extensively raised, but flax, hemp, tobacco, and hops are also cultivated. In 1849 Smolensk contained 4,962,698 acres of arable land; 612,201 of meadows; and 6,760,972 of forests. The timber of these forests is excellent, not only for fuel but also for ship-building, and especially it furnishes very fine masts. For this purpose, large quantities are conveyed to Riga. Many wild animals haunt the forests, such as bears, wolves, lynxes, wild boars, elks, deer, &c. Cattle and horses are reared in large numbers, the latter in general of the Lethuanian breed. The oxen are extensively used in agriculture, and many are also exported. There are large numbers of swine, but sheep do not thrive well. In 1849, the number of horses in the government was 478,571; of horned cattle, 549,243; of sheep, 557,129; of swine, 249,103; and of goats, 11,349. Large numbers of bees are also kept. The minerals found in the country are copper, bog-iron, and salt. The manufactures are not very numerous. Linen and woollen cloth are woven by the country people for domestic use. Besides this there are 96 manufactories in the government, employing in all 2507 hands. Of the former the most important are, 46 of leather, 17 of tallow and candles, 9 of cloth, and 8 of crystal and glass. Of more importance than the manufactures is the commerce of the government. This consists chiefly in the exportation of the produce of the country, and the importation of colonial produce, wines, and manufactured articles. Most of the articles of home produce are conveyed by land to Riga, Welna, and Moscow; large herds of cattle are also driven through Poland into Germany. The chief commercial towns in the government are Smolensk, the capital, Wiasma, and Gshatsk. The population is generally Russian, intermixed with a few Poles, Germans, and Jews; and the great majority of the inhabitants belong to the Greek Church. Smolensk is divided into twelve circles, as follows:—

	Pop. (1851.)		Pop. (1851.)
Smolensk	73,606	Sytschevka	93,535
Krasnoi	62,573	Jelnia	98,801
Dorogobusch	71,501	Bjeloi	108,586
Wiasma	78,984	Duchovschtschina	83,673
Poretchie	81,326	Juchnov	101,164
Gshatsk	116,535	Rosslavl	99,366
Total	1,069,650		

The total population of the government in 1856 amounted to 1,084,481.

SMOLENSK, the capital of the above government, on the right bank of the Dnieper, which is here crossed by a wooden bridge, 230 miles W. by S. of Moscow. It is surrounded by a strong, thick, and lofty wall, about two miles in circuit, but out of repair in some places, and is also defended by a citadel. Smolensk is one of the most ancient towns in Russia; but, as it was destroyed during the French invasion, and rebuilt since that time, it presents few marks of its high antiquity. It is now regularly laid out, and for the most part well built of stone. The public buildings are numerous, and many of them handsome. The most remarkable are two cathedrals, built in the twelfth century, one of which contains a bell weighing about 17 tons. There are numerous other Greek churches, a convent, a Roman Catholic, and a Lutheran church, several schools, and charitable institutions. Linen, leather hats, and soap are manufactured here, and an active trade is carried on. Smolensk is the see of a bishop, the seat of a military and civil governor, courts of law, and public offices. In the principal square stands a cast-iron monument to commemorate the great battle fought under the walls, August 17, 1812, in which, after being thrice repulsed, the French succeeded in entering the town. Smolensk seems to have existed as far back as the ninth century. It was for several hundred years an object of contention between the Lithuanians, Poles, and Russians; but since 1654 it has been in the possession of Russia. Pop. (1850) 10,792.

Smollett.

SMOLLETT, TOBIAS, whose writings have conferred distinguished honour upon the literature of his country, was descended from a family of considerable antiquity and opulence in the county of Dumbarton. His grandfather, Sir James Smollett of Bonhill, married a daughter of Sir Aulay Macaulay of Ardincaple, and by that lady had four sons, of whom Archibald, the youngest, was the father of the novelist. Archibald, who had been bred to no profession, died at an early age, leaving his family, consisting of a widow and three children, one of whom was an infant daughter, solely dependent on the bounty of his father. Smollett was born in 1721, in the old mansion-house of Dulquhurn, now a ruin. It is situated near the village of Renton, in the parish of Cardross. He was baptized Tobias George. The valley of the Leven, in which Smollett first saw the light, is surpassed by no other spot in our island, either for the grandeur of its scenery or for the venerable associations with which it is connected.

From the grammar-school of Dumbarton, in which he had imbibed the rudiments of classical learning, Smollett was transferred to the University of Glasgow, where he prosecuted his more advanced studies with application and success. He was afterwards bound an apprentice to Mr John Gordon, an eminent medical practitioner in that city. His elder brother James had adopted the profession of arms, an example which he was ambitious of following; but the old knight probably illustrated the advantages of the study of physic by reasoning which it would have been vain to controvert. When the young student had attained his eighteenth year, his grandfather died, without having made any adequate provision for the children of his youngest son. For this omission, his descendant furnished him with a niche in *Roderick Random*, more conspicuous than desirable.

The term of his apprenticeship having expired in his nineteenth year, and being now thrown upon his own resources, Smollett proceeded to London, where he attracted the notice of Lord Lyttelton. He had carried with him his tragedy of *The Regicide*, a juvenile performance of some merit, but indifferently adapted to the purpose of representation. The various efforts which he ineffectually used to bring his play upon the stage are detailed with indignant prolixity in the preface to that production, which he sent to the press some years afterwards, with a view of heaping confusion upon the lukewarm patronage of Lyttelton, and upon the evasions of Garrick. The patron and the manager were visited with many other tokens of his displeasure; but he lived to repent of the severe retribution which he had exacted for trivial wrongs, and made honourable mention of both in his *History of England*.

Thwarted in his expectations of earning fame and profit as a writer for the stage, Smollett was glad to accept the situation of surgeon's mate on board the Cumberland. That vessel, an 80-gun ship, belonged to the armament which was bound to the West Indies, to join the fleet under the command of Admiral Vernon. Of the disastrous expedition against Carthagena Smollett inserted an animated narrative in *Roderick Random*, and afterwards published a more detailed account in the *Compendium of Voyages*. When the discomfited squadrons returned to Jamaica, he quitted the service in disgust, and fixed his residence on the island. With Miss Lascelles, a fascinating West Indian, he there formed an acquaintance, which afterwards ripened into a matrimonial union. In 1746 he returned to London, which then resounded with acclamations occasioned by the victory at Culloden. With these were mingled some

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expressions of indignation at the atrocities inflicted by the royal army upon the helpless families of the insurgents. The voice of Smollett swelled the weaker cry, and he produced his pathetic ode, *The Tears of Scotland.* During the same year was published, *Advice, a Satire.* His next literary effort was *Alceste, an Opera,* which he wrote at the suggestion of Rich of Covent Garden Theatre. In consequence of some dispute with that patentee, the piece was withdrawn, and has never appeared in print. In 1747 he published *Reproof,* a second part of his former satirical production. The versification of these poems is sufficiently harmonious, and they abound with impetuous invective; but the rage of the satirist is without dignity, and rabid, without being infectious to readers of the present day. About this period he married Miss Lascelles, who was possessed of a small estate in the island of Jamaica; a precarious species of property, from which her husband appears to have derived little or no ultimate benefit.

In the year 1748, appeared *The Adventures of Roderick Random.* Fielding had already evinced himself a noble follower of Cervantes, and Smollett now stood forth a no less worthy disciple of Le Sage. It must be owned that in this, and in all the other novels of Smollett, humour frequently appears in very loose attire. These scenes, however, like sheet-lightning, are alarming, but perfectly innocuous. The solemn depravity of Rousseau is more dangerous than the ludicrous indecorum of Smollett. In 1749, *The Regicide* was published by subscription. During the summer of 1750, Smollett received the degree of M.D. from Marischal College, Aberdeen. The same year he went to Paris, where he is supposed to have occupied himself in composing *The Adventures of Peregrine Pickle,* which were published in 1751. This admirable novel is disfigured by the introduction of an impertinent episode, in which are detailed, with unrelenting minuteness, the tedious intrigues of Lady Vane; who is said to have rewarded Smollett handsomely for the drudgery of compiling that durable record of her infamy. To compensate for this blemish, and for some rash sallies of humour, *Peregrine Pickle* is an absolute mine of character and adventure. The entertainment prepared by the learned physician, in the manner of the ancients, is perhaps the most irresistible piece of pleasantry that was ever devised by a ludicrous fancy. In his heroes and heroines, Smollett is not happy. For Random we have no respect; for Pickle we have no esteem; and Narcissa and Emilia are only the objects of appetite. Since the days of Tom Bowling and the Commodore, we have seen many sailors in print, who display an accurate and profound knowledge of technical minutiæ; but their humour, if they have any, will not pass muster ashore, the medium through which it is conveyed being to uninstructed ears a mere succession of unintelligible gibberish. And these modern tars have all a striking family likeness to each other, with the exception of some sentimental rope-haulers of the American school, who are evidently monsters of the imagination. But each of Smollett's seamen, though drawn to the life, exhibits the strongest idiosyncrasy of character, and converses in a dialect which can be readily understood by those who have never seen a ship.[1]

The next production of Smollett's pen was *An Essay on the External Use of Water, in a letter to Dr ——— ;* with particular remarks upon the present method of using the Mineral Waters at Bath, in Somersetshire; and a plan for rendering them more safe, agreeable, and efficacious, 1752, 4to. At the period of this publication, Smollett resided at Bath, where he solicited professional employment; but the reputation of the satirist effectually marred the prospects of the physician. Despairing of success in his profession, Dr Smollett now hired a house at Chelsea, where he entirely devoted himself to literary pursuits. The first fruits of his retirement were, *The Adventures of Ferdinand Count Fathom,* which appeared in 1753. The author's object in this production is, to set up the principal character "as a beacon for the benefit of the inexperienced and unwary." This personage is as much below, as one of Richardson's heroes is above, the standard of general nature. Few men are so virtuous or depraved as to have much sympathy with either; and it may very reasonably be questioned, whether any one was ever allured to virtue by viewing the unattainable perfections of Grandison, or deterred from vice by contemplating the superlative villany of Fathom. Besides, a picture of insipid excellence is at least harmless; but there is a moral insanity about some men, which leads them not only to delight in, but sometimes to emulate the achievements of fictitious desperadoes. The most striking passage in this novel is the adventure in the forest, which creates terror as strong as the convulsions of laughter which reward the exploits of Trunnion and his myrmidons.

But although master of the passions of others, Smollett's own were under very indifferent control. A person, called Peter Gordon, whom he had maintained for a series of years, and in support of whose credit he had been prevailed upon to indorse notes, suddenly withdrew into the verge of the court, where, by means of insulting letters and messages, he provoked his benefactor to chastise him by a beating. An action of damages was commenced against Smollett. The Hon. Alexander Hume Campbell, who was counsel for the plaintiff, having opened the proceedings with much gratuitous insolence towards the defendant and his witnesses, Smollett addressed a letter to that barrister, couched in very indignant and sarcastic terms, which afterwards found its ways into the fifth volume of the *European Magazine.* This infamous prosecution terminated in the discomfiture of Gordon, but the issue of Smollett's dispute with Campbell is involved in obscurity. In the beginning of the year 1755, Smollett published his translation of *Don Quixote,* which was executed amid the anxiety of pecuniary embarrassment, and for which he had been paid by advance. This version, while more spirited and elegant than that of Jarvis, is much less faithful and close, and Smollett made no scruple to make free use of the work of his immediate predecessor. If Smollett has surpassed Motteux in maintaining the solemn fatuity of the knight, he is less happy in rendering the proverbial humour of the squire; for the corresponding phrases in the English had already been appropriated, and he was reduced to the necessity of alteration, when there was no room for improvement.[2] After the publication of *Don Quixote,* Smollett paid a visit to his native country. Upon his return to England, he undertook the superintendence of the *Critical Review.* The editorship of that journal involved him in a thousand vexatious disputes with persons who were utterly unworthy of being promoted to the rank of his antagonists. A con-

[1] The incident of Tom Pipes's concealing in his shoe his master's letter to Emilia, it is curious to trace to the following passage in Ovid's *Art of Love;* which has not escaped the laborious research of Hugo, *De prima Scribendi Origine,* p. 154:—

Cum possit solea chartas celare ligatas,
Et vincto blandas sub pede ferre notas.

[2] There have been no less than *seven* English translations of this immortal work. The first was by Shelton, 1612–20; which was followed by a very vulgar one by John Philips, the nephew of Milton, in 1687; the third was by Motteux, 1712—certainly too free, though agreeable and spirited; the fourth by Jarvis, a very faithful rendering of Cervantes, in 1742; the fifth by Smollett, in 1755; the sixth by Wilmot, 1774; the seventh anonymous, in 1818, which has acted on the eclectic principle of adopting portions of all that had gone before it. Those who know Spanish will prefer Jarvis, while the common English reader will give the precedence to Motteux.

temptuous critique on the *Rosciad*, of which he was entirely innocent, provoked the spleen of Churchill, whose brief career was a perpetual crusade against genius and virtue, and whose coarse and rancorous effusions are now consigned to merited oblivion; for posterity has not realized the hopes of an undying name, so confidently expressed by the reverend bard, who proposed to annihilate the reputation of Pope, and who launched his slight javelins at the massy buckler of Johnson.

In 1757, Smollett published a popular compilation, entitled, *A Compendium of Authentic and Entertaining Voyages*, 7 vols. 12mo. During the same year was performed and printed *The Reprisal*, a comedy in two acts. The characters in this piece are strongly marked, and the dialogue is extremely spirited, but the situations are conceived with little dramatic artifice; a species of knowledge which often enables the humble retainer of a playhouse to concoct a drama which shall be admirably well adapted for the stage, and yet prove not more entertaining in the closet than a book of arithmetic. In the same year was published the *Complete History of England, deduced from the Descent of Julius Cæsar to the Treaty of Aix-la-Chapelle*, 4 vols. 4to. This surprising effort of industry and genius is said to have been begun and completed in the course of fourteen months. If not the most accurate and philosophical of historians, Smollett yields to few in the unaffected elegance of his style, and in the graceful animation of his narrative. He had been bred a Whig; and whatever were the motives that led to the political tergiversation which is manifested in this work, it would be uncharitable to suppose that they were those of self-interest, a consideration which does not seem to have influenced any one action of his life.

In 1789, an article appeared in the *Critical Review*, animadverting in strong terms upon the conduct of Admiral Knowles, who had written a pamphlet to vindicate himself from the popular odium which attached to his character, in consequence of his share in a secret expedition to the French coast, which was planned and miscarried in 1757.[1] The admiral having commenced a prosecution against the printer, of which the avowed object was to induce the writer to declare himself, and give him satisfaction of another kind, Smollett, in this dilemma, solicited the good offices of his friend Wilkes, whose rhetoric made no impression on the incensed commander. At this juncture, Smollett stepped boldly forth, and proclaimed himself the author of the obnoxious article, offering the aggrieved party any satisfaction that he might desire. Upon this declaration, the magnanimous flag-officer immediately withdrew his action against the printer, and entered a fresh suit against the reviewer. The result of the action was, that Smollett was fined L.100, and sentenced to three months' imprisonment in the King's Bench.

To cheer the gloom of his confinement, this indefatigable writer employed himself in composing *The Adventures of Sir Launcelot Greaves*, which first appeared in the *British Magazine* for 1760 and 1761, and was published in a separate form in 1762. The eye of criticism has always looked coldly upon this performance. Although it is one of those works of which the execution must be admitted to surpass the conception, the story of the modern Don Quixote is no such incredible figment as it has been pronounced. Sir Launcelot Greaves is represented as a person of diseased understanding; and who shall set bounds to the vagaries of insanity? Nor does Captain Crowe appear to act out of character, in becoming a candidate for the honours of chivalry. For that original is in a state of happy ignorance concerning all terrestrial affairs; and the profession of a knight-errant appears to his unsophisticated understanding to be as lawful a calling as that of a tide-waiter; and it is one which is not at all discordant with the headlong courage and extravagant generosity of a British seaman.

To the *Modern Universal History*, which was begun in 1759, and completed in 1764, Smollett contributed the histories of France, Italy, and Germany. In 1761 had appeared the first number of his *Continuation of the History of England*, which he finished in 1765; the narrative comprehending the transactions down to that period.

Upon the accession of George III., Smollett appeared in the character of a political partisan, and drew his pen in defence of the administration of Lord Bute, in a weekly paper, entitled *The Briton*. But being speedily tired of protecting from obloquy a minister who was indifferent to public opinion, he retired from the strife, leaving his antagonist, *The North Briton*, master of the field. This contest terminated an intimacy of long standing between Smollett and Wilkes. Notwithstanding his inferiority in talents, that demagogue had some decided advantages over his opponent. Wilkes was a cool political pugilist, who gathered courage from the applauses of the mob; while Smollett was greeted with a general burst of popular execration, which worked him into a phrensy that deprived him of his strength.

Smollett's name stands in the title-page of a translation of the works of Voltaire, and also in that of a compilation entitled *The Present State of all Nations*. These works, to which he contributed sparingly, were published in 1763. In that year he sustained an irreparable loss in the death of his only child, a daughter named Elizabeth, who had attained the fifteenth year of her age. This calamity threw an impenetrable gloom over the brief remainder of his life. In the hope of dissipating his own grief and that of his wife, by change of scene, he passed over into France; in which country, and in Italy, he resided for two years. In 1766, he published his *Travels through France and Italy*. This production displays his usual acuteness of observation and felicity of expression, but he appears to have contemplated every object through the distorted medium of disease and lacerated feelings. Sterne, who had met the bereaved father abroad, took an opportunity of exulting over the infirmities of rival genius, in his *Sentimental Journey*.

In 1766, Smollett visited Scotland for the last time. At this period, he was a martyr to asthma and rheumatic pains, and afflicted with a virulent ulcer on his arm. In the following year, while residing at Bath, he enjoyed a short interval of convalescence, during which he wrote the *Adventures of an Atom*. In this political romance, he has blended, with greater dexterity than judgment, the reckless jollity of Rabelais with the withering sarcasm of Swift. With much wit and humour, this production betrays great physical indelicacy, a latent ferocity of sentiment, and an unqualified abhorrence of the lower order of the community, which is far from edifying. It may here be remarked, that the learning which is scattered through the fictitious narratives of Smollett, would, with proper management, make a most imposing show in works of much graver pretensions. Neither does he ever, like Fielding, hover on the verge of pedantry; nor resort to the disingenuous artifice of dazzling unlettered eyes with borrowed erudition, like Sterne, who had cool effrontery enough to express his sovereign contempt of literary larceny in the unacknowledged words of Burton. See Scott's *Biographical Memoirs of Eminent Novelists*, vol. i., p. 294.

[1] The offensive words were, "He is an admiral without conduct, an engineer without knowledge, an officer without resolution, and a man without veracity." Knowles was one of the heroes of Carthagena, at which memorable expedition he commanded the Weymouth, of 60 guns.

After the publication of this romance, Smollett's complaints returned with increased violence, and his medical friends declared that his only chance of life lay in a more salubrious climate. To the great he never applied in vain, for he never applied at all. His friends, however, made some fruitless efforts to interest the ministry in his behalf. But from Smollett was sternly withheld that bounty which has often, before and since, been lavished with a prodigal hand upon the most worthless and foolish of mankind. With a constitution worn out in the service of literature, and with a purse which had been emptied in the lap of indigence, Smollett proceeded to Italy in 1770.

The last, and perhaps the best of all his works, was *The Expedition of Humphrey Clinker*, published in 1771. Each character in the galaxy of originals which are there portrayed may submit without apprehension to Ben Jonson's test of humour:—

> "When some one peculiar quality
> Doth so possess a man, that it doth draw
> All his affects, his spirits, and his powers,
> In their conflictions, all to run one way,
> This may be truly said to be a humour."

Having bequeathed this legacy to the public, Smollett died at Monte Nero, a village in the neighbourhood of Leghorn, on the 21st of October 1771, in the fifty-first year of his age. A monument was erected to his memory by his widow, and a cenotaph on the banks of the Leven by his cousin, James Smollett, Esq. of Bonhill, which bore an inscription corrected by the pen of Samuel Johnson.

To a handsome person, and an address at once dignified and engaging, Smollett added colloquial powers of the highest order. His irascible passions were strong, but his social affections were not less so. If it is remembered that his personal and political prejudices were intense, let it not be forgotten that zealous friendship and ardent patriotism were among the number. He was improvident, for his hand was only closed to the necessities of others when he had nothing to bestow. He was a man of undaunted resolution, and lofty independence of mind. He was vindictive, but not implacable, and melted at the first appearance of contrition in those who had injured him. He was jealous of his fame, his sole possession, but he envied that of no other man, whether deserved or otherwise. Of Smollett, as an author, it may be truly said, that of the many different kinds of composition which he has attempted, there is none to which he has not communicated peculiar graces; nor can we hesitate for a moment in adding his name to the scanty list of those who have extended the limits of intellectual enjoyment. For more circumstantial details of the life of Smollett, the reader is referred to the narratives of Dr Anderson and Dr Moore.

SMUGGLERS, persons who import or export prohibited goods without paying the duties appointed by the law.

SMYRNA (Turk. *Izmir*), the most important commercial city of Asiatic Turkey, on the south shore of the gulf of the same name, near its head, N. Lat. 38. 25., E. Long. 27. 9.; about 210 miles S.S.W. of Constantinople. The situation is very fine. High mountains covered with forests inclose the gulf on all sides at a little distance, and close to the town there is a hill, the ancient Mons Pagus, now surmounted by a castle. On the western slope of this hill, and on a triangular plain between it and the sea, Smyrna is built; its houses, domes, minarets, towers, and cypress-trees rising with a fine effect from the margin of the sea. The interior of the town, however, like that of most others in Turkey, is by no means so pleasant. The streets are narrow, crooked, and dirty; the houses frail and wretched, being built, except in the Frank quarter, almost exclusively of wood. There are four different quarters in Smyrna, inhabited by different nations. The Turks occupy the upper part of the city, on the slopes of the hill; beneath them, on the lower slopes and centre of the plain, is the Armenian quarter; the Jews are confined to two or three small interstices between the two former; and the Franks occupy the best part of Smyrna, along the shore for about two miles. There is excellent anchorage in the bay, and the water is so deep as to allow large vessels to lie close to the shore. A series of quays extends along the margin of the bay, lined with many handsome stone-houses and whitewashed warehouses. Among the public buildings are several bazaars constructed of wood, dark and intricate, but stored with a profusion of various silk, woollen, and cotton goods. The vizier-khan is formed out of the remains of the ancient theatre. On the summit of the hill stands the extensive castle, occupying the site, and partially built with the remains of the ancient acropolis. It has a very incongruous appearance, as it has been frequently repaired, and is now deserted, though still mounted with a few cannons. Within the enclosure is a ruined mosque, said to have been the primitive Christian church of Smyrna, The present mosques are nineteen in number, all open to Christian visitors. The largest is profusely decorated with lamps, ostrich eggs, and horse tails, suspended from the ceiling. Smyrna has also seven synagogues; Protestant, Roman Catholic, Greek, and Armenian churches; a convent, Greek college, governor's palace, hospital, and barracks. Consuls from Great Britain, the United States, and most of the continental nations, have residences in the European part of Smyrna. The Turkish burying-ground, on the way up to the castle, is large and ancient, and contains many tall cypress-trees. The climate of Smyrna is very hot; as the surrounding mountains concentrate upon it the rays of the sun, and this, together with the crowded and dirty state of the town, renders it very unhealthy. The plague occasionally makes its appearance, and commits great ravages. It is to its trade that the town owes its great importance, and all its activity and animation. During the fruit season, long strings of camels are continually entering the town from all parts of Asia Minor. Figs, raisins, and other fruit, as well as silk, cotton, oil, opium, skins, &c., are exported; while coffee, sugar, indigo, tin, iron, lead, cotton cloth, rum, and brandy are imported. During the Russian war of 1854–6, the trade of Smyrna attained an extent previously unprecedented; but in the commercial crisis of 1857 it suffered considerably. The following table exhibits the value of exports and imports to and from the different countries that trade with Smyrna in 1858.

Countries.	Exports.	Imports.
Great Britain	L.1,059,540	944,197
Turkish ports	185,542	579,935
Austria	433,669	325,587
France	283,628	356,693
America	163,445	158,212
East Indies	92,628	...
Holland	18,123	34,190
Sardinia	16,587	32,722
Greece	15,410	31,692
Tuscany	16,108	20,116
Russia	35,819	...
Belgium	3,707	25,625
Malta	8,110	15,360
Ionian Islands	11,543	2,605
Hanse Towns	5,385	...
Two Sicilies	4,087	491
Papal States	612	3,600
Gibraltar	1,500	...
Total	2,345,450	2,531,025

The number of vessels that entered the harbour in 1855 was 1805, tonnage 420,438; those that cleared 1771, tonnage 411,157, exclusive of the steam navigation. Six journals are published at Smyrna, in five different languages. Steamers ply to Constantinople, Marseilles, Malta,

and other ports in the Mediterranean. The town is said to be of great antiquity; and if we may believe some traditions, it derived its origin as well as its name from an Amazon called Smyrna. It is regarded by some as having been originally a colony of Ephesus, subsequently occupied by the Æolians; but the account given by Herodotus represents it as first colonized by the latter, who possessed it till the year 688 B.C. It was then, by the machinations of some exiles from Colophon, transferred to the Ionian League, of which it formed the thirteenth city. Gyges, King of Lydia, made an unsuccessful attack upon the city; but a subsequent monarch, Sadyattes, about 627 B.C., took and destroyed it. From this time Smyrna lay in ruins for about 400 years. The design of Alexander to rebuild the city was cut short by his death, but afterwards resumed by Antigonus, and completed by Lysimachus. The new city, which did not occupy precisely the site of the old, became one of the finest then existing. It had regular, well-paved, handsome streets, several squares and porticoes, temples, and other public buildings. It was the largest as well as the most wealthy and commercial city in Asia Minor. Although in the civil war that followed the death of Cæsar, it was partially destroyed by Dolabella; yet it speedily recovered its former prosperity. After the Christian era, Smyrna was the seat of one of the earliest churches, one of the seven mentioned in the Book of Revelation. Polycarp, a disciple of the apostle John, is said to have been the first bishop; and he suffered martyrdom at an advanced age, about 167 A.D. In ancient times, as in modern, Smyrna seems to have been peculiarly subject to earthquakes; in 178 it was destroyed by one, but rebuilt by the Emperor Marcus Aurelius. Under the Eastern Empire, towards the time of its downfall, Smyrna experienced many vicissitudes of fortune. Near the end of the eleventh century, the city, having been occupied by a Turkish chieftain, called Tzachas, was nearly destroyed by a Greek fleet. It was rebuilt by the Emperor Comnenus, and afterwards came into the hands of the Genoese, who retained it till 1364. Tamerlane captured it in 1402, and soon after it came finally into the possession of the Turks, its present masters. It has suffered very frequently from earthquakes, conflagrations, and the plague. In July 1841, upwards of 12,000 houses were destroyed here by fire; and in 1846 an earthquake inflicted great damage. Smyrna was one of the many cities that contended for the honour of having given birth to Homer; and in the opinion of modern scholars, it is the one which has most in its favour. The city in ancient times possessed a Homerium or temple to the great poet; and a cave was pointed out in the vicinity where he wrote his poems. The population of Smyrna at the present day is estimated at about 150,000; of whom about 80,000 are Turks, 40,000 Greeks, 15,000 Jews, 10,000 Armenians, and 5000 Franks.

SNEEK, a town of Holland, in the province of Friesland, on a lake of the same name, 13 miles S.S.W. of Leuwarden. It lies low, and is enclosed and traversed by several canals or ditches, crossed by wooden bridges. Here are a neat small town-hall, court-house, prison, several churches, schools, and hospitals. The town has boat-building yards, rope-walks, potteries, tanneries, foundries, soap-works, and a considerable trade in butter and cheese. Pop. 7500.

SNELL, WILLEBRORD. See GEOMETRY.

SNIADECKI, JAN, a Polish astronomer and mathematician, was born at Znin on the 29th of August 1756. He began his education at Pozen, continued it at Cracow, and completed it at Göttingen. While at the university he was distinguished for his classical attainments, and it is told by his biographer, Balinski, that he had the whole of Horace by heart. In 1777 he was appointed teacher of statics, hydraulics, logic, and political economy at Nowodwov in Cracow. Some time after he visited Paris, where he made the acquaintance of Laplace, Condorcet and D'Alembert; and in 1787 he visited England, having previously mastered the English language so far as to be able to read the mathematical writings of Maclaurin and Simson. He visited Sir William Herschel and his observatory at Slough, and made the acquaintance of some eminent English mathematicians and astronomers. After his return to Poland he seldom left his post as professor of mathematics and astronomy at Cracow, till 1806, when he was transferred to the university seat of Wilna. Sniadecki here engaged in numerous astronomical observations, many of which will be found published in the *Transactions of the St Petersburg Academy*, and in the Berlin *Astronomische Jahrbücher*. On the suppression of the university of Wilna, Sniadecki retired, and died in 1830. A collected edition of his works, with a life by Balinski, was published in 8 vols., Warsaw, 1837-39. The mathematician and astronomer had a younger brother, ANDRZEJ SNIADECKI, who was an eminent physiologist. He was born in 1768, and died in 1838. He studied successively at Cracow, Pavia, and Edinburgh, and returned home to profess chemistry and physiology at the university over which his elder brother presided in his later years. The most important work of this writer was his *Theory of Organic Existences*, 2 vols., 1804–11, which has been translated into German and French, and is much esteemed.

SNORRO STURLESON, for so his name is most frequently written, was the last and the greatest of the northern scalds, and was born at Hoam, in the bailiwick of Dale, in the western province of Iceland, in 1178. He was descended, like all families of consequence among the Northmen, from the royal line of Odin, and held by hereditary right the dignity of a *godar*, or priest and judge over his immediate locality. Following the custom of the time, young Snorro was sent to be fostered by one John Lopston, a person of some consideration both for the literary renown which still lingered in his family, and from his near claims to the notice of royalty, being by his mother an illegitimate grandchild of King Magnus Barefoot. The reminiscences of such a household would be peculiarly favourable for the growing genius of the future chronicler. Before Snorro had reached his nineteenth year, his father, Sturla Thordarson, had died. He likewise lost, at that age, his generous foster-father, John Lopston. As he advanced in years he was observed to be passionate, sanguine, and daring. He married at the age of twenty-one, and got a considerable dowry by his wife. He had several children by this woman, besides a number of illegitimate ones. He made a journey to Norway about 1221, where it is supposed he collected the information given in his saga regarding Sweden, Denmark, and Norway; and where he was made cup-bearer or chamberlain to King Hakon. Tired of the affections of his first wife, in 1224, he took to himself a rich widow with a large fortune. His sons, and his sons-in-law, now allied themselves against him, and resolved, by fair or foul play, to seize upon the fortunes to which they were justly entitled. It is reported of Snorro that, when the young kinsmen strove to obtain their own by legal means, he went with 600 or 800 men, and obtained by force the decision which he desired. This passionate, self-willed, obstinate man, over whom the moral sense had no control, and in whom the intellect rose to the confines of genius, used all his Titanic strength, and rude, wild energy, to break up this family feud, and strew its dissentient members abroad over the world. The young scions of his house had probably not a little of his own fierceness and lawlessness, combined with a vindictiveness that would have done honour to a Corsican, and they resolved to wait and watch their opportunity, and accomplish by stealth what they could not compass by publicity.

This ambitious old scald was both rich and learned. He fortified and adorned his residence at Reikholt, with a barbaric magnificence quite unheard of. In 1237 he revisited Norway, but from ambition, or from some other motive, transferred his allegiance from King Hakon to Duke Skule, who had distant claims to the crown. The king now pronounced him a traitor. Snorro returned to Iceland, but the royal scouts were charged to bring him alive or dead to Norway. Iceland should see now what would become of the man who was accused of secretly negotiating for her subjection to the Norwegian crown! The domestic faction which Snorro had so relentlessly kindled still kept smouldering, and was kept warm by the ceaseless fanning of private animosity. We must not try the social morals of the thirteenth century by any standard of our own manufacture. The scale of manners was, doubtless, very low at that period in Iceland. Nothing but the most passionate lawlessness, and the bloodiest vindictiveness, were the current usage of that wild age. Christianity had not yet gained footing amid the peoples of the North; and their manners were, of course, as heathenish as the rudest Pagan could have desired. The three sons-in-law of Snorro, Gissur, Kolbein, and Arne, came by night to his strong residence at Reikholt, and murdered him in September 1241, in his sixty-third year. Thus died the Herodotus of the North, a wild, selfish, ambitious spirit, who discarded all moral and religious considerations; but who had a power of insight capable of seeing into the complicated mechanism of the human heart; and a power of portraying the character and individuality of each of his heroes, that has very seldom been surpassed by any writer in any age. As a slight palliation of the rude lines in which his character is drawn, we must mention that all that is known regarding the person of Snorro Sturleson is derived from the accounts handed down to us in his own family.

The *Heimskringla* (or circle of the earth) is the name by which Snorro Sturleson's greatest work is known. The name was derived from the first prominent word in the old scaldic manuscript of Snorro. He calls his book the *Saga, or Story of the Kings of Norway*; and it is in reality a connected series of memoirs of the kings and heroes who figured prominently on the Scandinavian peninsula, in Denmark, and in England, from the earliest period, when mythology and history are indistinguishably blended, down to the year 1178. It is a beautiful collection of sagas, or historical notices of incidents, anecdotes, and speeches, told in a fascinating manner by a man who could vividly recal and present the scenes which passed before his own imagination, hung out in all the rude drapery in which the actors delighted to appear. The work is thickly interspersed with rude snatches of scaldic song, which were introduced by the author to heighten the general effect of his narrative, or to add a kind of rough ornament to a story that had sufficient strength in it already. The copy of the *Heimskringla* made in 1230 by Snorro's nephew, Sturla, is considered the most authentic text of the work. Copies of this MS. were made as late as 1567. In 1594 a Danish translation of portions of the *Heimskringla* was published by Mortenssen. In 1599 Peter Claussen executed a Norwegian translation of it, which was published by Wormius in 1633. The first complete edition of the work was published in 1697, by Peringskiold, with Swedish and Latin versions of it. It was translated into Danish and Latin by Schöning, Thorlacius, and Werlauf; which, with the original Icelandic text very carefully collected, formed six volumes, and was published between 1777 and 1826. Grundtvig executed a Danish version of the *Heimskringla* in three volumes, 1818–1822. In 1838 Jacob Aal published an excellent Norse translation of the work; and in 1844 Samuel Laing translated the *Heimskringla* into English in three volumes, with a preliminary dissertation on the learning, religion, and social condition of the inhabitants of the North.

A number of poems, forming part of the *Skallda* of Rask, Stockholm, 1818, and Havn, two volumes, 1848–52, are ascribed to Snorro; besides some poems on contemporary heroes, and certain small scientific manuals.

SNOW. See Meteorology.

SNOWDON, the highest mountain in England and Wales, rises near the centre of the chain extending across the county of Carnarvon, from S.W. to N.E., from the coast near Nevin to Penmæn-mawr, near Conway. The length of the chain is about 35 miles, and its average breadth 6 miles. The highest point, which is distinguished by the name of y-Wyddfa, is 3571 feet above the sea; the second, called Carnedd Llewelyn, 3469. The nucleus of the ridge consists of primitive rocks, which are flanked by strata of slate and limestone. In several places copper is found. The western side of Snowdon is more steep than the eastern, and is partially formed of basalt.

SNYDERS, or Sneyders, Francis, one of the ablest coadjutors of Rubens, and the prince of animal-painters, particularly in the represention of wild animals in action, was born at Antwerp in 1579. Snyders followed the style of his master Henry Van Balen until the completion of his apprenticeship, when he pursued the bent of his own genius in the representation of fruit, vegetables, and dead game. It is admitted even by the most fastidious critics, that for masterly design, vigorous handling, and richness of colouring, he has never been surpassed in this particular department. Some writers report that this artist went to Italy, but as this statement does not hang well together, it may be judicious to give over repeating it. He subsequently adopted the study of wild beasts, and succeeded in representing such animals as the lion, the wolf, and the boar, particularly when roused to fury by the pursuit or attack of men or dogs, with amazing truthfulness of expression. Snyders afterwards became a coadjutor of the great painter Rubens. Fruit, vegetables, dead game, and wild animals, where they are introduced into the designs of this artist, were almost invariably painted by Snyders. Rubens reserved to himself the harmonizing of the whole picture, and he generally designed or suggested those wild animals which he left to others to paint. In numerous instances, pictures attributed to Rubens or to Jordaëns, were for the most part executed by Snyders. He usually painted the animals in a picture, and left it to others to execute the human figures and the accessories. Thus, in many of the pieces of Rubens, the human figure was executed by him besides the entire design, and his friendly rival, Snyders, completed the animal portion of the picture. Between Rubens, Jordaëns, and Snyders there seems to have been a more perfect artistic harmony, than can be pointed out in any other liberal brotherhood short of the dramatists of Queen Elizabeth's reign in England. Numerous illustrations of Snyders painting are to be seen in many of the English collections. The manner of this admirable artist has been imitated by his pupils Jacobs and Boël. Snyders died in 1657.

SOAP, is a peculiar chemical compound of animal or vegetable oils and fats, with the alkalies. The use of soap does not date from a very early period; although mentioned in the Bible there is much reason to believe that alkali used in washing is meant, and not manufactured soap. It appears to have originated in Germany, and was introduced to the Romans about the beginning of the Christian era. At first its use seems to have been greatly misunderstood, for Pliny says, "Soap, too, is very useful for this purpose" (the dispersion of scrofulous sores), "an invention of the Gauls for giving a reddish tint to the hair. This substance is prepared from tallow and ashes, the best ashes for the purpose being those of the beech and yoke

clm; there are two kinds of it, the hard soap and the liquid, both of these used by the people of Germany, the men in particular more than the women." It is more than probable that Pliny was mistaken in the motive of the Gauls for washing their heads with soap, and that the reason was cleanliness, which of course brightened the naturally light colour of their hair.

The aborigines of South America manufacture a kind of hard soap in a very peculiar manner; but whence they derived the art, or how long they have used it, is not known. They select a tree, which in the neighbourhood of Para is called Chereuba; this is cut down and burned to ashes, which are mixed with lime and Carapa oil, made from the large seeds of *Carapa Guianensis*, and, boiled, it is poured off from the ashes whilst liquid, and hardens on cooling. This soap is much used by the washerwomen in many parts of Brazil.

Many plants are found to have detergent properties similar to soap, and in the countries producing them are employed for washing. Thus, in the West Indies and tropical America, the berries of the soap-tree (*Sapindus saponaria*), are much used, and are found to be very far superior in cleansing power to common soap. Another South American tree, the *Quillaia saponaria*, and perhaps other species of the same genus, yields a bark which has very powerful saponaceous qualities, and is not only used extensively in its native country, but has recently been introduced experimentally to this country, several importations having been received at Liverpool, for making a saponacous solution for washing woollens. It is at least equal if not superior in strength to our best yellow soap. Where known, it is esteemed for washing the hair.

The natives of the Malayan Islands use the bark of the Gogo-tree (*Entada pursætha*) for the same purposes, and this bark is highly prized by the ladies of Manila for cleansing and brightening their beautiful tresses. Various other vegetable productions are used, but less extensively. The process of saponification is much varied, and considerable difference also exists in the oleaginous materials, consequently we find numerous kinds of soap in use for different purposes. The ordinary process consists in submitting oleaginous or fatty matters to the chemical action of alkaline lyes, and boiling the compound to get rid of a portion of the water used for the solution of the alkali. They may be arranged under the following heads—*Hard, Soft, and Medicated Soaps,* each of which comprises numerous varieties.

Common Hard Soap is of three kinds—*yellow, white, and mottled.* In making the yellow kind, the materials employed are tallow, grease, or kitchen and bone fat, palm-oil, resin, and the alkaline lye or solution of soda-ash, or crude carbonate of soda. The lye is prepared in the soda-vats, which are cast-iron cylinders about 6 feet wide by 4 or 5 feet in depth, and having perforated bottoms, below which is a large funnel for receiving the filtered lye. In the vat a layer of quick-lime is first placed, then successive layers of soda-ash and lime, through which water is allowed to percolate until it has dissolved about 2 per cent. of the alkali rendered caustic by the action of the quick-lime.

A ton of the fat melted in the boiler requires 200 gallons of the lye for the first process. They are gently boiled for four hours, and then allowed to cool; the partially formed soap subsides; and the lye is drawn off clear, and exhausted of its alkali. A second charge of fresh lye is then added, and the process repeated three times a-day for about six days. Previous to the last boil, the resin is added, as it is too liable to be liquefied by the alkaline lyes if exposed to the action of the whole series; the quantity of resin must always be less than half the fats employed, and before using must be reduced to coarse powder. Palm-oil is generally one of the fatty ingredients when resin is employed, its pleasant violet odour and bright golden colour serving to disguise the resin. The great soaperies of Lancashire and Cheshire, which supply the vast export trade from Liverpool, produce most of the yellow soap made in England.

The soap is transferred from the boilers to the frames in a liquid state, and allowed to solidify by cooling. These frames are made of thick bars of wood, of the same width and length as an ordinary bar of soap; four of these are joined together, forming a square frame, and a number of these frames being placed one upon another, iron rods are passed through holes in the thickness of the wood, and being screwed up tight, form a sort of tank in which the liquid soap soon becomes solid. When this has taken place, the iron rods are withdrawn, and a thin piece of wire is inserted between the top frame and the one below it, and is made to cut through the soap in the line of the lower part of the frame. The top frame with its square of enclosed soap is then lifted off, and the process repeated until all the frames are separated. After a little exposure to the drying influence of the air, the soap is easily detached from the frames, and is then cut into bars and packed into boxes for sale.

Common White Soap is made in the same manner, with the exception of the palm-oil and resin, which are omitted, tallow being chiefly used, to which, in some sorts, cocoa-nut oil is frequently added.

Mottled Soap, which is almost peculiar to the London soaperies, is made of the same materials as the white soap, but previous to the last boil the mass is watered with a strong lye of *crude soda*, poured upon it by means of an ordinary gardener's watering-pot with a large rose. The mottling of the celebrated Castile soap is produced by a similar process, a solution of sulphate of iron being employed instead of the crude soda. In Southern Europe olive-oil is used instead of tallow, and forms a hard white soap.

The finer kinds of Hard Soap, or *Toilet Soaps*, are made of fine white tallow, suet, palm, olive, or almond oils, or a mixture of two or more of these, according to the quality required. The best *Windsor soap* is made with nine parts of fine tallow and one of olive-oil, the latter being preferred to suet, which is used for the inferior sort, in consequence of its slower saponification insuring a more perfect combination of the alkaline with the *fat acids*. The perfume used is a mixture of 6 lbs. of oil of caraway seed, 1½ lb. of oil of lavender, and 1½ lb. of oil of rosemary, to every 1000 lb. of the soap. The brown kind is coloured with burned sugar, or umber and Armenian bole; the latter colouring is used only for inferior sorts.

Honey Soap, now extensively used, is made by re-melting three other kinds, namely, palm-oil, olive-oil, and curd soaps, and scenting with the citronelle oil or essential oil of *Andropogon citratum*, which gives it its peculiar honey scent. The other leading kinds of perfumed soaps are *almond, rose, cinnamon, musk, and orange-flower soaps,* all of which vary in their composition more or less, according to the taste of the manufacturer.

Soft Soap differs both in composition and in the process of its manufacture, from hard soap. Instead of soda being used for the alkaline, base potash is employed. The following is given by Dr Ure as the process:—

"A portion of the oil being poured into the pan, and heated to nearly the boiling point of water, a certain quantity of the weaker lye is introduced, the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and lye are added alternately, until the whole quantity of oil destined for the pan is introduced. The ebullition is kept up in the gentlest manner possible, and some strong lye is occasionally added, till the workman judges the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and it gradually

thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass plate assumes the proper consistency."

The peculiar granular appearance of the soft soap used in this country, and which makes it so much resemble the pulp of ripe figs, is produced by the addition of small quantities of tallow, which are disseminated through the mass, and form the white specks. From its appearance when complete, this operation is technically called *figging*. The oils generally used are the fish, whale, and seal oils, but on the continent various seed-oils, especially those from hemp-seed, linseed, colsa-seed, and poppy-seed. The continental soap-makers give the soft soap a green colour, which is sometimes produced by the addition of indigo.

Soft soap is much used in cleansing woollen fabrics, for which its superior solubility and great detergent power specially fit it. A very coarse kind is used by farriers under the name of black soap. There are a few varieties of soft soap used for toilet purposes, the principal of which is Naples soap, used chiefly for shaving. It is said to be made only from olive-oil and potash; but all imitations of it differ from the true Italian manufacture. It is much prized in consequence of its softening power upon the hair.

The MEDICATED SOAPS have lately acquired some importance in pharmacy, particularly on the continent. The Castile soap, previously mentioned, is generally used as the base of these preparations. The most valuable of all medicated soaps is the *Chlorinated*, the *Savon Antisyphilitique* of French pharmacy. It is made by working together one part of chloride of lime with eleven of Castile soap, using spirit of wine scented with oil of verbena to effect the incorporation. The mass is then fashioned into little flat cakes, and folded carefully in tinfoil or gutta-percha paper. It is powerfully detergent, and is very effective in removing stains, and is known to be of remarkable efficacy in preventing the effects of contagion, if the hands or clothes are washed with it. The other medicated soaps are antimonial, croton, guaiacum, iodine, mercurial, tar, turpentine, sulphuretted vitriol, &c., the formulæ for which are in the pharmacopœias.

Arsenical soap is of considerable importance to the naturalist, being an effectual preservative of the skins of animals, particularly of birds, and those most liable to the attacks of moths. It is composed of carbonate of potash, twelve parts; of white arsenic, common white soap, and air-slaked lime, each four parts; and powdered camphor, one part, with enough of water to make it into a paste.

The rationale of the process of saponification was first explained by Chevreul, who showed that in the combination new substances capable of forming salts and possessing true *acid* properties are generated out of the elements of the fat, under the influence of the alkaline base. Common fat saponified consists of a mixture of *stearic*, *margaric*, and *oleic* acids, each combined with the base, and the peculiar neutral liquid substance called *glycerine*, which resembles colourless syrup, and is miscible with water. Glycerine is obtained from other sources than soap, and for commercial purposes is generally procured by refining the *sweet liquor* of the stearine-makers; it is now extensively used chiefly in pharmacy for external applications. When pure it is colourless, odourless, sweet to the taste, and of a syrupy consistency; it feels soft like oil, but has no greasiness, and it does not evaporate at ordinary temperatures; hence its value to the surgeons for keeping inflamed parts moist.

The importance of this branch of manufacture is very considerable, whether it be viewed with respect to its sanitary effects upon the human race, or in its bearing upon other important manufactures. In no country is it used to the same extent as in Great Britain; and, as a consequence, the skill of our chemists has been specially directed to its improved and economical production with so much success that, now the excise restrictions have left the soap-maker unfettered, we are enabled to produce all the really useful kinds, not only much cheaper, but also better, than the manufacturers of other countries; while in the ornamental varieties we beat our neighbours in cheapness, and are rapidly approaching them in elegance of production. The rapidity with which this branch of industry has developed in this country is truly marvellous. In the first year of the present century the consumption of soap was 52,947,037 lb., but in 1850 it had reached the enormous quantity of 197,632,280 lb. This increase during the half century, viewed in relation to the increase in population, is quite as remarkable. In 1801 the quantity gave 4·84 lb. to each person, while that in 1850 gave 9·71 lb. It must not, however, be assumed from these facts that the personal use of soap had doubled, as a very great proportion of the increased consumption has been due to the extension of our manufactures in which soap is used, and to the origination of new branches of industry in which it is required.

The quantity of soap at present made in Great Britain cannot be ascertained with certainty, as the duty is now removed, and we have no excise returns; but the quantity is annually increasing to a great extent. Our exports alone amounted last year (1858) to 12,500 tons, the greatest portion of which was sent to our colonies. The States of South and Central America also received large quantities; the rest found its way to Austria, Italy, Sardinia, Turkey, Java, China, and Western Africa. (T. C. A.)

SOBIESKI, JOHN. See POLAND.

SOCAGE, in its most general and extensive signification, denotes a tenure by any certain and determinate service; and in this sense it is by our ancient writers constantly put in opposition to chivalry or knight-service, where the tenure was precarious and uncertain. The service must therefore be certain, in order to denominate it socage, as to hold by fealty and twenty shillings rent; or, by homage, fealty, and twenty shillings rent; or, by homage and fealty without rent; or, by fealty and certain corporal service, as ploughing the lord's land for three days; or, by fealty only without any other service; for all these are tenures in socage. Socage is of two sorts: *free*-socage, where the services are not only certain but honourable; and *villein* socage, where the services, though certain, are of a baser nature. Such as hold by the former tenure are called, in Glanville and other subsequent authors, by the name of *liberi sokemanni*, or tenants in free-socage. The word is derived from the Saxon appellation *soc*, which signifies liberty or privilege, and, being joined to an usual termination, it forms *socage*, in Latin *socagium*, signifying a free or privileged tenure. It seems probable that the socage-tenures were the relics of Saxon liberty; retained by such persons as had neither forfeited them to the king, nor been obliged to exchange their tenure for the more honourable, as it was called, but at the same time more burthensome, tenure of knight-service. This is peculiarly remarkable in the tenure which prevails in Kent, called *gavelkind*, which is generally acknowledged to be a species of socage-tenure; and its preservation from the innovations of the Norman conqueror is a fact universally known. And those who thus preserved their liberties were said to hold in free and common socage.

SOCIETY, as generally understood, is an association of individuals for the promotion of science, literature, or the arts. Under the head ACADEMY a detailed account is given of the principal institutions bearing that name, both in the United Kingdom and on the continent; and it only remains to present a tabular view of the more important societies of the United Kingdom.

Tabular View of the more important Societies of the United Kingdom.

Place of Meeting and Name.	Annual Subscription. £	s.	d.	Date of Foundation. Year.
LONDON.—Archæological Institute of Gt. Britain	1	1	0	1843
Architectural Association	0	12	6	1842
Architectural Museum	1	1	0	1853
Art-Union of London	1	1	0	1837
Arundel Society	1	1	0	1849
British Archæological Association	1	1	0	1843
British Association for the Advancement of Science (Perambulatory)	1	0	0	1831
British Institution for the Fine Arts	3	3	0	1805
Cambrian Archæological Association	1	1	0	1846
Camden Society	1	0	0	1838
Chemical Society	2	0	0	1841
Chatham Society	1	0	0	1843
Entomological Society	1	1	0	1833
Geological Society of London	3	3	0	1807
Graphic Society	1	1	0	1833
Hakluyt Society	1	1	0	1846
Horticultural Society of London	4	4	0	1804
Institute of Actuaries	3	3	0	1848
Institution of Civil Engineers	3	3	0	1818
Linnæan Society	3	0	0	1788
Medical Society of London	1	1	0	1773
Microscopical Society	1	1	0	1839
Middlesex Archæological Society	0	10	0	1855
Numismatic Society	1	10	0	1837
Parker Society	1	1	0	1840
Ray Society	1	1	0	1844
Royal Academy of Arts	None			1768
Royal Society	4	0	0	1634
Royal Asiatic Society of Great Britain and Ireland	3	3	0	1823
Royal Astronomical Society	2	2	0	1820
Royal Botanic Society of London	2	2	0	1839
Royal Geographical Society of London	2	0	0	1830
Royal Institute of British Architects	2	2	0	1834
Royal Institution of Great Britain	5	5	0	1800
Royal Medical and Chirurgical Society	3	3	0	1805
Royal Polytechnic Institution	2	2	0	1838
Royal Society of Literature of the U.K.	2	2	0	1823
Social Science Association (Perambul.)	1	1	0	1857
Society of Arts	2	2	0	1745
Society of Antiquaries of London	2	2	0	1717
Society of Painters in Water-Col. (Old)	None			1804
Society of Painters in Water-Col. (New)	None			1834

Place of Meeting and Name.	Annual Subscription. £	s.	d.	Date of Foundation. Year.
LONDON.—Statistical Society	2	2	0	1834
Surrey Archæological Society	0	10	0	1854
Sydenham Society	1	1	0	1843
United Service Institution	0	10	0	1830
Zoological Society of London	3	0	0	1826
Oxford.—Architectural Society of Oxford	1	1	0	1839
Ashmolean Society	1	1	0	1828
Cambridge.—Cambridge Philosophical Soc.	1	1	0	1819
Cambridge Antiquarian Society	1	1	0	1839
Cambridge Architectural Society	0	10	6	1847
EDINBURGH.—Royal Society of Edinburgh	3	3	0	1739
Royal Scottish Society of Arts	1	1	0	1821
Royal Physical Society of Edinburgh	0	5	0	1771
Royal Inst. for the Fine Arts in Scotland	None			1819
Royal Scottish Academy of Painting, &c	None			1826
Royal Association for the Fine Arts	1	1	0	1833
Harveian Society	0	5	0	1782
Medico-Chirurgical Society	0	5	0	1821
Educational Institute of Scotland	0	5	0	1847
Highland and Agricultural Society	1	3	6	1784
Architectural Institute of Scotland	1	1	0	1850
Juridical Society of Edinburgh	1	1	0	1773
Botanical Society	0	12	6	1836
Caledonian Horticultural Society	1	1	0	1809
Society of Antiquaries of Scotland	1	1	0	1780
Edinburgh Philosophical Institution	1	1	0	1846
Glasgow.—Maitland Club	3	3	0	1828
Philosophical Society of Glasgow	0	15	0	1802
Aberdeen.—Spalding Club	1	1	0	1839
DUBLIN.—Royal Dublin Society	2	2	0	1731
Royal Irish Academy	2	2	0	1785
Royal Hibernian Academy	None			1823
Royal Institute of the Architects of Ireland	1	11	6	1839
Royal Zoological Society of Ireland	1	0	0	1831
Geological Society of Dublin	1	0	0	1832
Dublin Natural History Society	1	0	0	1838
Dublin Statistical Society	0	10	0	1847
Irish Archæological and Celtic Society	1	0	0	1854
Royal Agricultural Society of Ireland	1	0	0	1841
Belfast.—Chemico-Agricultural Society of Ulster	1	1	0	1845
Belfast Natural History and Philosophical Society	1	1	0	1821

SOCIETY ISLANDS. See POLYNESIA.

SOCINUS, LÆLIUS, the founder of the sect of the Socinians, was born of an illustrious house at Sienna in Tuscany in 1525. Being designed by his father for the family profession of the law, he began very early to search for the foundation of that science in the word of God, and by that study discovered that the Romish religion taught many things contrary to revelation. Being desirous of penetrating farther into the true sense of the scriptures, he studied Greek, Hebrew, and Arabic. In 1548 he left Italy, to go and converse with the Protestants, and spent four years in travelling through France, England, the Netherlands, Germany, and Poland, and at length settled at Zürich. He by this means became acquainted with the most learned men of his time; but as he discovered to them his doubts, he was greatly suspected of heresy. Bullinger took a great interest in him; and Calvin, who had repeatedly broken off correspondence with him, could not forbear renewing it, and giving him a friendly warning regarding his doubts on the subject of the resurrection, baptism, the Trinity, &c. "And in truth," says Calvin (see his *Letters*, 1551, translated at Edinburgh, 1856), "I am very greatly grieved that the fine talents with which God has endowed you should be occupied, not only with what is vain and fruitless, but that they should also be injured by pernicious fancies. What I warned you of long ago, I must again seriously repeat, that unless you correct in time this itching after investigation, it is to be feared you will bring upon yourself severe suffering." The fate of Servetus, the following year, completed the effect of this letter, and henceforward he maintained a dignified silence in his resort at Zürich. He, however, conducted himself with such propriety, that he lived among the capital enemies of his opinions without receiving the least injury. He met with some disciples, who heard his instructions with respect: these were Italians who had left their native country on account of religion, and wandered about in Germany and Poland. He communicated likewise his sentiments to his relations by his writings, which he caused to be conveyed to them at Sienna. He died at Zürich in 1562, aged 37 years. Those who were of sentiments opposite to his, and were personally acquainted with him, confess that his outward behaviour was blameless. Illgen, in his *Vita Lælii Socini*, attributes to him the work published on occasion of the death of Servetus, entitled *Martini Bellii Farrago de Hæreticis*, 1553. This book has likewise been ascribed to Castalio. L. Socinus also wrote *Paraphrasis in Initium Evangelii S. Johannis, scripta in* 1561.

SOCINUS, *Faustus*, nephew of the preceding, and principal founder of the Socinian sect, was born at Sienna in 1539. The letters which his uncle Lælius wrote to his relations, and which infused into them many seeds of heresy,

made an impression upon him; so that, knowing himself not innocent, he fled as well as the rest when the Inquisition began to persecute that family. He was at Lyon when he heard of his uncle's death, and he departed immediately to take possession of his writings. He returned to Tuscany; and made himself so agreeable to the grand duke, that the charms which he found in that court, and the honourable posts which he filled there, hindered him for twelve years from remembering that he had been considered as the person who was to put the last hand to the system of divinity, of which his uncle Lælius had made a rough draught. At last he went into Germany in 1574, and paid no regard to the grand duke's advices to return. He stayed three years at Basel, and there studied divinity; and having adopted a set of principles very different from the system of Protestants, he resolved to maintain and propagate them; for which purpose he wrote a treatise *De Iesu Christo Servatore.* In 1579 Socinus retired into Poland, and desired to be admitted into the communion of the Unitarians; but as he differed from them on some points, on which he refused to be silent, he met with a repulse. He did not, however, cease to write in defence of their churches against those who attacked them. At length his book against James Palæologus furnished his enemies with a pretence to exasperate the King of Poland against him; but though the mere reading of it was sufficient to refute his accusers, Socinus thought proper to leave Cracow, after having resided there four years. He then lived under the protection of several Polish lords, and married a lady of a good family; but her death, which happened in 1587, so deeply afflicted him as to injure his health; and to complete his sorrow, he was deprived of his patrimony by the death of Francis de' Medici, Great Duke of Florence. The consolation which he found in seeing his sentiments at last approved of by several ministers was greatly interrupted in 1598; for he met with a thousand insults at Cracow, and was with great difficulty saved from the hands of the rabble. His house was plundered, and he lost his goods; but this loss was not so uneasy to him as that of some manuscripts, which he extremely regretted. To deliver himself from such dangers, he retired to a village about nine miles distant from Cracow, where he spent the remainder of his days at the house of Abraham Blonski, a Polish gentleman, where he died in 1604. All Faustus Socinus's works are contained in the first two volumes of the great collection entitled *Bibliotheca Fratrum Polonorum.*

The followers of the Socini were called *Socinians.* They maintain—"That Jesus Christ was a mere man, who had no existence before he was conceived by the Virgin Mary; that the Holy Ghost is no distinct person, but that the Father is truly and properly God. They own that the name of God is given in the Holy Scriptures to Jesus Christ; but contend that it is only a deputed title, which, however, invests him with an absolute authority over all created beings, and renders him an object of worship to men and angels. They deny the doctrines of satisfaction and imputed righteousness; and say that Christ only preached the truth to mankind, set before them in himself an example of heroic virtue, and sealed his doctrines with his blood. Original sin and absolute predestination, they esteem scholastic chimeras. They likewise maintain the sleep of the soul, which they say becomes insensible at death, and is raised again with the body at the resurrection, when the good shall be established in the possession of eternal felicity, while the wicked shall be consigned to a fire that will not torment them eternally, but for a certain duration in proportion to their demerits."

SOCONUSCO, a town of Mexico, in the department of Chiapas, 46 miles S.W. of Ciudad-Real. It is the capital of a district, about 120 miles long by 40 broad, which formerly belonged to Guatemala; but was seized by Mexico in 1843, in spite of a protest on the part of Guatemala. It forms the southern part of Chiapas, and has a seaport in the Pacific.

SOCORRO, a town of New Granada, capital of a province in the department of Boyaca, 65 miles S.W. of Pamplona. Though containing some good houses, it is for the most part ill-built and dirty. Cotton cloth and straw hats are made here; and a considerable trade is carried on. Pop. 12,000.

SOCOTRA, an island in the Indian Ocean, about 150 miles E. of Cape Guardafui, the eastern extremity of Africa, and 220 S.S.E. of Ras-Fartak in Arabia. N. Lat. 12. 39.; E. Long. 54. 1. Its length from E. to W. is about 70 miles, its average breadth 15, and its area about 1000 square miles. The centre of the island consists of a table-land, from 700 to 800 feet high, on the north and south of which there are tracts of lowland along the coast. On the north edge of the table-land rises a ridge of granitic mountains, having a general height of 3000 feet, and several peaks rising as high as 5000. The rest of the table-land is slightly undulating, forming broad valleys stretching north and south. The coasts of the island are generally abrupt, and in some places lofty. A few perennial rivulets, and a number that are dry in summer, water the land. The climate is temperate, and the soil productive: aloes and the gum of the dragon's-blood tree, both of excellent quality, are the chief commercial products; but dates, tamarinds, tobacco, &c., are also raised. On the extensive pastures, oxen, sheep, and goats are reared. Some trade is carried on with Muscat; and the island is subject to the Imam of that town. Population estimated at 4000.

SOCRATES.

The name of Socrates is familiar to every one among his earliest classical recollections. Who has not heard of the Athenian sage, the great moralist of heathenism, and his persecution and constancy even to death? There is no name indeed which stands forth more conspicuously in the history of the philosophy, or of the religion, or of the general civilisation of the ancient world. It marks a distinct era in the history of the human race. The character of a great period in the history of man is concentrated, in fact, in the life and teaching of this extraordinary individual; and his name accordingly has descended to us with all the importance of the crisis itself at which he flourished; recommended as it is to our affection and admiration, not so much by the characteristics of his personality, as by the tradition of his influence and authority.

For when we come to consider his particular biography, we find our attention arrested by little that belongs merely to the individual. We read of a long life passed for the most part in uniform tenor within the walls of his native Athens; and, until we come to its tragical close, scarcely distinguished in point of intellect from that of the mass of his contemporaries. When, again, we ask for writings from which, as from the proper mirror of the philosopher's mind, we may collect some express lineaments of his character and teaching, we find nothing even on this ground on which our curiosity can fasten; so little have we derived that interest which the mention of Socrates now awakens from himself immediately; and so much, on the other hand, are we indebted for our acquaintance with this philosopher to a popular feeling preserving and handing down to us the name which represents the thought and character of an age.

The conjuncture of events at the time of Socrates was

peculiarly favourable to the development of such a character. Socrates, born at Athens in the year 469 or 470 B.C. grew up to manhood during those years when Athens, standing on the proud eminence of her victories of Marathon and Salamis, was consolidating her power as a sovereign state and seat of empire. In the course of the fifty years which intervened between her triumphant resistance to the Persian invasion and the commencement of the Peloponnesian war, Athens, like Rome in her struggle with her Italian neighbours, had gradually converted her allies in the islands and on the coasts of Asia Minor and Thrace into dependent subjects and tributaries. But Athens had not, like Rome, the prudence to combine these scattered members of her empire, elements of discord and trouble as much as of strength to the sovereign state, by the free communication of the rights of citizenship. Nor indeed could this wise expedient have availed in the case of Athens as in that of Rome. For the states over which the empire of Athens extended were either independent governments reluctantly submitting to her yoke, or the weak dependencies of a rival power, and indisposed to acknowledge the sovereignty of Athens but so long as that power wanted the vigour and the enterprize to head a coalition against the common oppressor. There were thus in the very constitution of the Athenian empire, materials of jealousy and disunion, which no line of conduct but the impolitic one of surrendering an arbitrary rule into the hands of the people who had groaned under it, could long have kept from explosion. And, in fact, it was not the policy of Athens (masterly as that policy was under the hands of her great leaders) which sustained her empire for more than fifty years, so much as the inertness of her great rival, Lacedæmon, and the difficulty of bringing the several grievances of the subject-states to bear on some decisive point, capable of influencing the movement of the whole in a strenuous concerted effort of resistance. At length we see this effort in the outbreak of the Peloponnesian war, as well as the difficulty of it in the complicated diplomacy by which that great movement was preceded, and in the reluctance of Lacedæmon to bring home to herself the necessity of exertion.

But, whilst Athens was thus aggrandizing herself against a day of retribution from the insulted states of Greece, she enjoyed the sunshine of her day of empire, in the brilliant assemblage, which she then witnessed within her walls, of the great, and the learned, and the eloquent, from all parts of Greece.[1] While her arms and her enterprize were setting foot on every sea and land, her attractiveness as a home of genius and civilization, was evidenced in the number of strangers frequenting her porticoes, and groves, and theatres, and temples, and the houses of her nobles. During thirty years of this period of glory, the philosopher Anaxagoras was employed in propagating there the doctrines of the Ionic school, honoured by the patronage of her great men, and the revered master of her choicest spirits in the newly-acquired taste for philosophical inquiry. During, also, a considerable portion of the same period, the sophist Prodicus was domesticated within her walls, surrounded by crowds of admiring pupils from the highest ranks of her citizens, eagerly catching the inspiration of that rhetorical ability for which he was famed. Occasionally, too, amongst the distinguished visitors of the city, might be seen other illustrious professors of the day, also familiarly known by the name of sophists, then a complimentary designation,—Protagoras of Abdera, Gorgias of Leontium, Hippias of Elis,—drawn there by the demand for that literary merchandize, of which they claimed the monopoly. There also were now collected, as in a school of all arts, the great masters of the drama, of sculpture, and painting, and music, and the gymnastic exercises. So that Athens, at this time, contained within her own bosom abundant resources for the enlargement of the mind, whether in the eminent men who formed her society, in the lectures and conversation of the professors of science, or in noble works, the specimens and examples of what genius could effect. Athens contained, also, doubtless, much to enervate and corrupt the moral judgment, whilst she presented every thing to exalt the imagination and refine the taste. Her political institutions, well-balanced as they had been left by Solon, were now violently disturbed. In the course of these years of imperial greatness and prosperity, they received a large infusion of that licentious spirit, which the naval successes of the Athenians had engendered in the lower order of the citizens,[2] and the flattery of successive demagogues had fostered and diffused through the whole of the state. Now, also, faction divided the ties of family and kindred, and formed associations of the people for every lawless purpose of private ambition and cupidity. Their highest and purest court,—one principal anchor of the state, according to the intention of their great legislator,[3]—the Areopagus, was mutilated in its powers. And whilst numerous courts of law, thronged by their hundreds of judges, chosen by lot from the whole body of citizens, were constantly open,[4] and an idle populace were encouraged, by pay from the public treasury, to attend on the business of these courts, the functions of the legislative and deliberative bodies were virtually suspended. The peremptory power of these judicial committees, in which the people at large felt and exercised a despotic authority, became the real executive of the state. Then came into intense activity the vile system of sycophancy,—a system, under which the life and property of the wealthy were at the mercy of every needy adventurer who could speak to the passions of the people, and earn a livelihood for himself by a career of successful prosecutions.

Nor was public corruption unattended by its usual evils of private luxury and debauchery. At this time too, there might be observed in the heart of a city which prided itself on its pious feeling,[5] and amidst the frequency and splendour of festivals and external rituals of religion,[6] a profane scepticism with regard to the fundamental principles of religion and morality. A spirit of self-conceit and of presumption of knowledge, already natural to the Athenians, had now widely spread among the people; and every one was by turns dogmatist or sceptic,—according as it was his own opinion that he asserted,—or as he might display his ingenuity in questioning some received principle, or disputing some opinion proposed by another.

Add to these circumstances, the effect of a large slave population, the degraded ministers to the wants and the wealth of an insolent body of citizens, and of a number of resident foreigners engaged in carrying on the manufactures and trade of the city, paying a tax for their protection, and contributing to the military strength of the state, though excluded from its franchise. The slave, indeed, and the

[1] Isocrat. Panegyr. Καὶ τὸ πλῆθος τῶν ἀφικνουμένων ὡς ἡμᾶς τοσοῦτον ἐστιν, κ.τ.λ. p. 59.

[2] Aristot. Polit. ii. 9, τῆς ναυαρχίας γὰρ ἐν τοῖς Μηδικοῖς ὁ δῆμος ἄιτιος γενόμενος ἐφρονηματίσθη, κ.τ.λ.

[3] Plutarch. Solon, 19, οἰόμενος ἐπὶ δυσὶ βουλᾶις ὥσπερ ἀγκύραις ὁρμοῦσαν, ἧττον ἐν σάλω τὴν πολιν ἔσεσθαι, κ.τ.λ. Tom. i. p. 352, ed. Reiske.

[4] Aristoph. Nub. 208, ἅιδε μὲν Αθῆναι. Στ. τί σὺ λέγεις; οὐ πέιθομαι, ἐπει δικαστας οὐχ ὁρῶ καθημένους.

[5] Soph. Œd. Col. 1006, ἐί τὶς γῆ θεοὺς ἐπίσταται τιμᾶις σεβίζειν, ἧδε τοὐνθ' ὑπερφερει.

[6] Xenophon, in his *Memorabilia*, i. c. 4, gives an instance in Aristodemus of one who not only had a contempt for all religion, but even derided those who concerned themselves with it.

Socrates. foreigner, lived more happily at Athens than at Lacedæmon, or perhaps any other city of Greece, especially during a time of war, when their services were needful to the state.[1] Slavery, therefore, acted probably less injuriously on the character of the Athenian master, than it did elsewhere in Greece. It was tempered by the social humour of the people. But the facility thus afforded to the citizens of living in indolence and ease, and abandoning all domestic employment for the excitement of the public assemblies, and the courts, and the spectacles, naturally induced a neglect of the private and domestic duties. There is reason to believe, that whilst the Athenians appeared in the face of the world the most light-hearted of men, they were secretly unhappy in their homes; living in listlessness from day to day on the alms of their public pay; many of them reduced from affluence to poverty through the loss of lands and property by the ravages and pressure of war, and yet unable or unwilling to use the necessary exertions to relieve themselves from their distress. It is evidently no singular instance which Xenophon has given of this state of things at Athens, when he tells us of Aristarchus complaining to Socrates of the number of poor female relatives who, from losses in the course of the Peloponnesian war, were thrown on him for support. The difficulty which Aristarchus felt, was, that he could not expect persons who were free-born and his own kindred, to undertake any manual labour, so as to assist in maintaining themselves. Happily, however, he adopts the friendly suggestion of Socrates, and makes the experiment of setting them actively to work. The experiment succeeds; and thus contentment and cheerfulness are introduced to a home where before all was gloom and mutual suspicion.[2]

In the meantime, a great number of mechanics and tradesmen had risen to wealth and importance, in consequence of the demand for every species of labour and trade, resulting from the multiplied population of the city and its numerous foreign dependencies and connexions, and, in particular, from the magnificent public works carried on during the administration of Pericles. All this while, Athens was becoming more and more a mercantile community, in the midst of strong aristocratic prejudices, still surviving, and rendered, indeed, more intense by the opposition growing up around them. In many instances, the older families would be declining in wealth, exhausted by the burthens of the state or the extravagance of individual expenditure; whilst new families, the creations of successful trade and enterprize, would be obtaining influence by the force of their wealth, and encroaching on the privileged ground hitherto occupied only by right of birth. It may be easily conceived, therefore, that the mass of the society of the city would be now all fermentation and restlessness; the one class pushing their interests and their claims to equality founded on their personal title, whilst the other obstinately clung to the exclusiveness and the pride of hereditary right.

But we shall best judge of the distempered state of the social atmosphere of Athens, by adverting to the character of female society as it existed there. It has often been remarked, as the glory of modern and Christian civilization, that it has restored woman to her due place in the scale of social importance, and thus most effectually chastened and elevated the general intercourse of human life. In a country so essentially social as Greece, and especially at Athens, it was practically impossible to impose on the women the absolute seclusion of eastern despotism. Still it was even at Athens considered the rule of propriety, that the wives and daughters of citizens should live in the strict privacy of their homes, and be known and noticed as little as possible among the other sex, even for their virtues.[3] But whilst the virtuous matron was excluded from the social circles, the place which she should have held in Athenian society was filled by other females, strangers to family ties, and attracted to Athens by the licentiousness and wealth of an imperial city. The union of high intellectual endowments, and a masculine dignity of understanding, in some distinguished individuals of this class, with the graces of female loveliness, appealed with a powerful interest to the sensual elegance of Grecian taste. We find, accordingly, at Athens, at this time, forming, as it were, the female court of the sovereign people, the Milesian Aspasia, and others of less note, living in the profession of a scandalous course of life, not only without shame, but even in the enjoyment of public respect. It was not the general of the commonwealth only that felt the spell of the charms of Aspasia, but grave philosophers resorted to her house; and even the ladies of private families, in violation of the restrictions of custom, were taken there by their friends; all eager to hear those interesting conversations, and lectures in political and rhetorical science for which she was famed.[4] We may judge how deeply corrupted must have been the standard of public opinion in Greece, when female profligacy could thus veil itself from the eye of moral observation, under the graces of splendid accomplishments of mind and person. So thoroughly had refinement of intellectual taste and of manners, together with the grossest impurity of morals, pervaded the whole society of Athens, that even those who were elevated above the world around them in talents, and strength of character, and kindliness of disposition, as Socrates was, imbibed in some measure the poison of the infected atmosphere which they breathed.

Such, then, was that state of things in which Socrates was trained, and which will greatly account to us for that peculiar form which the character of his philosophical teaching exhibits. For he was ever an Athenian instructing Athenians. He spoke as one fully conversant with the habits of thought and action of his countrymen; as knowing what kind of instruction they most needed, and by what mode of address he might best win their attention. We might expect, therefore, to see in him some leading traits of the Athenian civilization of his time; a teaching, admirable indeed in its main features, but bearing, at the same time, some marks of that corrupt state of society which called it forth, and to which it was immediately addressed.

The son of Sophroniscus a sculptor, and Phænareté a midwife, and himself brought up in his father's art, he yet enjoyed those advantages of mental culture and social refinement which were common to every citizen of the democratic Athens. The meanness of his birth and his poverty, much as high birth and wealth were esteemed there, would not exclude him from familiar intercourse with persons of the highest rank and consideration in the state. Nor, indeed, could the advantages of education be restricted to a privileged few, where every one lived in public, and where knowledge was for the most part acquired and communicated by conversation and oral discussion.

If, in the general relaxation of discipline at Athens, the citizen was no longer obliged to submit himself to a prescribed course of education under the eye of the state, and it was

[1] Aristoph. Nub. 5, ἀπόλοιο δῆτ', ὦ πολέμε, πολλῶν ὄυνεκα ὅτι ὄυδὲ κολάσαι ἔξεστί μοι τοὺς οἰκέτας.

[2] The story is beautifully told by Xenophon in his simple manner in the *Memorabilia*, book ii. chapter 7. See also Mem. ii. 8.

[3] Thucyd. ii. 45, τῆς τε γὰρ ὑπαρχούσης φύσεως μὴ χείροσι γενέσθαι ὑμῖν μεγάλη ἡ δόξα, καὶ ἧς ἂν ἐπ' ἐλάχιστον ἀρετῆς πέρί ἢ ψόγου ἐν τοῖς ἄρσεσι κλέος ᾖ.

[4] Plato, Menex.—Xenoph. Mem. ii. 6.—Plutarch. Pericles. 24. Καὶ γὰρ Σωκράτης ἐστιν ὅτε μετὰ τῶν γνωρίμων ἐφοίτα. καὶ τὰς γυνᾶικας ἀκροασομενας οἱ συνήθεις ἦγον ὡς ἀυτην, κ.τ.λ. Tom. i. p. 638, Reiske.

left to each person to avail himself, or not, of the sources of instruction presented in the intellectual society of the city, Socrates was not a person to neglect the advantages placed in his way. Money he had not, to pay to the Sophists, the great masters of his day. But he had from childhood an inquisitive mind. He felt that he was thrown on his own resources of thought, and that he must be his own master in the art of education. And to this great object he appears to have bent, from the earliest time, all the powers of his energetic mind, making it his constant employment to inquire from every one,[1] and collect on every occasion, some hint towards the right prosecution of it. We may picture to ourselves the young Socrates, resembling the Socrates of mature life, freely entering into conversation with all to whom he had access; feeling and acknowledging his own ignorance; listening attentively to all that he heard; weighing and discussing it in his own mind with patience and acuteness; and not resting until he had traced it out in all its bearings to the utmost of his power. Thus would he gradually form and strengthen that faculty of observation, and that analytical acumen for which he was afterwards so eminently distinguished.

Nor has Plato improbably put a prophecy of his future eminence in the mouth of one of the great masters of the day, when he makes Protagoras say of him, with the self-complacency of the man of established reputation: "For my part, Socrates, I commend your spirit, and the method of your reasoning; for whilst in other points I am no bad sort of person, as I think, I am the farthest from being an envious one. For concerning you in particular, I have already observed to many, that of all I meet, I admire you by far the most; of those of your own age, even to the extreme; and I say too, I should not be astonished if you were to turn out a man of celebrity for philosophy."[2] To the same effect is the story, that his father, being at a loss how to educate him, consulted the Delphic oracle, and was advised to leave him entirely to his own bent, inasmuch as he had a director in himself superior to a thousand teachers.[3] The simple interpretation of what is here thrown into the form of marvel probably is, that he gave, even when a child, striking indications of a devotedness to those studies which became the business of his manhood.

The notice of a wealthy individual of Athens, the excellent Crito, appears to have been early attracted to Socrates. Crito was of about the same age as Socrates;[4] and an attachment to the pursuit of philosophy, and an admiration of the character of Socrates, naturally led to that intimacy which he now commenced with the young philosopher, and steadily maintained through his subsequent life. Through him Socrates was relieved from the necessity of earning his livelihood by the profession of a sculptor; or, as Laertius expresses it, "was raised from the workshop."[5] Sculpture, indeed, was in high honour at Athens, especially at this time. For Phidias, enjoying the protection of Pericles, was now adorning the city with the immortal productions of his own chisel, as well as other noble works of art executed under his taste and direction. But to follow up the profession with success, required a devotion of mind and hand that must preclude the opportunities indispensable for the moral student. And though, for a time, Socrates worked at the art,—and with success, if a statue of the Graces in the citadel of Athens, attributed to him, were really his workmanship;[6]—we may imagine how distasteful the occupation, however intellectual in itself, must have been to a mind, so eager for observation on living man, so intent on mental and moral phenomena, as that of Socrates; and how gladly he would exchange the labour of his paternal art for that philosophic leisure which the friendship of Crito held out to him.

The world of that day reproached the philosophers with servility, taunting them with being ever seen at the "gates of the rich." In some instances, the reproach may have been just. But in general, the fact was the reverse. Their society rather was courted by the great and wealthy, who were proud of the reputation of being patrons of philosophy. To Socrates, indeed, the patronage of a man of wealth would be peculiarly acceptable, not so much for the means of subsistence, about which he was absolutely thoughtless and indifferent, as for the society itself to which he would thus be introduced, and the opportunity of carrying on his researches into philosophy, both by books and by the oral instructions of its living professors. To him it would be the very means by which he would enlarge his field of moral observation. The social evenings of Athens were the natural sequences of the mornings of the agora, and the courts, and the council, and the assembly. They prolonged in festive conversation that strife of words and competition of argument, which had been begun in the busy and serious discussions of the morning, and of which the last murmurs had scarcely died away on the ear of the assembled guests. For Athenian life was a life of constant excitement. What Demosthenes observed an hundred years afterwards, and an apostle four hundred years later still, —that the Athenians did nothing but go about and ask the news of the day,—was a characteristic of the people already strongly developed at this period of their history. Socrates, who, in his own person, gave a philosophical cast to this inquisitive spirit, would be peculiarly interested by such opportunities of exercising it as were presented in the animated encounters of the symposium. There he would see human nature displayed in some of its most striking forms. There he would meet the citizen full of years and honours, experienced in the arts of government and diplomacy, and in the service of the state by land and sea; the poet flushed with his victories in the dramatic contest; the sophist armed at all points for the display; the philosopher expounding his theories; the orator, the idol of the people in his day; the courtly patron of literature; and a circle of young men, the flower of the highest rank in the state; each bearing his part in the free and lively interchange of thought, emulously provoking one another to discussion, and contending for the mastery in the conflict of debate.

By such society Socrates would be effectually prepared for that active enterprize of philosophy, which formed the whole engagement of his life. In the meagre information handed down to us respecting the details of his history, we are not able to ascertain at what precise period of life he began his career of public teaching, or at least attracted notice as the philosopher of Athens. The transition would probably be gradual, from the youthful inquirer, to the mature and expert teacher of others. This transition would be the less perceptible in the case of Socrates, from the circumstance, that he never professed to *teach*, even when he was most actively employed in teaching; but still, at the last, as he had done from the first, merely to *inquire*.[7] For his part, he disdained the *profession* of philosophy. He was disgusted with the vain pretension advanced by the Sophists, of being masters of every science, and capable of imparting instruction on any given subject. He accordingly set out with the antagonist position, that he *knew nothing:* that his only wisdom, if he possessed any beyond other men, consisted in his being *aware* of his real ignorance, whilst others ignorantly presumed on the possession of a knowledge which they had not. His teaching, therefore, was only a continuation of the process of educa-

[1] Plato, Laches, p. 186, c., ἐγὼ μὲν οὖν, κ.τ.λ. p. 176, Bip. ed. [2] Plato, Protag. Op. iii. p. 193. [3] Plutarch. de Gen. Socr.
[4] Plato, Apol. p. 78, ἐμος ἡλικιώτης. [5] Diog. Laert. in vit. ii. 5.
[6] Xenoph. Mem. i. 2, οὐδὲ πώποτε ὑπέσχετο διδάσκαλος ἐ͂ιναι τόυτου. [7] Diog. Laert. ii. 5. Pausanias, i. 22; ix 35.

tion of his own mind, by extending it to the minds of others. He was fond of describing it as an *examination* or *scrutiny* of the mind; a method of finding out the real condition of each mind, and so of preparing it for the due exercise of its powers in the practical emergencies of human life. He saw that the evils of life arose, in great part, from the wrong judgments of men,—from their mistaking their own powers, presuming on their knowledge, and ability, and the truth of opinions adopted without inquiry. He endeavoured then to effect the cure of human error and unhappiness by a reformation of the intellect. The first step towards this would be taken, if men could be only divested of this vain self-confidence; if they could be brought to *suspect* that they might be mistaken in their judgments, and so to *question* themselves. This preliminary labour was employment enough for any one man's life, especially in a society such as that of Athens, so entirely infected with the sophistical leaven. Socrates wisely confined his exertions to this simple object. He is content to excite inquiry,—to provoke discussion,—and thus to suggest the necessity of self-discipline in order to right judgment. He does not, like other philosophers, quit the seclusion of a study, or the field of foreign travel, to come forth to the world the accomplished teacher of the accumulated wisdom of years of solitary thought and reflection. Whilst philosophizing in the agora and the streets of Athens, in the workshops of the artizan, or at the banquets of the rich, he is still employed in the work of *disciplining* the mind. Thus he passes on insensibly from the education of himself to the education of others, and it is difficult consequently, or rather impossible, to say in his case, where the character of the learner ends, or where that of the philosopher and teacher begins.

Yet, entirely as Socrates disregarded all positive knowledge, and threw himself on the resources of a shrewd and extensive observation of human nature, we must not suppose that he neglected to inform himself in the existing systems of philosophy, and the particular sciences as they were then understood and taught. There is reason to believe, that he had accurately studied the systems of the early physical philosophers of the Ionic school, as well as the moral and mathematical theories of the Pythagoreans, and the dialectics of the school of Elea. Without supposing him so deeply versed in the doctrines of the several schools, as would be inferred from his exact discussions in the dialogues of Plato, there is still ample evidence, from the more direct account of Xenophon, that he was by no means ignorant of them. He had doubtless read much,[1] as well as observed much, when he commenced his philosophic mission. Xenophon indeed tells us that Socrates considered the physical and dialectical theories of his predecessors as unprofitable. But he takes care to add, that Socrates was not unacquainted with these theories. And in particular, as to the sciences of astronomy and geometry, he thought the attention of the student wasted in investigating their more abstruse theorems. But he was able (as Xenophon further observes), to speak on the subjects of these sciences also from his own knowledge of them.[2]

Nor are we to suppose that, whilst he had properly no master in that line of philosophical study which he had marked out for himself,[3] he had no aid in the cultivation of his mind, from the living masters of philosophy in his day. The long residence of Anaxagoras at Athens, probably coincides in time with part of the early life of Socrates.[4] To him, therefore, Socrates would naturally have access, as well as to Archelaus,[5] his disciple, and the inheritor of his doctrines. If he had no personal intercourse with Anaxagoras, it is at least highly probable, from the testimony of Plato, that he was acquainted with the famous treatise of Anaxagoras, which contained his theory of the universe.[6] And perhaps we may distinctly trace the early and abiding influence of the lessons of this great philosopher throughout the teaching of Socrates, in his uniform maintenance of the principle of an all-disposing mind, the glory of the system of Anaxagoras.

To the writings of Heraclitus, his attention appears to have been drawn by the poet Euripides; if the anecdote be true, as related by Laertius, that on being asked by Euripides, who had put them into his hand, what he thought of them, he replied, alluding to the studied obscurity of that philosopher; "What I understand is excellent; so also, I suppose, is what I do not understand; only there is need of some Delian diver to reach the sense."[7] He had also opportunities of conversing with Zeno the Eleatic, and Theodorus of Cyrene; the former eminent for his dialectical skill, the latter the most distinguished geometrician of the time. And though his scanty means precluded his attendance on the professional lectures of Prodicus, the fashionable teacher of rhetoric at that day at Athens, it cannot be doubted that he would on several occasions have been among the company assembled at the house of some wealthy citizen, and there heard from the lips of that accomplished master of language those elaborate oratorical displays which made his name proverbial for wisdom.[8] With the poet Euripides, indeed, the disciple of Anaxagoras and Prodicus, and who was his senior only by a few years, he appears to have lived in habits of intimacy. With Euripides he would probably often have discussed those ethical topics which the poet so greatly delighted to transfuse into his tragic scenes, and associate with the interest of dramatic incident. They were in fact brother-labourers in the same cause, though in different ways. For whilst Euripides endeavoured to work a reformation of his countrymen, by didactic addresses insinuated through their feelings, amidst the interest of tragic story, Socrates appealed at once to their understandings, and amidst the business or pastime of real life. The envy of contemporaries was prone to attribute the excellence of the poet in some of his dramatic efforts, to the aid of his philosopher-friend.[9] The truth probably is, that the benefit of their intercourse was mutual; that, whilst the poet's imagination was informed and chastened by the shrewd and severe wisdom of the philosopher, the philosopher also, ever intent on his calling, would enlarge his mind with riches drawn from the genius, and taste, and learning of the poet.

The co-existence of literary and philosophic elegance with the most disgusting coarseness of moral feeling and conduct, in the character of the Athenian courtesan, has been already noticed. To Aspasia, the heroine of her class, as we may call her, when we refer to her influence over Pericles, and the encomiums of her by Plato and others, Socrates is expressly stated to have been indebt-

[1] Xenoph. Mem. i. 6.

[2] Xenoph. Mem. iv. 7.

[3] He reckons himself in Xenoph. Conviv. i. 5. among the *αὐτουργὸι τῆς φιλοσοφιάς*.

[4] It must be admitted, however, that the chronology of the life of Anaxagoras is very doubtful.

[5] Archelaus is called both a Milesian and an Athenian. The probability is that he was a Milesian, since philosophy had scarcely yet found a home at Athens.

[6] See the Phædo, p. 97. The writings of Anaxagoras appear to have been extensively circulated. Socrates is made in Plato's *Apology* to say to Meletus, *ὄιει αὐτοὺς ἀπειρους γραμμάτων εἶναι, ὥστε ὀυκ ἐιδέναι ὅτι τ' Ἀναξαγόρου βιβλία τôυ Κλαζομενίου γέμει τουτων τῶν λόγων*.

[7] Diog. Laert. in vit. ii. 7.

[8] Plato, Meno. p. 96. *Κινδυνεύομεν, ὦ Μένων, ἐγώ τε καὶ σὺ, φâυλοι τινες ἐῖναι ἄνδρες, καὶ σέ τε Γοργίας ὀυχ ἱκανῶς πεπαιδέυκεναι, καὶ ἐμὲ Πρόδικος*. P. 382. Bipont.

[9] Aristoph. Nub. Diog. Laert. in vit. ii. 5.

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ed for instruction in rhetoric, as also in other subjects.[1] Whilst Xenophon also introduces him familiarly conversing with Theodota, whom he describes as living in great splendour at Athens, the object of general admiration for her personal charms, and inviting her to become his disciple,[2]—Plato leads us to believe that Socrates was himself the disciple of another of the same class, the Mantinean Diotimè, who, among her other accomplishments, was distinguished in particular for her skill in the art of divination.[3]

Instruction in music formed an important part of Athenian education. Socrates, it seems, did not neglect the opportunities which the presence of the great masters of the art in Athens afforded him of learning its principles. Connus accordingly is claimed for him, as his master in music.[4] Damon, another celebrated musician, though not more eminent in the science which he professed, than as a politician and sophist, was resident at Athens during part of the administration of Pericles, the intimate and counsellor of that great statesman, as well as his instructor in music.[5] From him also, we are told, Socrates received instruction in the art. By these accounts, however, we may probably understand, not that he became a proficient in the musical art, but that he had listened to Damon as well as to Connus, discoursing on the subject, and studied its theories under them, so far, at least, as music entered into the general pursuit of philosophy.[6]

It should be observed, indeed, that though Socrates strongly discouraged the *presumption* of knowledge in all with whom he conversed, he did not disapprove of the acquisition of particular kinds of knowledge. He communicated whatever he knew to every one that came in his way; and where he was himself unacquainted with any subject, he referred his hearers to those who possessed the information.[7] He was not in fact opposed to knowledge in itself. He was glad to embrace it wherever it could be found. But he was an enemy to the substitution of mere intellectual acquisitions,—and those often superficial and unreal,—for *education* of the mind and character. He felt, and justly felt, that knowledge by itself was vanity. The tendency of the age was to ascribe value exclusively to mental acuteness and dexterity. Ingenuity and cleverness obtained the merit and the prize of wisdom. His labour was to draw his countrymen from thinking too highly of their boasted knowledge. He wished them to see how greatly they overrated intellectual acquirements,—how much they had yet to learn if they would be real proficients in wisdom.

Socrates indeed appears to have regarded philosophy in the light of a sacred mission, to which he was specially called, rather than of a study and exercise of the mind. This notion of philosophy had already been exemplified by Pythagoras and his followers. But they had realized it by forming themselves into distinct communities or colleges; separating themselves from the world around, by a solemn initiation, and the practice of an ascetic discipline. Socrates, however, had no thought of changing the outward form of society. He did not propose, like Pythagoras, to institute a refuge from the pollutions and misery of the world, or to educate a peculiar brotherhood, who should afterwards act on the social mass. He did not address himself to the few. His school was all Athens. or rather indeed all Greece. Leaving society as it was, he sought to infuse a new spirit into it, by carrying his philosophy into every department of it. He therefore went about among all classes of people, preferring none, despising none, but adapting his instructions to every variety of condition and character. Thus did he in truth, according to the observation commonly applied to him from the time of Cicero, bring down philosophy from heaven to earth; but not so much by being the first to give a moral tone to philosophy, as by the universality and philanthropy of his teaching. Philosophy in his hands was no longer an exclusive and privileged profession. It no longer spoke as from an oracular shrine, and in the language of mystery. It now conversed with every man at his own home,—submitted to be familiarly approached and viewed without reserve,—and, instead of waiting to be formally consulted by its votaries only, volunteered to mingle in the business, and interests, and pleasures of every-day life.

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His manner of life and of teaching is thus described by Xenophon.[8]

"He was constantly in public. For early in the morning he would go to the walks and the gymnasia; and when the agora was full, he was to be seen there; and constantly during the remainder of the day, he would be wherever he was likely to meet with the most persons; and for the most part he would talk, and all that would might hear him."

The nature of his conversations is thus further reported by the same faithful authority:

"No one ever saw Socrates doing, or heard him saying, any thing impious or profane. For not only did he not discourse about the nature of all things, as most others, inquiring how, what by the sophists is called the universe, consists, and by what laws each heavenly thing is produced; but he would point out the folly of those who studied such matters. And the first inquiry he would make of them was, whether they proceeded to such studies from thinking themselves already sufficiently acquainted with human things; or whether they thought they were acting becomingly in passing by human things, and giving their attention to divine. He would wonder, too, it was not evident to them, that it was not possible for men to find out these matters; since even those who most prided themselves on discoursing of them, did not agree in opinion with each other, but were affected like madmen in relation to one another. For of madmen, whilst some did not fear even the fearful, others were terrified at things not terrible; whilst some were not ashamed to say or do any thing even before the multitude, others objected even to going out into the world; whilst some paid no honour to sacred things, or altars, or any other religious object, others worshipped even stones, and common stocks, and brutes. So of those who speculated on the nature of the universe, whilst some thought that Being was one only, others thought it was infinite in number; whilst some thought that all things were in perpetual motion, others thought it impossible for any thing to be moved; whilst some thought that all things were in a course of generation and destruction, others thought that nothing could possibly be generated or destroyed. He would further consider respecting them thus: whether, as the learners of human things think they shall be able to make practical use of their knowledge for themselves and any one else at pleasure, so also the searchers into divine things hold, that having ascertained by what laws each thing

[1] Xenophon, Mem. ii. 6. Μὰ Δί', οὔχ, ὥς ποτε ἐγὼ Ἀσπασίας ἤκουσα. ἔφη γὰρ, τὰς ἀγαθὰς προμνηστρίδας, κ. τ. λ. P. 101. Plato, Menexenus, p. 235. Καὶ ἐμοὶ μέν γε, ὦ Μενέξενε, οὐδέν θαυμασὸν οἵῳ τ' εἶναι εἰπεῖν, ᾧ τυγχάνει διδάσκαλος οὖσα ὀυ πάνυ φαύλη περὶ ῥητορικῆς, ἀλλ' ἥπερ καὶ ἄλλους πολλοὺς καὶ ἀγαθοὺς ἐποίησε ῥήτορας, ἕνα δὲ καὶ διαφέροντα τῶν Ἑλλήνων, Περικλέα τον Ξανθίππου. Μ. τίς αὕτη; ἢ δηλονότι Ἀσπασίαν λεγεις; Σ. λέγω γάρ; καὶ Κόννον γε τὸν Μητροβίου. οὗτοι γάρ μοι δυο εἰσὶ διδάσκαλοι· ὁ μὲν μουσικῆς, ἡ δὲ ῥητορικῆς. P. 277. Bipont.

[2] Xenophon, Mem. iii. 12. Ælian. Var. Hist. xiii. 31.

[3] Plato, Conviv. p. 201. op. t. 10. p. 227. Bipont.

[4] Plato, Menexenus.

[5] Plutarch in Pericl. op. t. i. p. 594. Reiske.

[6] Diog. Laert. in vit. ii. 5, 15. Laertius says that Socrates learned to play on the lyre.

[7] Xenoph. Mem. iv. 7.

[8] Mem. i. 1. 10; also Plutarch, *Utrum seni ger. Resp.*

is generated, they shall be able to produce at pleasure winds, and waters, and seasons, and whatever else of the kind they may want; or whether they have no such expectation, but it suffices them only to know how every thing of this kind is generated. Such, then, was his manner of speaking about those who busied themselves with these matters. But, for his part, he was ever discoursing about human things, inquiring what was pious, what impious, what honourable, what base, what just, what unjust, what sobriety, what madness, what courage, what cowardice, what a state, what a statesman, what a government of men, what the character of a governor; and about other subjects, which, by being known, would make men honourable and virtuous, whilst those who were ignorant of them, would justly be called slavish."

Xenophon has thus fully touched the character of the teaching of Socrates in its leading points, and the nature of his constant occupation at Athens. The intermissions of military service appear to have been the only occasions of any variation in this uniform course of life. No other country had any charms for him, as no other afforded such rich opportunities of conversing with men, and studying human nature.[1] His activity was essentially different from that either of his predecessors or successors in the path of philosophy. They travelled from place to place searching for knowledge, storing their minds with various observations, and making philosophy their formal business. Socrates, as he had no stated school or place of audience, so he had no design of framing any system of philosophy, or of enlarging the researches and discoveries of former philosophers, or of pursuing knowledge as an ultimate object. He regarded himself as called by the voice of Deity, to undertake the reformation of men, and especially of his fellow-citizens, as constituting his proper sphere of duty, from their corruptions of sentiment and conduct. He stood, therefore, by the great stream of human life which was ever flowing at Athens, and watched its course. He is said once to have visited Samos in company with Archelaus, the disciple of Anaxagoras, and also to have gone to the Pythian and the Isthmian games. With these exceptions, and those of the occasions of military service abroad, he appears to have constantly remained at home, unattracted from the town, the seat of his philosophic mission, by invitations even to the courts of princes. In vain did Scopas of Cranon, and Eurylochus of Larissa, offer him money, and invite him to visit them.[2] He could refuse also the hospitality of Archelaus, king of Macedonia, the same with whom the poet Euripides found a kind and honourable refuge in his old age, from the envy of his countrymen, and domestic grievance. His refusal of the invitation of Archelaus is said indeed to have been accompanied with the declaration of his feeling, that he could not brook the acceptance of a favour which it was entirely out of his power to return.[3] Nay, so entirely engrossed was he in the work to which he had devoted himself, that he was a stranger, as Plato represents him, even to the immediate neighbourhood of the city. The banks of the Ilyssus, even then classic ground, rich with legendary associations, could not seduce him from the agora and the crowd; so that he seemed scarcely at home beyond the walls of Athens.[4]

No Athenian, however, could decline the military service of the state. And this service, at the time of Socrates, often engaged the citizen in hazardous enterprizes and long absences far from his home. The first occasion on which Socrates is related to have served, was in the Chersonese at Potidæa, just before the opening of the Peloponnesian war. The service in which the Athenian soldiers were engaged here was one of great hardship. It was in the winter season, and the climate in those parts was most severe. Amongst those who distinguished themselves by their resoluteness and gallantry, none was so conspicuous as the philosopher. Whilst others were clothing themselves with additional garments, and wrapping their feet in wool, he was observed in his usual dress, and walking barefoot on the ice, with more ease than others with their shoes. Nor even amidst these circumstances, did he merge the character of the philosopher in that of the soldier. He was seen one morning at sun-rise fixed in contemplation. At noon he was in the same position, and still in the evening, and so continued through the night, until the sun-rise of the following day. Such, too, was his bravery in the engagements at Potidæa, that he earned for himself the prize of distinction, but readily sacrificed his claim to the wishes of the generals, in favour of a more illustrious candidate in the person of Alcibiades. Alcibiades himself would have refused the honour as due rather to Socrates; for to the unwillingness of Socrates to leave him wounded on the field, he had been even indebted for his own life, and the preservation of his arms, after the battle. But the philosopher, with a true magnanimity, insisted on the award of the generals.[5]

The next occasion of military service, in which he was scarcely less distinguished than at Potidæa, was in the eighth year of the Peloponnesian war, at the battle of Delium in Bœotia. The battle was an unsuccessful one to the Athenians, and they were forced to retreat in disorder. Alcibiades was also present on this occasion, and overtook Socrates in company with Laches, one of the generals, on the way. He was on horseback, and comparatively therefore out of danger, whilst they were on foot. He had opportunity, therefore, of admiring the presence of mind which Socrates displayed on the occasion, even beyond Laches, and the steadiness and vigilance with which he kept the enemy from pressing upon them, and so secured their retreat.[6]

These incidents seem to rest on indisputable evidence. The account of them is put into the mouth of Alcibiades by Plato, in that most ingenious of his dialogues, the *Banquet.* The very form in which they are introduced, related as they are by an eye-witness, and that witness Alcibiades, the person, next to Socrates himself, most interested in them, may justly be regarded as giving a sanction to their history, independent of the fictitious circumstances of the dialogue.

The third occasion on which Socrates served as a soldier

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[1] Plato, Laches, 187, e. *῎Ου μοι δοκεῖς εἰδέναι ὅτι ὃς ἂν ἐγγυτάτω Σωκράτους ᾖ λογῳ, ωσπερ γένει, καὶ πλησιαζῃ διαλεγόμενος, ἀνάγκη αὐτῷ . . . . περιαγόμενον τῷ λόγῳ, μὴ παύσασθαι ὑπὸ τοὐτου πριν ἐμπέσῃ εις το διδόναι περὶ αὐτοῦ λόγον, ὅντινα τρόπον νῦν τε ζῇ, καὶ ὅντινα τὸν παρεληλυθότα βίον βεβιώκεν, κ. τ. λ.* P. 180.

[2] Diog. Laert. in vit.

[3] Aristot. Rhet. ii. 23.

[4] Plato, Phædr. 230. *Συ δε γε ὦ θαυμάσιε, ἀτοπώτατός τις φαινῃ· ἀτεχνῶς γὰρ ὁ λέγεις, ξεναγουμένῳ τινὶ καὶ οὐκ ἐπιχωρίῳ ἔοικας· ὅυτως ἐκ τοῦ ἄστεος οὔτ᾽ εἰς τὴν ὑπερορίαν ἀποδημεῖς, ὀυτ᾽ ἔξω τείχους ἔμοιγε δοκεῖς τοπαράπαν ἐξεἶναι. ΣΩ. Συγγίνωσκε δὴ μοι, ὦ ἄρισε, φιλομαθὴς γὰρ ἐιμι· τὰ μὲν οὖν χωρία καὶ τὰ δένδρα οὐδὲν με θέλει διδάσκειν, δι δ᾽ ἐν τω ἄστει ἄνθρωποι.* P. 287; also Crito, p. 120.

[5] Plato, Conviv. 220, a. p. 266; also Charmides.

[6] Plato, Conviv. p. 270. The story is again alluded to by Plato, in the dialogue, *Laches.* Laches is made to say that he had had experience of the *actions* of Socrates, and reminds Socrates of the day of their common danger, *ᾗ μετ᾽ ἐμόυ συνδιεκινδύνευσας, κ. τ. λ.* P. 182. Laertius says that Socrates saved Xenophon, who had fallen from his horse in the battle of Delium, (in vit. Soc. ii. 5–7.) But this cannot be true, as Xenophon would be much too young at that time for military service. In the Deipnosophists of Athenæus, (v. 55), doubt is thrown on these accounts of the military service of Socrates, and instances are given of the historical inaccuracy of Plato. The objections, however, as there given, are evidently thrown out in the way of discussion, and not with perfect seriousness, as if the speaker really thought them of weight.

was again in Thrace, at Amphipolis,[1] in the same year as that of the unfortunate expedition to Delium. No particulars are mentioned of this adventure. But the fact itself is sufficiently attested. Nor, though it follows immediately on the affair of Delium, is it improbable on that account. For at this busy period of the war, when the Athenians were making demonstrations of their power, by the presence of their forces in different places at once, and when Brasidas was pushing his successes against them in Thrace, no individual of the military age, (and Socrates was not more than forty-six or forty-seven years of age at this time), would enjoy any long interval of relaxation from foreign service.

With these exceptions, Socrates appears then to have constantly resided at Athens. All this time, throughout his whole life indeed, he lived in great poverty, content with the least that might suffice for mere sustenance and clothing from day to day.

Yet it was no artificial, and melancholy, and fanatical life that he led. He accustomed himself to a strict moderation, not with any view to the mortification of the body, or as thinking that abstinence was in itself a virtue, but in order to self-command; by rendering himself as independent as possible of the circumstances of the body, to disencumber the soul of every burthen and obstruction to its free operation. There was nothing, indeed, of austerity in his life or manner. He might be seen walking barefoot, but it was not for the pain that it might inflict. It was only that he might bear cold and privations of every kind the better, and suffer the less inconvenience when exposed to necessary hardships, and require the less for his ordinary subsistence. So far was he from studying a discipline of bodily severity for its own sake, that he was observed at times mingling in the social festivities of his fellow-citizens with the full freedom of Athenian conviviality, and shewing that he could bear excesses which mastered others, without losing his self-command.[2]

One account, indeed, but not a very credible one, as it rests on the authority of Aristoxenus, an invidious writer, states that he was supported by the alms of friends, contributed from time to time for his relief. With his very limited wants, and his ready access to the house of Crito and other liberal patrons of philosophy at Athens, he would not have to depend on this precarious charity. The pittance which sufficed for the humblest citizen would suffice for him. He is said to have inherited a patrimony of seventy or eighty minæ.[3] But this sum, it is added, he lost (though the time is not stated when the loss occurred) by the failure of the person with whom it had been placed at interest. He possessed also a house in Athens; and he was able, however scantily, to support a family. So that we cannot suppose he was absolutely destitute of all resources of subsistence. He appears then rather to have voluntarily renounced every kind of worldly possession, so far as his own personal comfort was concerned, than to have been absolutely reduced to want by the pressure of circumstances. Poverty, in fact, was his profession, and not the mere necessity of his case. If he prided himself in any thing, it was in his avowal of his contempt for riches, and disregard of domestic interests and comforts, in contrast with the general habits of an age of selfish activity and profusion. The means of enriching himself, at least of extricating himself from want, were often placed in his power, and he as often rejected them. Alcibiades offered him land on which he might build a house, but he refused it pointedly, observing, "Had I wanted shoes, would you have offered me leather to make shoes for myself?—and ridiculous should I have been in taking it." Charmides would have given him slaves, as a source of revenue by their labour. This offer also he refused.[4] In the same spirit, he would often cast a look at the number of things that were sold, and say to himself, "Of how many things I have no need!"[5] Thus was his whole plan of life studiously opposed to the acceptance of any provision for his comfort or ease. It was a service of the Deity in which he felt himself engaged, and in the prosecution of that, solemnly devoted to a course of hardy poverty.[6]

In the domestic relations of life, he lived an Athenian among Athenians. He differed from other heads of families at Athens in this respect, that in his dedication of himself to his philosophic mission, he took no thought about the management of his private affairs. His home was abroad; his household the people of Athens. Still he discharged the duties of a husband, and the father of a family; and that under trying circumstances, unless the proverbial severity of temper of his wife Xanthippe be esteemed an idle scandal of the day. No Athenian, indeed, was truly domestic, in the sense of making his home the scene of his highest interest and enjoyment. Nor was Socrates domestic in this sense. Still less was he so than other Athenians; inasmuch as his very profession of life was a call from the bosom of his family. But in the midst of these avocations from his immediate home, and the vexations to which he was subjected there, he was not estranged from the ties of domestic affection. Xenophon has recorded a simple and touching trait of the character of Socrates under this particular point of view—a trait the more interesting, as almost every thing else that we know of the philosopher is drawn from his life in public. It occurs in the course of a conversation between Socrates and his son Lamprocles, who had complained of the insufferable temper of his mother Xanthippe. "What," said he to the youth, "do you think it more annoying to you to hear what she says, than it is to the actors, when in the tragedies they say every thing bad of one another?" "But they, I conceive," replied the son, "bear it easily, because they do not suppose that the speaker, in contradicting them, intends to hurt them, or that, in threatening, he intends to do them any ill." "Then are you," resumed Socrates, "vexed, when you well know that what your mother says to you, she says, not only intending no evil, but even wishing more good to you than to any one else; or do you regard your mother as unkindly affected towards you?" Lamprocles disclaiming this latter supposition; "Do you, then," he added, "say of her, who is both kind to you, and takes every possible care of you when you are sick, that you may recover, and want nothing proper for you, and who, moreover, prays to the gods in your behalf for many a good, and pays vows,—that she is vexatious? For my part, I think, if you cannot bear such a mother, you cannot bear what is good for you."[7]

From the description given by Plato of the family of Socrates in the prison-scene, it would appear, that Socrates had other three children besides Lamprocles,—for Lampro-

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[1] Plato, Apolog. 28. c. op. i. p. 67. Diog. Laert. in vit. Ælian, Var. Hist. iii. 17.

[2] Plato, Conviv. Ælian, Var. Hist. iv. 11.

[3] About L.400 of our money. Plutarch (in his life of Aristides) finds fault with Demetrius Phalereus for having endeavoured to remove the imputation of poverty from Socrates, by stating that Socrates had land of his own and seventy minæ put out to interest by Crito. Demetrius, however, seems only to have stated what he believed to be the truth. The idea of his extreme indigence originated probably with the caricatures of his profession of poverty by the comic poets; and true as it was substantially, was afterwards, it seems, maintained by his friends and admirers, as the evidence of the consistency of his life with his avowed contempt for worldly possessions.

[4] Diog. Laert. in vit.

[5] Ibid.

[6] Plato, Apolog. 'Αλλ' ἐν πενίᾳ μυρίᾳ εἰμι διὰ τὴν τοῦ θεοῦ λατρείαν. Op. i. p. 5.

[7] Xenoph. Mem. ii. 2.

Socrates.

cles died at an early age, before his father,[1]—who were yet children, one of them a boy, another a child in the arms, at the time of their father's death.[2] We learn from other authorities,[3] that two of his children were named Sophroniscus and Menexenus; but they are said to have been the children, not of Xanthippe, but of another wife, Myrto, the grand-daughter of Aristides the Just.[4] To account for this, it has been stated, that after their disasters in Sicily, the Athenians made a decree authorizing double marriages, with the view of recruiting their exhausted population. But this statement does not appear to be borne out by the earlier authorities on the subject of Athenian legislation. Nor is it probable that a law should have been enacted, directly sanctioning a form of polygamy. It appears, that during the pressure and confusion of the Peloponnesian war, persons obtained the freedom of the city of Athens, whose title was objectionable on the constitutional ground of their not being born of citizen-parents on both sides. Thus had Pericles, after the death of his two legitimate sons, obtained the admission of his son, Pericles, by Aspasia, to the privilege of citizenship;[5] though he had himself carried, some time before, a law of strict limitation, under which, nearly four thousand were deprived of the franchise.[6] Such extension of the privilege to the offspring of illegal unions, possibly gave a pretext to the supposition, that a decree passed at Athens sanctioning bigamy.

Some difficulty, however, arises on the subject of the marriage of Socrates, from the conflict of authorities. Whilst it is asserted on the one hand, that he was married to Myrto and Xanthippe at the same time; on the other hand, others assign them both as his wives, but in succession, and also differ as to the order of succession. But the silence of Plato and Xenophon respecting any other wife of Socrates but Xanthippe, and their coincidence in speaking of her only as the mother of his children, may be regarded as sufficiently decisive of the point against every subsequent authority. Indeed, the reference to Aristotle, given by Laertius, which is the chief ground for believing that Socrates was married also to Myrto, is very questionable. Plutarch doubts whether the treatise to which Laertius appeals for the fact, is the genuine work of Aristotle. From the manner, too, in which the name of Myrto appears to have been introduced in the account, nothing more may have been intended, than that Socrates found her in a state of widowhood and distress from poverty, and took care of her at his own home.[7] Aristides belonged to the same tribe and the same demus or borough, as Socrates; and a reverence for the virtues of the grandfather, may have combined with these almost domestic ties, to call forth such an act of friendliness to the disconsolate Myrto. And, if this be the case, as is probable, it would only add an interesting instance of that liberal benevolence which characterized the whole conduct of Socrates.[8]

It is a confirmation of this conclusion, that all the anecdotes of the private life of Socrates, with one exception, and that evidently a fabricated instance,[9] bring Xanthippe on the scene. On his inviting some wealthy persons to supper, it is Xanthippe who is distressed by their deficient means of hospitality, and to whom he replies, "Take courage; if they are worthy people, they will be satisfied; if they are worthless, we shall care nothing about them."[10] It is Xanthippe whom he reproves for her particularity about her dress on the occasion of some public spectacle, as more desirous of "being seen than to see."[11] It is of her again that Alcibiades expressed his wonder how he could bear with her, when he simply, but pointedly referred him to her just claims on his affection as the mother of his children.[12] On another occasion, his disciple, Antisthenes, is said to have asked him, with reference to Xanthippe, why he did not study to improve the disposition of his wife, whose violence of temper (he observed) was unexampled in the history of domestic life. Instead of confirming the censorious remark, he turned it, according to his usual method, to a practical illustration of his philosophy. "If Xanthippe was hard to be controlled," was the tenour of his answer, "it was only a proper discipline to him for the management of men; as those who would be masters in horsemanship, began with managing the most spirited horse, after which, every other would be tractable."[13] These stories, and the like, handed down or invented by the humour of the times, may be merely exaggerations of the fact of the inconvenience and dissatisfaction occasionally felt at the philosopher's home, by his habitual neglect of his domestic concerns, and the duty of exertion consequently imposed on Xanthippe beyond Athenian women in general. She appears indeed to have tenderly loved her husband, if Plato has faithfully traced the picture of her visit to his prison, and her extreme anguish at that trying hour. And he also knew her value, if his affection may be judged of, as surely it may, by the kind and gentle considerateness of his manner in committing her to the care of his friends at parting, and his absolute reserve of his feelings on that occasion.[14] The picture indeed is drawn by the hand of a consummate master; and Plato, it is true, was not present on the occasion. But we must believe, that in painting a scene that must have been impressed on the mind of the disciples of the philosopher, above every other incident of his life, and of which persons then living must have retained a lively recollection, he took his outlines at least of these interesting particulars from the real state of the case.

But the allusion to these circumstances brings us prematurely to the solemn tragedy which closed his intrepid and energetic career. We have yet to contemplate him pursuing for many a year his unwearied labour of awakening his countrymen from their dreams of knowledge and happiness to the realities of their condition in the world. Great indeed must have been the address, which could recommend the severe and wholesome truths inculcated by him, to the hearing of the vain and volatile Athenians. To none is the practical application of a principle, so condemnatory of human folly and impertinence, as the maxim, "know thyself," truly welcome. And yet this was the burthen of the teaching of Socrates for a series of years, among a people, whom it was far easier to please by praising to excess, than not to displease by censuring ever so slightly. They would listen, indeed, patiently to general invectives on their public conduct, conveyed in the impassioned eloquence of their orators; as persons will even now sympathize with general descriptions of the depravity of human nature, or of whole classes of men. But all refuse the pain of direct self-appli-

[1] Plutarch, De Gen. Socr. p. 331.
[2] Plato, Phædo, pp. 135, 262.
[3] Aristotle, cited by Laertius in vit. Socr.
[4] Diog. Laert. in vit.
[5] The same who was among the generals at the battle of Arginusæ, and who were cruelly and iniquitously sacrificed to party spirit after their great victory.
[6] Plutarch in Pericl. Op. i. p. 667.
[7] The poverty of the family of Aristides appears from Ælian, Var. Hist. x. 15.
[8] Plutarch in Aristides, Op. ii. p. 542. Plutarch adds, that Panætius had sufficiently refuted the story of the double marriage in his observations on Socrates. The story is also questioned by Athenæus. Deipnosoph. xiii. 2.
[9] Porphyry in Theodorit. Therapeut. xii. tells of altercations, even to blows, between Xanthippe and Myrto, whilst Socrates stands by and laughs, amidst their joint attacks on himself. Such stories are evidently untrue.
[10] Diog. Laert. in vit.
[11] Ælian, Var. Hist. vii. 10.
[12] Diog. Laert. in Vit.
[13] Xenoph. Conviv. ii.
[14] Plato, Phædo, p. 135.

cation of the truth; and Athenians, especially, regarded with invidiousness every attempt to impart to them moral instruction. Every Athenian, they thought, was capable of communicating this kind of knowledge, at least every educated Athenian, every individual of the higher order of citizens.[1] They wanted no one to teach them virtue. Hence the allusion made on so many occasions by Socrates to the question, whether virtue could be taught or not. It was, indeed, part of the profession of the Sophists to teach virtue;[2] but it was as an accomplishment or art, and not as a *discipline of life*, that it entered into the system of the Sophists. Socrates uprooted this vain notion. He laboured to impress on the Athenians, that so far from their being able to teach virtue, there were none who knew what virtue was. They had yet to learn *themselves* in order to that purpose. This, then, was his great difficulty. It was not the difficulty of communicating *new* knowledge, but that of leading men to unlearn their presumptions and conceits, and to *feel the necessity* of moral instruction.[3] That he should have succeeded then in any degree in such an attempt,—that he should have been able to carry on the effort for so many years, in the very centre of Greek civilization,—that, proceeding on so broad and fundamental a principle of reformation, presenting no definite system on which a sect might fasten, no specific lure to the zeal of party, he should have drawn around him so many followers and admirers,—this is the extraordinary effect in the case of Socrates, which shews the powerful charm of his address. To persons offering any particular instruction, or professing to qualify them for the office of statesmen and orators, the Athenians were most ready to attend; and many doubtless did attend to the conversations of Socrates with this view. They could not but admire the skill which he displayed in arguing with every one that came in his way; not with the vulgar only, but with those who had the highest reputation for talent in reasoning, and for the extent of their knowledge. They saw his superiority to the Sophists, on the very ground on which the Sophists set up their pretensions. Many, accordingly, flocked to him as the best master in political science and dialectical skill, particularly as he was always accessible, and his instructions were perfectly gratuitous. Some, too, of a better nature than the rest, were won by the honest and manly purpose which shone through his teaching and manner on all occasions; whatever disguise of irony, or humour, or sophistry, he might assume. There were even some of the young men, whose habits of life were reproved, and principles condemned, by his searching interrogatories, but who yet were won to attention by the charm of his instruction, and patiently heard from him truths which they would not have listened to from any other lips. For who else could stay, even for a moment, the wild impetuosity of Alcibiades, or the ferocious arrogance of Critias? Their motives in resorting to Socrates were chiefly selfish and political. It was in pursuit of their schemes of ambition that they sought his society. Still he was able to retain them for a time at least, though they found his instructions very different from what they calculated on receiving; and so long as they continued to associate with him, they exercised a degree of self-restraint which strikingly contrasted with the habitual profligacy of their lives.[4] Alcibiades is represented by Plato, as confessing that he, to whom the feeling of shame was scarcely known, yet felt abashed before Socrates; that he was enchanted by him as by the flute of Marsyas, and constrained to acknowledge his own deficiences and neglect of private duty in the midst of his officious zeal for the public service. And this feeling, Alcibiades says, was general; for that there was no one, woman, or man, or boy, that could hear him, or even his words repeated by the most indifferent speaker, but felt taken by surprize, and riveted in attention.[5]

This attention, too, it should be observed, was excited by the address of Socrates, amidst much in his outward form and mien, that, by exciting ridicule, might have repelled the sentiment of respect. The comparison of him to the satyr Marsyas, with all allowance made for comic exaggeration, was true in more respects than that of the enchantment of his conversation. His countenance, strongly marked by that arch intelligence, which half-concealed, half-betrayed, the earnest deep thought, under the light veil of irony and humour, presented features resembling those of the grotesque images of the Sileni. There were the prominent dilated eyes, scarcely parted by the low ridge of the nose, the broad expanded nostrils, the wide mouth with its thick lips, such as the sculptors delighted to represent in those rude but poetic forms.[6] Then his manner of looking about him, his head fixed, whilst his eyes traversed the space around, glancing from side to side, excited the smile of wonder in the spectator, as to what this strange solemnity of aspect might portend. Add to this, the clumsy protuberance of his figure, so repugnant to Grecian notions of the symmetry of form, and the awkwardness of his movement[7] before the eyes of a people who had a lively perception of elegance in every gesture and motion.[8] These were circumstances which, to the fastidious taste of the Greeks, would appear more important than we, in these times, can well conceive. They judged of intellectual character more from physiognomy[9] (physiognomy, that is, considered as a science, of mental indications from bodily forms in general) than we are apt to do. Thus in regard to Socrates, the physiognomist, Zopyrus, who, as Cicero informs us,[10] professed to discern the manners and natures of men from their body and features, pronounced that Socrates was stupid and heavy, because the outline of his throat was not con-

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[1] Xenoph. Mem. iv. 2. 24. Κατέμαθες οὖν πρὸς τῷ ναῷ που γεγραμμένον τὸ Γνῶθι σαυτόν; Ἔγωγε. Πότερον ουν οὐδέν σοι τοῦ γράμματος ἐμέλησεν, ἢ προσέσχες τε καὶ ἐπεχείρησας σαυτὸν ἐπισκοπεῖν ὅστις εἴης; Μα Δί, οὐ δῆτα ἔφη. καὶ γὰρ δὴ πάνυ τοῦτό γε ᾤμην εἰδέναι· σχολῇ γὰρ ἂν ἄλλο τι ᾔδειν, εἴγε μηδ᾽ ἐμαυτὸν ἐγίγνωσκον, κ.τ.λ.

[2] Isocrates speaks of them as σύμπασαν ἀρετὴν καὶ εὐδαιμονίαν πωλοῦντες, and, again, as τὴν εὐδαιμονίαν παραδιδόντας Or. c. Soph. 3. 4.

[3] Plato, Euthyphro, 3. c. Αθηναίοις γάρ τοι, ὡς ἐμοὶ δοκεῖ, ου σφόδρα μέλει, ἄν τινα δεινὸν οἴωνται εἶναι, μὴ μέντοι διδασκαλικὸν τῆς αὐτοῦ σοφίας· ὃν δ᾽ ἂν καὶ ἄλλους οἴωνται ποιεῖν τοιούτους, θυμοῦνται· εἴτ᾽ οὖν φθόνῳ, ὡς σὺ λέγεις, εἴτε δι᾽ ἄλλό τι. Op. 1. 6.

See the same indicated at the opening of the Protagoras, where Socrates ironically throws out his opinion, that virtue cannot be taught; founding it on the fact of the indiscriminate admission of all persons to advise on political affairs in the Assembly, whilst on particular subjects, as in a question of building, those only were consulted who were proficients in the art. Ἐπειδὰν δέ τι περὶ τῆς πόλεως διοικήσεως δέῃ βουλεύσασθαι, συμβουλεύει αὐτοῖς ἀνιστάμενος περὶ τούτων ὁμοίως μὲν τέκτων, ὁμοίως δὲ χαλκεύς, σκυτοτόμος, ἔμπορος, ναύκληρος, πλούσιος, πένης, γενναῖος, ἀγεννής. Plato, Op. iii. p. 105; also Meno. Op. iv. p. 375.

[4] Xenoph. Mem. i. 2. 24.

[5] Plato, Conviv. 215, Op. x. p. 257.

[6] Xenoph. Conviv. v. Plato, Theætet. 143 e.

[7] The idea of his attempting to dance excites a laugh in the guests in Xenophon's Banquet. Xenoph. Sympos. He says there that he practised dancing for the sake of exercise.

[8] Xenoph. Conviv. ii. 19.

[9] Aristotle introduces in his Analytics (Anal. Prior. ii. c. ult.) a notice of the subject, as affording matter of consideration to the dialectician.

[10] Cicero, De Fato, c. 5.

Socrates. cave, but full and obtuse. Prejudices accordingly drawn from the personal appearance of Socrates may reasonably be believed to have tended to render his teaching unwelcome in its first impressions. But soon this fastidiousness would give way as he proceeded; and those who began to listen with a smile at the uncouthness of his form, and the quaintness of his manner, would be attracted to admiration of the intelligent and kindly expression which lighted up those rude features, and would find themselves lingering in his presence in spite of themselves.

The story of Euthydemus "the handsome," as he was called, may be taken as a specimen of such an effect. Euthydemus, proud of his personal accomplishments, and not wishing to be thought indebted to any one for his learning and eloquence, had studiously avoided the society of Socrates. Socrates, however, with his usual dexterity, contrives to excite his attention, and gradually interests him in conversation. Euthydemus shrinks back at first on his self-conceit, but at length is so won upon by the persuasive reason of the philosopher, as freely to acknowledge his own ignorance and need of instruction; and, ever afterwards, he is found by the side of Socrates, his devoted admirer and follower.[1]

Some, indeed, took offence at the plain truths which Socrates brought home to them, and no longer frequented his society.[2] But these were the inferior sluggish minds, which no arts of address could rouse to a sense of their intellectual poverty. Generous, susceptible minds overcame their first reluctance, and yielded themselves fully to his guidance. The faithful attachment of many was evidenced, to the last moment of the philosoper's life. He might have commanded the use of Crito's wealth, had he desired it. Such, indeed, was the confidence which Crito reposed in his sincerity of purpose, and so highly did he value his instructions, that to no other would he commit the education of his sons, but made them fellow disciples with himself of his own revered master and friend. And this friendship was warmly requited by Socrates. For it was by his counsel that Crito was saved from the malicious arts of the sycophants. These pests of Athenian society were not to be encountered by the simple testimony of a life contradicting their mercenary calumnies; and Crito was one of those who would rather pay their money, and compromise the attack, than take the trouble of defending themselves. They were only to be foiled by turning their own weapons against themselves. By the suggestion of Socrates, accordingly, Crito enlisted in his service a clever individual of this class, Archedemus, who effectually checked the iniquities of which his patron was the object, by counter-prosecutions of the sycophants, and exposure of their conduct; acting as a watch-dog, according to Xenophon's description, against those rapacious wolves.[3]

The devotedness of Plato and Xenophon to their master, speaks from every line of their writings. These writings are, in fact, as much monuments of the influence of Socrates over their minds, as of their own genius. And what human teacher has ever had such glorious trophies erected of the conquests of his philosophy as the extant works of these master minds? Entirely different as they are in character,—the one flowing with the full stream of impassioned feeling, and lively elegant imagination, and the abundant treasures of literary and traditionary wisdom,—the other sensible and acute and practical, forcible by his very simplicity and the terseness of his unaffected eloquence,—they bear distinct yet conspiring evidence of the ascendancy of that mind which could impart its own tone and character to such disciples. Both of them, indeed, lead us to think that they felt his society as a kind of spell on them. For, when Plato speaks of the charm of the discourses of the Sophists, he seems to speak in irony of them what he thought in truth of Socrates himself. So too, when Xenophon introduces Socrates describing himself as skilled in "philters and incantations," he is evidently presenting that idea which the conversations of Socrates impressed on his own mind. He seems almost to confess this of himself when he informs us, how Socrates triumphantly appealed to the marked devotedness of his followers, in saying, "Why think you that this Apollodorus and Antisthenes never quit me? Why too, that Cebes and Simmias come here from Thebes? Be assured, that this is not without many philters, and incantations, and spells."[4] Socrates.

To the same honourable band of attached disciples might be added many other names afterwards renowned in the annals of Grecian history and literature. Isocrates, Aristippus, Antisthenes, each of whom became afterwards masters themselves, were content to follow in his train. Antisthenes especially, who, by perverting the Socratic simplicity of life into a profession of austerity, became the founder of the Cynic school, was never from his side. He would walk from the Piræus to Athens, a distance of about four miles, every day, in order to be with Socrates. And whilst Cebes and Simmias came from Thebes, Euclid, the founder of the Megaric sect, was not deterred by the bitter hostility between Athens and his own city of Megara, from seeking the society of Socrates at the hazard of his life. Even during the war, when the Megareans were excluded by a rigid decree, he continued his visits to Athens, adopting, it is said, the disguise of female attire, and so passing unobserved into the city at nightfall, and returning at daybreak.[5] The same individual gave still more conclusive evidence of his zealous attachment to Socrates afterwards; when he opened his house and his heart to receive, at Megara, his brother disciples, in their panic on the death of their master. So strong was the tie of reverence and affection which subsisted between the philosopher and those whom he drew around him. They formed, indeed, a sort of select family, each of whom was engaged in the pursuit of his own peculiar employments and tastes in the world, whilst all looked up to Socrates as their father and head, and ever recurred to his society as to their common home.

This domestic intercourse subsisted in the midst of a city harassed with jealousies and dissensions, and with severe afflictions of war and pestilence. Socrates remained unmoved through all these convulsions of the city, preserving a constant evenness of temper, so that Xanthippe could testify of him, that she never saw him returning at evening with a countenance changed from that with which he left home in the morning.[6] Nor could even the merriment of which he was sometimes the object, discompose his settled gravity and good humour. On one occasion, returning from supper late in the evening, he was assaulted by a riotous party of young men, personating the Furies, in masks, and with lighted torches.[7] The philosopher, however, without being irritated by the interruption, suffered them to indulge their mirth; only he required them to pay that tribute which he exacted from every one that came in his way, to stop and answer his questions, as if he had met them in the Lyceum, or any other accustomed place of his daily conversations. Himself sound in mind and body, (for his habitual temperance saved him from the infection of the plague which so obstinately ravaged Athens,) he was enabled to give advice and assistance to all of his country in the midst of the physical and moral desolation, in which every one else then seems, more or less, to have participated.

Thus were the years of a long life quietly and usefully spent; and he had nearly reached that limit at which

[1] Xenoph. Mem. iv. 2. [2] Ibid. 40. [3] Ibid. ii. 9. [4] Ibid. iii. 2.
[5] Aul. Gell. vi. 10. [6] Ælian, Var. Hist. ix. 7. [7] Ibid. c. 29.

nature herself would have gently closed the scene of his philanthropic exertions, when the hand of human violence interposed to hasten the approaching end.

The annals of party spirit at Athens had already recorded many a deed of dark and wanton cruelty. But they were yet to be stained with the iniquity of a persecution even to death, of him, who had been the greatest benefactor and ornament, not only of Athens, but of the whole community of the Grecian name.

The banishment by ostracism had this redeeming merit, that it was an avowal in the face of Greece, of the envious and factious spirit, which drove from the state the individual whose talents or virtues too greatly distinguished him among his fellow-citizens. The enmity to which Socrates fell a sacrifice, exhibits a deeper character of malignity; inasmuch as it masked itself under a hypocritical zeal for religion and virtue, and thus courted public sympathy for proceedings, against which every voice in Athens and in all Greece should have indignantly protested. Ostracism, again, was content to remove the obnoxious great man from the eyes of his fellow-citizens. The attack on Socrates was satisfied with nothing short of the destruction of its victim.

It was in the midst of the tranquil, but busy course of his daily engagement, that Socrates was suddenly arrested, and without, it seems, any previous intimation of the intended attack, summoned to the portico of the king-Archon, to answer a charge of impiety.[1]

The accusation was in this form: "Socrates is guilty of the crime of not acknowledging the gods whom the state acknowledges, but introducing other new divinities: he is guilty also of the crime of corrupting the young." The penalty proposed was death. It has been commonly supposed that the charge was laid before the court of Areopagus. But it would appear rather, from the course of the trial, to have been before one of the popular courts, and probably, from the great number of dicasts or jurors who voted on the cause, before the principal court, the Heliæa.

The circumstances connected with the accusation remain, after the utmost inquiry now possible, involved in considerable mystery. We are told that Meletus was the accuser, and that he was supported in the prosecution by Anytus and Lycon. These three individuals are also said to have represented distinct classes of persons interested in the proceedings; Meletus, who was himself a poet, appearing in behalf of the offended poets; Anytus, a wealthy tradesman and demagogue, resenting the affronts of his brother-tradesmen; Lycon, an orator, or politician by profession, standing up as the assertor of the pretensions of his factious order. But these particulars, though they may account to us in a great measure for the success of the prosecution, do not exhibit the secret agency by which it was effected. The accusers themselves were men of no note or importance in the state. Meletus was a young man; a vain and weak person, it seems, of whom nothing more is known than that the accusation was made in his name. Nor of Anytus and Lycon have we anything to mark the importance, beyond the fact, that the former was included, together with Alcibiades and Thrasybulus, among the persons exiled by the Thirty, and the notice taken of him by Plato, where he represents him the inexorable foe of every thing in the shape of a philosopher, and as parting from a conversation with Socrates in anger.[2] Merely personal offence, however, could not have given sufficient pretext or weight to so grave an accusation. Nor can we suppose that it was even the combined interest of the three classes represented by the three accusers—the poets, the tradesmen, and the orators—which carried the condemnation of so respected a person. The ground of the attack must lie deeper; and the men whose names appear so prominently in this fatal conspiracy against the life of the venerable old philosopher, could only have been the puppets moved by some secret and more commanding force. The trial would seem to have been only a solemn pageant, exhibited before the public, as a prelude and justification of a deed of murder already resolved on by its real though invisible perpetrators. Whilst the charges themselves, as set forth by the nominal accusers, were but feebly sustained, it is evident that no defence, however just and able, could have availed to avert the sentence of condemnation. The body of jurors before whom the cause was heard, appear to have been disposed to acquit the accused, if we may judge from the number of votes which were given in his favour; and yet the majority were overruled. This in itself would lead us to think that some secret influence had been exercised, to obviate the chance of failure of the ordinary ostensible means of judicial assault. And so Socrates himself appears to have felt; if Plato and Xenophon have faithfully reported the substance of his reply to the accusation in their Apologies. His defence, as there represented, is that of one who retires, on his own consciousness of right, from a bootless conflict with adversaries who are not to be appeased by argument and persuasion. It does not set forth the strength of his cause as against an opponent, but simply asserts the truth and merit of the course of life which he had been pursuing.[3] The sentence accordingly excites no surprize in him. He yields himself up as to the sweeping of a tempest, with which it is vain to parley. Would we then explore the circumstances of the trial and condemnation of Socrates, we must obtain a deeper insight into the moving power of Grecian politics, —the spirit of the heathen religion, and the mode of its action on the conduct of states and individuals. This appears to be the proper solution of the case of Socrates. The circumstances of the case evidently point to this. And though, from the want of information, we cannot very distinctly trace the working of the religion of the times in the particular instance before us, we may, from a closer consideration of the facts, not unreasonably suspect its active operation and instrumentality.

Speculators have sometimes spoken of the mild and tolerant spirit of paganism. The observation, however, is superficial and untrue. The facility with which the polytheistic worshipper transferred his offerings and prayers to every new idol, has been mistaken for a readiness to admit any variation from the established worship, or any freedom of opinion respecting divine things, without offence. The contrary is the fact. The heathen, resting his religion on ancient tradition[4] and the authority of the priests, and not on any intrinsic evidences of its truth, could not but feel a jealousy of any departure from what he had thus received,

[1] Plato, Thætet. ad fin. Euthyphro. et alib. The king-Archon was a sort of minister of state for the department of religion—the representative, under the democracy, of the priestly office of the king during the monarchy at Athens. See Demosthenes, c. Neær. p. 1370, ed. Reiske.

[2] Xen. Hell. ii. 3. 42, 44.—Plato, Meno.

[3] See the same exemplified in what Socrates is made to reply to Callicles in the Gorgias of Plato, p. 162, τοσοῦτον μέντοι καὶ ἐγω οἶδα ὅτι παθος παθοιμι ἀν εἰσελθὼν εις δικαστήριον, κ.τ.λ.

[4] Demosthenes, in his Oration against Neæra, p. 1370, speaks of a column erected in the temple at Limnæ, ἐν τῷ ἀρχαιοτάτῳ ἱερῷ τοῦ Διονύσου καὶ ἁγιωτάτῳ, and standing in his time, which stated, among other things, ἵια κατὰ τὰ πάτρια θύηται τὰ ἄῤῥητα ἱερὰ ὑπὲρ τῆς πολέως, καὶ τὰ νομισμένα γίγνηται τοῖς θεοῖς εὐσεβῶς, καὶ μηδὲν καταλύηται, μηδὲ καινοτομῆται: and he sums up the account with εἰδῆτε, ὡς σεμνὰ καὶ ἅγια, καὶ ἀρχαῖα τὰ νόμιμά ἐστιν.

or any attempt to bring the subject into discussion. It was not only the primitive Christians that were stigmatized by heathens as atheists, because they renounced the divinities of the heathen creed, but the same reproach was long before cast upon those among the heathens themselves, who, with however pious disposition, ventured to speculate on religion. A traditionary religion will tolerate any laxity of thought or conduct which professedly admits its authority, whilst it peremptorily puts down every thing which impugns the principle of absolute deference to its authority. Thus we shall find, that, where that principle is carried to the utmost, there co-exists with it a scarcely concealed infidelity, and an unrestrained licentiousness of conduct; and, at the same time, also an extreme sensitiveness in regard to deviation from the orthodox profession and language. We have unhappily seen this in those Christian countries, where the true faith, the principle of devout submission to the word of God, has been transformed and perverted into a doctrine of implicit deference to the authority of the ministers themselves of that word. There,—as, for example, in Spain and Italy,—where the authority of the church is bowed to most submissively, practical infidelity and immorality shew their front with impunity, whilst the expression of opinion or argument on questions of theology is discouraged and silenced, if no longer now, as once, crushed at its outbreak by the dark terrors of an Inquisition. The same fact was intensely exemplified in heathen Athens. At no place was piety, as piety was understood by heathens, more in honour. No state boasted such a tradition of sacred associations as Athens. In none were there so many festivals and solemnities of religious observance, as in Athens.[1] In none did the priests of religion hold such sway. Witness their power over Alcibiades, at the moment of his political triumph, and amidst the caresses and admiration of his fellow-citizens, when he felt himself obliged to relinquish his command in Sicily, and desert his conntry, rather than encounter at home the threatened prosecution for his profanation of sacred things. Witness their power again in the instance of the same Alcibiades, at his restoration to the command of the army, when, to conciliate their favour, he delays the urgent expedition, and keeps the soldiers under arms along the road by which the sacred procession passed from Athens to Eleusis. Witness further, the frequent prosecutions at Athens on charges of impiety of which we read, and of which we have monuments in extant orations. But, amidst this strictness of external profession, in no place was there a more entire license as to practical irreligion. Their festivals abounded with rude and obscene mirth. Their drama, whilst it inculcated in direct precept the belief and worship of the gods, indulged in the most profane ribaldry and ludicrous representation of sacred things. Yet were these follies and excesses tolerated, because under them a regard was still maintained to the authority which upheld the religion, as in the "mysteries" and "moralities" enacted with the connivance of the papal power in modern times; and the people at large were satisfied with a religious system, which was exhibited to them as so good-humoured and humane. They were tolerated, indeed, but not without the like injury to the religious feelings, as in the parallel cases, where a corrupted secular Christianity has ventured on the like palliations of its despotism. For all the while the people were losing their hold of the popular religion. Those who thought at all on the subject, either rejected it altogether, or accounted it a mere matter of opinion and external ordinance; whilst those, on the other hand, who were content to receive every thing traditionary as divine on the mere principle of deference to the priests, readily engrafted every new superstition on the received religion. Thus, whilst infidelity and superstition grew up at Athens, and flourished together, and often perhaps in the same mind, the connexion between religion and morality was altogether lost sight of and dissolved. Men began to regard themselves as devout, and friends of the gods, whilst they were committing deeds of violence and lust, and blindly and wickedly endeavoured to support the cause of religion by forcible suppression of the truth, and persecution of those who subjected their tenets or their rites to the test of inquiry. Thus, whilst Aristophanes was amusing the people, not of Athens only, but from all parts of Greece, at the public festivals, with ludicrous representations of the popular theology, and loosening more and more any existing associations of reverence towards the objects of their worship, severe prosecutions were carried on from time to time against all who in any way made religion a matter of debate, or seriously brought it into question with the people. The same persons can take part in the vulgar low jest, and shew their real contempt of religion by their carelessness about oaths and the practical duties of religion, and yet join zealously in the prosecution of offenders against established notions of religion. It is the same habit of mind in both cases; a habit of looking at religion as a general rule of orthodox profession,—as a rule binding on a community, and a test of its soundness of doctrine,—rather than as a personal concern, and a trial of the spirit of a man. "He has brought Gentiles into the temple, he has abolished circumcision, he has profaned our religion," was the outcry against St. Paul; and yet these same persons thus clamorous against the apostle, were minding earthly things all the while, sticklers for externals, yet idolaters in their personal religion, as men of covetousness, and slaves to the appetites of the body.

At Athens, accordingly, though there was no freedom of religious opinion, the religion might be employed to excite festive mirth, and gratify the levity and licentiousness of a dissolute yet intellectual populace, amidst the charms of poetry and music and the solemn graceful dance. For then the associations of deference to the mysterious agency which held together the traditions of the popular creed were not violently broken asunder. There still remained in the minds of the people an awe at the indefinite mystic truth, hidden under the embroidered veil held before their eyes. They knew that the splendid drama of religion, which at once gratified their refined intellectual taste and their sensibility, was not the whole of their religion. They had also the Eleusinian mysteries; rites of religion performed in secrecy, and fenced round with the terror of death to him that should divulge them; delegated to a few, the initiated only, and incommunicable to the vulgar; of which the popular rites were but the rude symbols.[2] The popular wor-

[1] Aristoph. Nub. 298. οὗ σέβας ἀῤῥήτων ἱερῶν, ἵνα
μυστοδόκος δόμος
ἐν τελεταῖς ἁγίαις ἀναδείκνυται,
οὐρανιοίς τε θεοῖς δωρήματα,
ναόι θ' ὑψερεφεῖς καὶ ἀγάλματα,
εὐστέφανοί τε θεῶν θυσίαι θαλίαι τε
παντοδαπαῖς ἐν ὥραις, κ.τ.λ.
Also Thucyd. ii. 38; and De Repub. Athen. attributed to Xenophon.

[2] Isocrat. Panegyr. p. 54. Ἃς οὐχ οἷόντ' ἄλλοις ἢ τοῖς μεμυημένοις ἀκούειν . . . καὶ τὴν τελετήν, ἧς οἱ μετέχοντες περί τε τῆς τοῦ βίου τελευτῆς, καὶ τοῦ σύμπαντος αἰωνος, ἡδίους τὰς ἐλπίδας ἔχουσιν.

Socrates. ship might wear the form of caricature, the grotesque, the farcical, and even the profane, as being merely the pantomime in which some recondite interior religion was dimly and wildly shadowed. The people laughed at what they saw and heard at their festivals. But amidst their laugh there was evidently a feeling of awe, which subdued the luxury of their mirth; a consciousness that, whilst they sportively shook the chain of their superstition, its iron entered into their soul. We see, on the other hand, Aspasia, the favourite of Pericles, at the time of the greatest popularity of that most popular leader, summoned before the courts, to answer a charge of impiety, and scarcely defended by the eloquence and the tears of Pericles himself, from the inexorable power, whose vengeance she had provoked by her philosophical speculations. Protagoras, admired as he was and courted at Athens for his talents in his profession of a Sophist, was expelled from the city and borders of Attica by the Athenians, and his books were collected by proclamation and burnt in their agora, for his avowed scepticism as to the existence of the gods.[1] Æschylus, whose very poetry is instinctive with religion, was accused before the Areopagus of divulging the mysteries in one of his tragedies.[2] The philosopher Anaxagoras, like Galileo under his papal inquisitors, suffered imprisonment at the hands of Athenian persecutors, for having asserted the material nature of the heavenly bodies, and only escaped death by the intervention of Pericles, and by exile from his adopted home. The extent again, to which prosecutions for offences against the popular religion could be carried at Athens, is shewn in the number of persons who were imprisoned on suspicion of being implicated in the impieties charged on Alcibiades, and the execution of so many, on that occasion of panic, on the unsupported evidence of secret informers. Lastly, not many years before the accusation of Socrates, Diagoras the Melian, and Theodorus of Cyrene, were branded with the epithets of atheists; and the former was forced to fly from Athens on a charge of profanation of the rites, with the price of a talent set on his head for any one who should kill him. And long after the time of Socrates, the same spirit subsisted to drive Aristotle from the Lyceum, and later still, to intimidate the speculations of Epicurus. So strictly was the *authority* of the established worship guarded by a jealous and watchful inquisitorial power, in a state which boasted of its perfect liberty of speech, its παῤῥησία, above all others.

In fact, there was no liberty of speech on this subject in Greece. Every thing relating to religion was to be received as handed down from former ages; as the wisdom of an immemorial antiquity, borne along on the lips of the priest and the prophet, or impressed on mystic rituals, the hereditary trust of sacred families, or symbolized in the pomp and pageant of festivals and games, in the graceful majesty of temples, and the solemn shadows of sacred groves. The inward devotion of such a religion naturally took the form of silence, and reserve, and awe. It was concentrated in the simple dread of profanation. The more superstitious indeed a people is, the more necessary is it that the rites of their religion should be strictly shut up from all inquiry, and a feeling of reserve should be inculcated as essential to the religious character. It is the indefiniteness of superstition that holds together the system. Let any one part of the vaguely-floating system be touched too palpably, and the whole crumbles. Thus it has been found, that superstition and infidelity have always gone hand in hand. Diagoras was made an atheist from being at first superstitious. The Athenian people, in like manner, from their superstitious character, were peculiarly exposed to a reaction of impiety. And it was but a wise policy, therefore, that the religion of Athens should be jealously guarded with an awe forbidding all inquiry into its truth.

The colloquial and lively spirit of the Athenians mitigated the intensity of this feeling in the minds of the people at large; and the managers of the system were fain to relieve it, by blending recreation, and mirth, and interesting spectacles, with its public celebration. Grecian superstition accordingly, whilst it bore the essential marks of its oriental origin, in the submissiveness exacted of its votaries, and its mystic reserve, assumed also the mask of cheerful expression characteristic of the genius of the people. Still we see that submissiveness and that reserve strongly marked in the stern denial of the right, not only of private judgment on questions of religion, but even of bringing such questions at all into discussion.

Now, though, as we have already observed, we cannot distinctly trace the steps by which this spiritual despotism was brought to bear on Socrates, we cannot doubt that his was a case which must have attracted its notice. During more than forty years, Socrates had been seen at Athens, going about among all classes of the people, exciting among them a spirit of moral inquiry, urging on them the importance and the duty of self-knowledge, of taking no opinion on mere hearsay, or indolent and self-satisfied trust, but of bringing every thing to the test of discussion and learning, of acquainting themselves, as their first step to knowledge, with the depth and extent of their ignorance. Observers saw in this extraordinary teacher, one of their own citizens, educated in their own institutions, familiar with the habits of Athenian life, ever at home among themselves, recommending himself alike to the young and the old, by the honest though quaint dignity of his manner, and the interest and charm of his conversation. He was not, like Anaxagoras, or Protagoras, or Prodicus, a stranger sojourning among them; a philosopher or rhetorician by profession, or one pursuing philosophy as a trade and a source of subsistence, waiting to be resorted to and courted by the affluent and noble, and reserving himself for occasions of display or profit; but he was found, an Athenian among Athenians, in the market place, in the streets, in the work-shops, at the tables of the wealthy, himself seeking out persons to instruct, asking questions of all around him, and engaging them, even in spite of themselves, in conversation with him.[3] In other teachers, philosophy had spoken, according to the observation already made, as from an oracular shrine, to those only who came to inquire of it as votaries and disciples. With Socrates, philosophy walked abroad, insinuating itself into the scenes and business of daily life, and drawing forth the secret treasures of men's minds with its own hands. According to that homely but apt illustration of his mode of teaching, which he was so fond of employing, from midwifery, Socrates.

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[1] Diog. Laer. ix. c. 8. Cic. De Nat. Deor. i. 23. See the story of the daughter of Neæra, as told by Demosthenes, in his oration against Neæra, p. 1369. She had been married under the pretence of being an Athenian citizen, to an Athenian who served the office of the king-archon. As the wife of this officer of the state, she was admitted to the rites of religion, and solemnly inducted into the mystic temple of Bacchus at Limnæ. But it was unlawful for any but a true-born citizen to enter into the temple, or to witness the rites; and her husband consequently was tried before the court of Areopagus for the impiety, and only escaped on the plea of his ignorance of the fact, and on the condition of his dismissing her from his house.

[2] Ælian, Var. Hist. v. 19.

[3] Plato, Euthyphro. 3 d. "Εγὼ δὲ φοβοῦμαι, μὴ ὑπὸ φιλανθρωπίας δοκῶ αὐτοῖς ὅ, τι περ ἔχω ἐκκεχυμένως παντὶ ἀνδρὶ λέγειν, οὐ μόνον, ἄνευ μισθοῦ, ἀλλὰ καὶ προστιθεὶς ἂν ἡδέως εἴ τις μου ἐθέλοι ἀκούειν." Op. t. i. p. 6. Xenoph. Mem. i. 2. 'Αλλὰ τῶνδέ τοι σε ἀπέχεσθαι, ἔφη, δεήσει, ὦ Σώκρατες, τῶν σκυτέων καὶ τῶν τεκτόνων καὶ τῶν χαλκέων, καὶ γὰρ οἶμαι (Critias is speaking) αὐτοὺς ἤδη κατατετρίφθαι διαθρυλλουμένους ὑπὸ σοῦ. P. 21.

his method freely offered its services in assisting at the birth of the thought with which the pregnant mind was labouring. He busied himself, he used to say, with the officiousness of his maternal art, in exploring the genuineness of the fruit of the intellectual womb, which his dexterous questions had brought to light.[1] Such a person then could not but fix on himself the eyes of every attentive observer of the state of society in Athens. Such teaching evidently could not but have a very considerable influence on public opinion. Particularly when he was seen to be acceptable to men of all parties in the state, to the leaders of the aristocratic faction as well as the humblest citizen, it could not but be inferred that his influence was not a transitory one, dependent on the predominance of any party, but that it would reach to the fundamental constitution of the society at large of the city, and be a leaven of fermentation to the whole mass. What, then, it would naturally be asked, must be the effect of such a teacher on existing opinions in religion? He taught, indeed, that men should acquiesce in what was established in religion; that they should inquire no further here than what simply was the law of the state. He treated, too, the popular imagery of religion with respect. For he would often clothe his instructions in the language of the legends and traditions of their mythology. Nor did he attempt to explain them away, though he waived all discussion of them. He was seen, too, on all stated occasions, sacrificing at the altars of the gods, and joining in the rites.[2] But, it would be asked, if the citizens were taught to examine into received opinions generally, would they abstain from carrying this principle into the subject of religion? Would they continue still blindly and submissively to follow the voice of authority? Would they not rather, so far as they were disciples of Socrates, begin to speculate on divine things, abandoning that reverence which they had hitherto maintained for the objects of public worship, disputing and discussing without reserve, and exposing to the vulgar gaze what had been all along venerated in mystic silence, and under the veil of symbol? The mercurial temperament of the Athenian was just the soil in which the seeds now scattered by the hand of Socrates might be expected to vegetate. The excessive prosperity, too, of Athens, during the fifty years immediately following the Persian war, and then its condition of struggle against internal faction and the confederate arms of Peloponnesus, were circumstances calculated to foster the profane irreligious spirit in a light-hearted people. Then, instances were not wanting of young men, the intimates of Socrates, and whose minds had been especially cultivated by conversation with him, who proved in the end traitors to the religion, as well as to the civil liberties of their country. Critias,[3] afterwards one of the thirty tyrants, and Alcibiades, at once the pride and the pest of his fellow-citizens, whom they loved and hated, and banished and longed for by turns, were striking evidences to the superficial observation of the evil apprehended from the teaching of Socrates. For here were young men of genius, susceptible by nature of the fullest influence of the lessons of the philosopher. And yet these had failed under his hands. What, therefore, might not be expected of minds of inferior order? How would not the religion and the institutions of the city fall into profane neglect and contempt, should the Socratic spirit of inquiry be imbibed by the next generation of citizens? The observation, indeed, was only a very superficial one, which would infer from such instances the evil of the teaching which these individuals misapplied. Still it is plain, that such cases were pointed at with invidious reference to Socrates and philosophy in general. We find the orator Æschines attributing the death of Socrates to the circumstance of his having educated Critias;[4] not that he must be supposed to have believed this to have been the whole account of the trial and condemnation of Socrates; but as an orator, he states for the purposes of his argument, what he conceives would be readily believed as part of the account of that event. Plato also studiously addresses himself to the defence of philosophy, from objection on this ground, with evident allusion to Alcibiades and the like cases; arguing that the same individuals who were most susceptible of the good of philosophy, were also such as would be the most apt to abuse it. And probably he had the same design, and refers to the degenerate sons of Pericles himself, as an instance in point to those who cherished the memory of that great man, and of the times in which he flourished, to shew that the philosopher was not to be held responsible for the extravagances and vices of the disciple.[5]

The exhibition of the comedy of "The Clouds," appears to have been designed to bring before the people the supposed evil tendency of the teaching of Socrates, as exemplified in such distinguished instances. It was produced in the year B.C. 423, when the philosopher had attained his forty-seventh year, and was at the height of his reputation throughout Greece, and about twenty-three years before his death. There we have Socrates introduced by name under broad caricature, as the representative of the class of sophists, and a consummate master of the arrogant pretension, and sordid cunning, and impiety of the class. The clouds are his only divinities. A profligate spendthrift youth, and a dotard father, are his dupes. The inquisitive method which Socrates practised, is also held up to ridicule and contempt, by identifying it with the frivolous questionings of the grammarians, and dialecticians, and rhetoricians of the day, and with the perverse sophistry which held truth a matter of indifference, or, which amounted to the same thing, called every man's opinion truth, and boasted of its skill to make the worse appear the better cause. It was but too evident to Athenian spectators at least, that the Socrates of Aristophanes was not the Socrates whom they had been accustomed to see and converse with in real life. And the play accordingly failed at the first exhibition. Not all its charms of poetry, and humour, and skilful composition, could obtain for it a favourable reception. Though Aristophanes was aware that the portrait which he had drawn, was not a portrait of the individual, but of a class, there can be little doubt, that he calculated on the sympathy of the people, in giving the name of Socrates to his personification of the sophistical spirit; and that he felt it necessary to depreciate the influence of Socrates as the commanding influence of the day, by attributing to his method all the vices of the schools of the sophists. Socrates is honoured and complimented in the very attempt to weaken the respect for his instructions, and to awaken a clamour against him. The failure of "The Clouds," at the first representation, and one account adds, even at the second, (for the play is said to have been retouched for the third time), has

[1] See especially Plato's Theætetus in illustration of this.

[2] Plato, Euthyphr., pp. 11–13, and Phædrus.

[3] Critias is placed by Sextus Empiricus among the atheists. He is said to have resolved all religion into the enactments of legislators providing against the secret commission of crimes, by inculcating the all-seeing power of the gods. He gives also several lines from a poem of Critias to this effect. Adv. Math. lib. viii. p. 318.

[4] Æschin. con. Timarch.

[5] See the Protagoras and Repub. vi.—Xenophon adverts in like manner to the charge of corruption as supported by the instances of Critias and Alcibiades. Memor. i. 2. See also the conversation which Xenophon reports between Socrates and Hippias. Isocrates, in *Busir.* p. 222, c. with the like feeling, *denies* that Alcibiades was educated by Socrates; meaning, it seems, that Alcibiades was too short a time with Socrates to be benefited by the instructions of the philosopher.

been attributed to the influence of Alcibiades. Alcibiades indeed has been supposed by some commentators to have been no less the object of attack in the play than Socrates himself, and to have been designated under the name of Phidippides, the youthful and accomplished victim of the sophist. There are certainly some traits in the character of Phidippides, which would seem to point at Alcibiades, whom perhaps the poet, bold as he was, could hardly venture to bring on the stage by name or closer description at this particular time. And we may perhaps justly allow some weight to party influence in neutralizing the effect of "The Clouds" at its first exhibition. Still, when we observe in other instances the great power which the comic muse could wield against a political opponent, as in the attack on Cleon in "The Knights," we cannot but think that there was some strong countervailing feeling in the estimation of Socrates himself. If the account of Ælian be true, Socrates could join in the laugh raised against him; for he was present in the theatre during the acting of the play, and finding that he was the object of attraction, placed himself where all could command a view of him.[1] He knew, and every one in Athens knew, that he was a very different person from the sophists with whom the play identified him. They indeed were corrupters of the young; for they unsettled every established principle in the minds of the young, and gave no substitute for what they profligately swept away. They left the young to be drifted away by the tide of their passions, with no criterion of truth or of right beyond the present opinion or the present interest. But Socrates, whilst he taught the young to inquire into the truth of their opinions, lessened their presumption and self-confidence, by shewing them how apt they were to mistake mere assumptions for knowledge, and to be conceited of their ignorance. His object was truth, and accurate knowledge. He stated difficulties and objections, but not in the spirit of a sceptic, but in order to awaken curiosity, to clear away confusion of thought, and inculcate sound principles of judgment and conduct. He could well then laugh at the jest which glanced from him to its proper objects, the sophists themselves, the very persons against whom his whole teaching was directed. He felt doubtless that he had a hold on the people at large, which the sophists had not. They were for the most part known only to the great and wealthy; those who could receive them into their houses, as they went from city to city through Greece; who sought their society as patrons of literature, or aspirants after political distinction, and who could pay for their instructions.[2] He on the contrary was accessible to all. He would receive no money from any one. He was the frequent guest of the rich; but he was no less the associate of the artizan and the poor. And too many must have been present in the theatre, when the Socrates of "The Clouds" was amusing the audience by his sleight-of-hand philosophy, who would remember the real Socrates as a man of honesty, and truth, and disinterested benevolence, from whom they had received much useful counsel from time to time, and whom they had ever found affable, and at leisure to enter into their feelings and views with patience and kindness. If we compare the Socrates of the Memorabilia of Xenophon with the Socrates of "The Clouds," we may judge how great was the contrast to those who compared the well-known philosopher of the agora with his portrait as drawn by Aristophanes. If we can smile at the caricature of "The Clouds," and yet love the excellent moralist of the Memorabilia, we may also conceive how harmless the satire of Aristophanes would really be against the object of it; whilst the jokes of the poet, true as to the personal peculiarities of the philosopher, amused a volatile and clever people. For them to have confounded Socrates with the class of sophists, would have been in them the like palpable mistake, as it would be to confound the philosopher Bacon, on account of some points of resemblance, with the alchemist and empiric of the preceding ages.

It might seem matter of reproach against Aristophanes, that, in selecting the name of Socrates to represent the sophistical spirit which had then so largely corrupted the education and the government of Athens, he pointed the shafts of the comic muse against the very person who was in truth its most successful antagonist. In such a view of the case, however, sufficient justice would not be done to the discernment of the poet. He shrewdly observed in Socrates the master genius which would ultimately cast into the shade all those busy professors of the art of education, who, under the name of sophists, or professors of all knowledge, were then attracting the notice of the world to themselves and their doctines. Socrates, in himself, Aristophanes could not but admire and recommend to the imitation of his country. He doubtless knew Socrates to be a true patriot no less than himself,—to be steadily aiming to bring back the Athenians to the purity of their institutions, from which they had so sadly degenerated, by his instructive conversations, as he was by the satirical strokes of the drama. Socrates, too, appears to have been his personal friend; for Plato introduces them in his Banquet as meeting on terms of intimacy, about the very time of the exhibition of "The Clouds." But with that freedom which the state of manners, under an absolute democracy, sanctioned and encouraged, Aristophanes did not scruple to bring even the revered name of Socrates on the stage, to give the due point to his satire. He overlooked the individual, the Socrates with whom he familiarly conversed, and presented before the spectators what he saw in Socrates, the living speaking impersonation of the influence of education on the character of a people, for good or for evil. Anaxagoras, or Protagoras, or Prodicus, or any other of the well-known philosophers or sophists of the day, might have occupied the foreground in the comedy of "The Clouds;" had the poet sought to give merely a fugitive sketch of the sophistical spirit of his times, or to single out for ridicule some of its external superficial features. This is what Plato has done on many occasions, and especially in that most animated picture in the dialogue entitled Protagoras, where he groups together the figures of the leading sophists in such admirable relief with each other, and such happy contrast with the unpretending but dignified form of his own loved master and friend. Such a view, however, could not have answered the design of Aristophanes in his play of "The Clouds." His object was to seize the deep, influential characters of the system of education which was then extending itself throughout Greece, and especially as it was manifested at Athens, the great school of all Greece. Naturally, therefore, and wisely, he fixed his eye on an Athenian—and that Athenian, Socrates,—not only as the first Athenian who had appeared in the office of a philosophical instructor, but who, as an Athenian, gave to his lessons the character of Athenian civilization, and fitly exemplified the influence of philosophical education in the hands of an Athenian, and as operating on Athenians.

The poet, indeed, as addressing the eye and the ear of the ordinary observer, and not Athenians only, but strangers of the Grecian name from all parts, mingles with his colouring some playful lights borrowed from the forms of the well-known professional sophists of the day. But neither are these representations, nor the allusions which he

[1] Ælian, Var. Hist.

[2] Plutarch well characterises the teaching of Socrates, in speaking of him, as *ἀνδρὸς ἀτυφίᾳ καὶ ἀφελείᾳ μάλισα δὴ φιλοσοφιαν ἐξανθρωπήσαντος*. De Socr. Gen. p. 301.

Socrates. makes to the real eccentricities of manner and uncouthness of person in Socrates, the points on which he desires to fix the attention of the theatre. It is the important modification of the Athenian character, under a system of education which had now reached its maturity. Under the administration of Pericles, that system had already infected the policy of the state, and perverted its courts of justice into sinks of corruption and oppression. Now, at length, it was found domesticated at Athens in the sanctuary of private life. An Athenian had appeared in the character of a professor of philosophy; and around him were gathered citizens of all ranks, from the noble youth who aspired to the helm of the state, and the wealthy patron of literature, to the mean artizan who worked at the forge, and the drudge of the market. What was further to be observed now, was, that the system came recommended by the eloquence of lively and exciting conversation. And how powerful must have been such conversation, as it came forth from the lips of the speaker in the elegant and terse Attic idiom! It was no wonder, therefore, that the comic poet should have seized this moment for portraying the danger which he anticipated to his country from the fashionable education of the day, and thrown all the force of his ridicule on the most attractive form in which it then presented itself, as displayed in the personal teaching and example of Socrates.

The testimony of Plato is to the same effect. Plato has not given us an exact portrait of Socrates any more than Aristophanes has; for he has evidently transferred to the Socrates of his Dialogues, not less of his own cast of mind and manner, than Aristophanes did to the Socrates of his comedy, of the general tone of the sophists. And this is to be accounted for, as in the case of Aristophanes, from the fact, that Plato regarded Socrates as the impersonation of the philosophy of the times. He felt that, to give his own doctrines a proper authority and weight, he could not employ a more effectual organ than the tongue of him who had first given to philosophy an Attic expression, and from whom it would henceforth derive its proper Grecian character.

But though the drama of "The Clouds" was unsuccessful as an attack on Socrates, if it were intended as such, or as an attack on the sophists under the name of Socrates, which is the more probable view of its design, it must not be supposed that the play produced no effect unfavourable to Socrates. The tradition, that Aristophanes was employed by Anytus and Meletus to write down Socrates, does not seem altogether without reason; though it can hardly be literally true, when we look to the distance of time which intervened between the production of the play and the accusation. In the *Apology* of Plato there is an allusion to the prejudice excited in the young men by the representation given of the philosopher in this play. Nor had "The Clouds" been the only attack on Socrates by Aristophanes; not to mention other comic writers who had made him the object of their humour. In the year 405, not more than five years before the prosecution, the play of "The Frogs" had been exhibited, in which a pointed allusion is made to the influence of Socrates in terms of reprobation.[1] In the mean time, also, the same note had been struck; for the play of "The Birds" was produced in the middle of this interval between "The Clouds" and "The Frogs," in the year 414; and in that again the Athenians are warned against the corruptions and enchantments of the philosopher.[2] And it is very possible that many who lived to witness the formal accusation of Socrates, might have received their earliest prejudices against the philosopher by what they heard in the theatre then,—prejudices, too, which the course of events, the miseries of the Peloponnesian war, and the anarchy consequent upon it, may have ripened into exasperation.[3] For they saw their country fallen from its proud station in Greece, to the condition of a dependent state; and they were led to ascribe their misfortunes to a change of habits since the days of Marathon and Salamis,—to their having deserted the palæstra and the field, and become, from a body of devoted patriots and soldiers, students of rhetoric and masters in debate.[4] During all this time Socrates continued the unrivalled teacher of the youth of Athens; increasing, indeed, in renown and popularity; and surrounded by a number of students of philosophy and political science from all parts of Greece. He had, in fact, converted Athens into a university of Greece. For though he had no professed school,—no φροντιστήριον, as Aristophanes jocosely represents the scene of Socrates amongst his disciples,—no regular place of meeting, such as Plato had in the Academia, and Aristotle in the Lyceum;—there might be seen around him in familiar conversation, in every part of the city, day after day, the statesmen, and orators, and generals of the republic,—philosophers of established repute from other cities,—the sons of the noblest families of Athens as well as of the humblest citizens,—and the resident foreigners and occasional visitors of the city; some seeking instruction in the art of government, some investigating by his guidance the chief good of man, some studying the theory of eloquence and criticism, some exploring, by the light of his searching questions, the depth of metaphysics, and the subtile speculations of the earlier philosophers; all according to their different pursuits, and in their different degrees, receiving information and general mental culture from the great Athenian sage. Those who clung to the thought of Athens in its days of military glory and empire, would painfully observe how great a change had taken place in the internal habits of the city. Formerly it was enough for the intellectual improvement of the youth, that in childhood he had the grammarian for his instructor, and as he grew up to manhood, was consigned to the poets;[5]

τοῖς μὲν γὰρ παιδαριοισιν
ἔστι διδάσκαλος ὅστις φραζει, τοῖσιν δ' ἡβῶσι ποιῆται[6]

Now even the slaves were becoming literary. The distresses of war had occasioned the addition to the roll of citizens, of many even from that class. And these might be seen, as the comic poet represents them, "each with his book, learning clever things;"

βιβλίον τ' ἔχων ἕκαστος μανθανει τὰ δεξιά.[7]

Formerly, their wise men were obliged to leave the ignorance and rudeness of their own city, and learn philosophy by foreign travel. Solon had brought back with him from his travels the wisdom of Crete and of Asia to enrich their code of laws, but had not given philosophy a domicile at Athens; had not affected domestic life there with its refinements.

[1] Aristoph. Ranæ, 1487. [2] Aristoph. Aves, 1282, 1554. [3] See Thucyd. iii. 82, ἐν μὲν γαρ εἰρήνῃ καὶ ἀγαθοῖς πράγμασιν, κ.τ.λ.

[4] In Xenoph. Mem. iii. 5, the younger Pericles asks Socrates how the Athenians are to be brought again to become enamoured of their ancient virtue, glory, and happiness; and afterwards he expresses his wonder how the state ever began to decline. Socrates imputes their degeneracy to their neglect of the institutions of their ancestors. The particulars mentioned are, want of respect to elders, neglect of bodily exercises, even to the ridicule of them, insubordination to authorities, mutual irritation, envy, quarrelsomeness, litigation, covetousness, incompetence of their generals.

[5] If we except the profession of the Sophists, when at its height of public favour, skill in the composition of tragedy was the most highly rewarded of all talents at Athens. Plato, *Laches*, 183, b. p. 169. The poets of Athens, therefore, were naturally jealous of the popularity of philosophers and sophists.

[6] Aristophan. Ran. 1052. [7] Aristophan. Ran. 1111.

From that time, however, a change, introduced by the literary taste of Pisistratus, had gradually prepared the way for establishing a school of philosophy at Athens.[1] Pericles, too, had given a great stimulus to the literary spirit by his own fondness for intellectual pursuits, and the society of intellectual men. In the midst of his active political life, he could find time and thought for the elaborate disquisitions of the ingenious persons whom he invited to him. He could spend a whole day in disputing with Protagoras on so subtile a question as the theory of causation;[2] such was the intense interest which he displayed in every thing tending to the development of mental energy, and such the encouragement he gave to the change of taste then in progress by his own example. In the person of Socrates was found the genius formed to preside over the growing taste for literary and philosophical refinement, and to give it the form of an established institution. What, therefore, were merely indefinite fears at the time of the exhibition of "The Clouds," assumed a more distinct character of alarm to ancient prejudices within a quarter of a century afterwards. The rapidity and violence of several successive revolutions of the government during the latter part of that interval, further prepared the minds of the people for any sudden outbreaks of party spirit, and made every man an object of suspicion to his neighbour. A democracy of an hundred years' existence[3] had been overthrown, and first an oligarchy of four hundred, then a tyranny of thirty, established by foreign arms, in its place. Nor, as it had not been without fraud and bloodshed that the people had been spoiled of their "ancient liberty,"[4] were they disposed to surrender it in quiet; or were those who seized on the government able to retain it long on the same footing. A struggle ensued; in which the individuals of contending parties only sought to provide, each for his own aggrandizement and interest, or at least his own safety, under the constant expectation of some counter-revolution.[5] The people had found that some of those very persons who would never have been suspected of oligarchical views, had in the late changes taken part against the popular government, so that they knew not, at last, whom to trust even of themselves.[6] We are not to wonder that an accusation of Socrates should have succeeded before an Athenian jury at this period of morbid sensitiveness of the public mind.

An accusation of impiety was, we must remember, too, an accusation of a political offence. A change of the popular religion was a change of the fundamental constitution of a Greek state. And as in the absolute rule of a single despot, so in the tyranny of a multitude, the reputation of zeal for religion is studiously maintained from policy, if from no higher motive, to throw around its arbitrary acts the reverence and fear due to the religious character. The teaching of Socrates was indeed eminently religious, but it differed from what the state regarded as such. He proved the existence of an invisible divine power, wisely designing and governing all things, and inculcated the duties of piety and morality as flowing from the belief of such an agency. Such clearly was not the state-religion.[7] This was no system of truth or morality. It was tradition and legend, and immemorial usage, and ritual observance.[8] And it was enough for a charge of impiety that Socrates rested religion on other grounds. A pious Athenian, and yet not pious after the manner of the Athenians, was, in their view, an introducer of new gods. He might well be believed to be a worshipper of the clouds and the air, when he pointed out to them, that the gods would not receive the sacrifice offered by wicked men,[9] that even their silent counsels were not concealed from the divine cognizance, and that justice was an indispensable duty of the worshipper of the gods.[10]

That the accusation further should be credible, as brought in this form, is not strange, when it is known that, during the Peloponnesian war, the worship of new gods had been introduced into the city; as at Rome during the depression of its fortunes in the first years of the second Punic war. So greatly had the vicissitudes of fortune influenced the minds of men, observes Livy, describing this effect,—so great was the influx of religion, and that chiefly foreign, into the state,—that either the men or the gods appeared to have suddenly become different.[11] So at Athens, it appears, the forms of superstition had been multiplied, under the pressure of civil and domestic calamity acting on the fears and credulity of the people. The strong reproof which Euripides puts into the mouth of Theseus, of the austere life of Hippolytus, would seem to point at some ascetic devotees among the Athenians themselves, practising a more refined and scrupulous religion, distinct from that of the vulgar;

> Ἤδη νῦν αὔχει, καὶ δι' ἀψύχου βορᾶς
> Σίτοις καπήλευ, Ὀρφέα τ' ἄνακτ' ἔχων,
> Βάκχευε, πολλῶν γραμμάτων τιμῶν καπνούς.[12]

In Aristophanes[13] we find still more evident allusion to the introduction of new objects of worship, new fanatical rites, in which the women chiefly officiated, and in which a gross licentiousness mingled with the gloom and solemnities of barbaric superstition.

Again, education was intimately connected with politics in a Grecian state. The state took in hand its youthful citizens, and trained them according to its peculiar institutions, and in its own spirit. At least, in all the early constitutions, great attention was paid to education. Lycurgus made Sparta a constant school of war to his citizens. So too Solon, though he had, with greater knowledge of human nature than Lycurgus, adapted his institutions to the people for whom he legislated, provided that the people should be trained to the system of laws prescribed to them. But this care of the early legislators had begun to be lost sight of in practice.[14] In Aristotle's day it had disappeared everywhere.[15] In Sparta it was still nominally reverenced. In Athens, an entire relaxation of the educational discipline had taken place already in the time of Socrates. Pericles, flattering the democratic spirit of the Athenians of his day, could boast of their ease from labours and the obligation of exercises, and congratulate them on the courage which they could display at the time of action, without being inured beforehand by a course of hardy discipline.[16] But now, whilst the state was remiss in not enforcing education according to its ancient system, a new system had grown up, the offspring of the luxury and refinement of its days of imperial greatness. This new and unauthorized education was diffused throughout the mass of the inhabitants beyond the pale of the citizens. Solon's law imposed the duties of

[1] Aul. Gell. vi. 17. Libros Athenis disciplinarum liberalium publice ad legendum præbendos primus posuisse dicitur Pisistratus tyrannus, &c.
[2] Plutarch in Pericl. Op. i. p. 665.
[3] Thucyd. viii. 68.
[4] Thucyd. viii. 71; 72.
[5] Thucyd. iii. 82. πάντων δ' αὐτῶν αἴτιον, κ.τ.λ.
[6] Thucyd. viii. 66.
[7] Aristotle, Pol. v. 9.
[8] Cic. de Legib. ii. 16.
[9] Xenoph. Mem. i. 3.
[10] Xenoph. i. 6.
[11] Liv. xxv. 1. Quo diutius trahebatur bellum et variabant secundæ adversæq. res non fortunam magis quam animos hominum; tanta religio, et ea magna ex parte externa, civitatem incessit, ut aut homines aut Dii repente alii viderentur facti, &c.
[12] Euripid. Hippolyt. 952.
[13] See Pax. 410, 428. Lysist. 389.
[14] Lysimachus, in the Laches, complains of their fathers having neglected their education, ὅτι ἡμᾶς μεν εἴων τρυφᾶν, p. 162. See this dialogue of Plato throughout, on the subject of Athenian education.
[15] Aristot. Pol. v. 7. ὀλιγωροῦσι πάντες.
[16] Thucyd. ii. 39.

the exercises on the citizens, but excluded the slaves from the gymnasium. Now all classes were hearers of the philosopher; the smith, the carpenter, the fuller, the dresser of leather, were engaged in discussing problems of ethics and politics, no less than the high-born and wealthy citizen, and the orator, and the statesman, and the general. This was an evident indication of a corresponding change in the government itself; a change, which really came to maturity not long after the time of Socrates, when the machinery of the government passed from the hands of the generals and the men of practical ability, into those of the orators of the republic, and when rhetoric, or oratory, became the master science, and only another name for politics.[1]

Those, then, whose attention had been drawn to the person of Socrates many years before, and had then only laughed at the exaggerations of the comic muse, might naturally begin to suspect, in the progress of events at Athens, that there was a real danger to the institutions of the country couched under the humorous mien and conversation of the real Socrates. They would now, as they watched his increasing influence and reputation, recal their early associations of the ludicrous with the name of Socrates, not with the good humour with which they were originally received, but with the undefined fears since acquired, in the course of their daily observation, of one in whose hands the destinies of their country seemed to be placed. They would probably then think that they had judged his case too leniently before as spectators, and that they were now called upon to pronounce authoritatively as judges, not so much from the representations and arguments of the accusers, as from their own experience of the great change which their country had evidently undergone, and was still undergoing. Even indeed at the time of trial, nearly half of the great body of jurors were in favour of his acquittal; and Meletus would have failed altogether, but for the speeches of Anytus and Lycon, men of popular and rhetorical powers, who addressed the court in support of the charge; so strongly did the weight of his personal character, and the interest which he had excited by his friendly and instructive intercourse with every class of citizens, prevail in his favour.

We should take into account, further, the general neutrality of Socrates on questions of politics, and his decisive energy on particular political occasions, in which he was called upon by the circumstances of his position to take part. Both lines of conduct would create enemies. Neutrality in a state distracted with parties is the most unpopular course which can be adopted; however candid and reasonable the principle of such conduct may be, all parties look with jealousy at one who will not be associated with them in the guilt and the danger of party-struggles. They envy him his exemption from their violence, his reputation of candour, his safety under every vicissitude of party-ascendancy. Corcyra, as a state, was obnoxious to the other states of Greece for its neutral policy. So was the individual at Athens who kept aloof from public business, amidst that restless pragmatical spirit which actuated the state and its citizens. Athenians could not understand and appreciate the motives of one who abstained from the public assemblies, and the courts, and the theatres,—who shrank from all public offices,—was a member of no faction or club,—engaged in no trade,—disregarded even his own domestic concerns,—and lived a private man, where every one else was the servant of the public, busy with the affairs of the state, and incessantly pushing his own interests by his political activity.[2] The laws of Solon indeed inculcated the principle, that every one should take his side in the contention of parties.[3] Solon wished to interest the people in the maintenance of the constitution which he had given them; and accordingly, obliged them by penalties to attend to public affairs. This was evidently his reason for compelling their attendance in the assemblies and courts, as also for this singular provision. The increased action of the democratic spirit in the time of Socrates must have greatly fostered the opinion thus declared in their ancient laws. And thus we find philosophers in general held in disrepute at Athens, on account of their inactivity and unconcern in public affairs. The busy sophist, the orator, and the man of the world, censured them as pusillanimous, and indolent, and incapable of the duties of a citizen. Some of the early philosophers, indeed, had been distinguished as statesmen, and legislators, and generals. The Pythagoreans in Magna Græcia appear still to have sustained this character in some measure. But now philosophers were observed, for the most part, to lead a contemplative life of leisure, and to present a striking contrast to the general society of Grecian states. Plato takes every opportunity in his writings of defending philosophy from this calumny directed against the persons of its votaries, evidently treating it as a grievance which he had felt in his own case. Aristotle also indicates the prevalence of the same objection against philosophers at his day, when he studiously maintains that exertions of the mind in mere speculation are to be regarded as even more really practical than those which are directed to external results.[4] Socrates accordingly was a puzzle to many of his contemporaries. They wondered that he should freely dispense the treasures of his wisdom, and not convert it into a marketable commodity. Whilst they gave him credit for integrity, they regarded such a proceeding as mere folly.[5] They asked how he could think to qualify others for public life, without taking part in it himself, if he really knew what it was to be a statesman. But he was content, in reply, to point to the number whom he had laboured to render capable of public duties, as a more effectual service on his part to the state, than a mere personal activity.

But though the general conduct of Socrates was to avoid all interference in affairs of state, he had shewn on one or two very important occasions his patriotic feeling, and the energy with which he could carry it into effect. He had served with distinguished courage at Potidæa, Amphipolis, and Delium, as we have seen; and proved himself, on those hard-fought days, one who, as Pericles characterizes the Athenians, could philosophize without effeminacy, and, without being inured to the dangers of the field, could brave them at the moment of trial with no diminished spirit. But still greater occasions of trial were those of civil exertion at home, to which he was called not long before the accusation of impiety. Perhaps one of the most memorable instances of resolute firmness which history presents, is to be observed in the fact, that when the uproar of faction was demanding the iniquitous condemnation of the generals who commanded at Arginusæ, Socrates stood alone among his colleagues in office, and refused to put the question to the vote, as the epistates, or superintendent of the

[1] Aristot. Eth. Nic. x. Τὰ δε πολιτικὰ ἐπαγγέλλονται μὲν διδάσκειν οἱ σοφισταὶ, πράττει δ' αὐτῶν οὐδείς, ἀλλ' οἱ πολιτευόμενοι, κ.τ.λ. Τῶν δε σοφιστῶν οἱ ἐπαγγελλόμενοι . . . οὐ γὰρ ἂν τὴν αὐτὴν τῇ ῥητορικῇ οὐδὲ χείρω ἐτίθεσαν. c. ult.

[2] Thucyd. ii. 40. ἔνι τε τοῖς αὐτοις οἰκείων ἅμα καὶ πολιτικῶν ἐπιμέλεια, καὶ ἑτέροις πρὸς ἔργα τετραμμένοις τὰ πολιτικὰ μὴ ἐνδεῶς γνῶναι· μονοι γὰρ τόν τε μηδὲν τῶνδε μετέχοντα οὐκ ἀπραγμονα ἀλλ' ἀχρεῖον νομιζομεν.

[3] Plutarch, Solon, 20, tom. i. p. 354, ed. Reiske.

[4] Aristot. Pol. vi. 3. Ἀλλὰ τὸν πρακτικὸν οὐκ ἀναγκαῖον, κ.τ.λ. Also Ethic. Nic. x. 7. The oration of Isocrates against the sophists is addressed to the same popular calumny against philosophy.

[5] Xenoph. Mem. i. 6. Ὦ Σώκρατες, ἐγώ τοι σὲ μὲν δίκαιον νομίζω, σοφὸν δὲ οὐδ' ὁπωστιοῦν, κ.τ.λ. . . . Καὶ πάλιν ποτὲ τοῦ Ἀντιφῶντος ἐρομένου, κ.τ.λ. Ibid.

day, in the form proposed.[1] Each of the ten Athenian tribes had its turn of presidency in the council of Five Hundred for thirty-six days of the year; fifty out of the whole tribe being chosen by lot as its representatives during this period. These fifty were further subdivided into tens; and each of these tens, under the name of proëdri, served a week in succession, as it was allotted, until the official term of the tribe was completed. Again, of these ten presidents, seven were appointed by lot, to occupy the chair in succession during their week of office; each one of the seven becoming in his turn epistates, or superintendent for a day. The tribe Antiochis, to which Socrates belonged, happened to be the presiding tribe on the occasion of the impeachment of the generals; and it came to the lot of Socrates to be in the chair of office on the day when the question of their condemnation was so passionately debated. The generals had nobly done their duty to their country, and gained the most brilliant victory which had been achieved at sea in the course of the war by the Athenian arms. But the crisis was an unfortunate one for them. Athens was then on the verge of ruin. The jealousy of parties was at its height. The hopelessness of recovering the lost ground by military strength at this time, gave an opening and encouragement to personal intrigue, and the arts of an unscrupulous diplomacy; and a victory, however honourable to their arms, and hopeful as to the future, seems only to have been hailed with very doubtful congratulations by the struggling factions of the city; each looking at it rather as it might act for or against his party,—as it might tend to the strength of his rivals or their depression,—than as a great public triumph. However this may be, for the event remains a matter of perplexity to the historian, the successful generals were brought to trial through the treachery of their own officers, on the specious charge of having neglected the collecting of the dead bodies of their men after the action.[2] The charge was specious, because it was partly true, and was attested indeed by the very officers who were sent by them on that service, and who were now brought as witnesses against their commanders. It was true, so far as the endeavour to collect the dead bodies had been frustrated by a violent storm which followed the engagement. Still the endeavour had been made. The charge was further specious, because it appealed to religious prejudices, as well as to the democratic spirit. The generals seemed to have been regardless of the solemn rites due to the dead, and of the persons and feelings of the lower orders of the people. The occasion therefore furnished abundant topic of invective to the demagogues; and their addresses too fatally succeeded in obtaining an ungrateful and factious vote of death against the generals. Socrates was threatened with criminal information by the orators of the people; and the people themselves were urging on his assailants, and clamouring against him. Still he remained unmoved, and would not put the unjust question to the vote; preferring the hazard of bonds and death to himself, on the side of the law and right, to a compliance with the popular will in an illegal act.[3] The iniquity was perpetrated ultimately in spite of his resistance; but he at least did his utmost to prevent it.

Such was his conduct under the ascendancy of the democratic power. Afterwards, when the oligarchy was established, and the Thirty were exercising their acts of cruelty and extortion without restraint, he was the first to give a check to their tyranny. In their career of confiscation and blood, they marked out Leon of Salamis for destruction. They conceived that the terror of their power would compel even Socrates to be a ready instrument to their rapacity; and they were desirous also doubtless to implicate him in the criminality of the act. Accordingly, they appointed him with four others to go to Salamis, and bring Leon to Athens, that he might be put to death. They were disappointed, however, in their expectation, so far as they depended on Socrates as an instrument in the dark deed. The order was executed, and the unhappy Leon was sacrificed to their cruel avarice and fears. But Socrates had no hand in it, and resisted it as far as he could. Unawed by their stern command, he said nothing, but as soon as he had left the Tholus, the place where the Thirty were assembled, he left his four colleagues to proceed on their bloody errand and went home. He would not, indeed, have dared thus to disobey the order with impunity; he would surely have felt their vengeance;—for there is nothing that tyrants resent more than a clemency volunteered by the ministers of their cruelties,[4]—but that happily that reign of terror was soon after put down.

By these intrepid acts, Socrates had shewn that the philosopher, in declining the contentions of political life, did not incapacitate himself for his duties when the exigencies of his situation should require him to perform them.[5] As Thales had proved that the philosopher could, if he pleased, make money, by applying to that purpose his observations on the seasons, and his prognostics of an abundant crop of olives;[6] so did Socrates defend philosophy in his own person, and by his conduct on these great occasions, against the imputation of inactivity and selfish ease. It is quite evident, too, that such a spirit as that displayed in these remarkable instances, had he entered into political life, would have subjected him to violent collisions with the successive leaders of party at Athens. "You well know, Athenians," are the words which Plato's "Apology" puts into his mouth, "that had I long ago attempted to take part in political affairs, I should long ago have perished, and I should neither have done you any service nor myself. And be not aggrieved with me for saying the truth. For there is no one of men that can be safe, in giving a spirited opposition either to you or to any other popular government, and in preventing the occurrence of many unjust and iniquitous things in the state; but he that would in reality fight for the right, must, if he would be safe but a little while, lead a private life and not engage in public business."[7] "Think you, indeed," he further asks, "that I should have lived for so many years, had I engaged in public business; and had I, engaging in it in a manner becoming a good man, succoured the cause of right, and, as behoved me, made that the thing of greatest consequence? Far from it; for neither could any one individual of men."[8]

The time, then, appears to have arrived, when the accusation was brought by Meletus, for his exemplification of the truth of this observation in his own person. He had hitherto avoided the impending storm by the quiet tenour of his private life. But he had done enough to offend the partizans of either extreme in the state. Both extremes would be united against him in their enmity to all moderation; for the ascendancy of such counsels as his, would have been a death-blow to their own reckless lust of power. Hence, they were readily disposed to concur in sacrificing him to their mutual resentments. And we thus behold

[1] Xenophon, whose own reputation for courage gives a strong sanction to his opinion, says of this act of Socrates, ἣν οὐκ ἂν οἶμαι ἄλλον οὐδένα ἄνθρωπον ὑπομεῖναι, Mem. iv. 4, p. 208. He alludes in the same place to the story of Leon.

[2] Thucyd. ii. Plat. Apol. 28.

[3] Plato, Gorgias.

[4] Herodot. Thalia, 3. 6. Cambyses was glad that his order, given in a moment of passion, to kill Crœsus, was not obeyed; but he could not forgive those who had ventured to reckon upon his return to better feelings; and he accordingly commands that they should be executed for their disobedience.

[5] Plato, Apol. 32.

[6] Cicero, De Divin. i. 49.

[7] Plato, Apol. 31, 32.

[8] Ibid.

the sad spectacle of one who had been the friend of every poor man at Athens, no less than of the rich and noble, requited with prosecution and death by those very hands conjoined in the unnatural act, which should each have warded off the blow, if inflicted by the other. The genius of Intolerance was indeed behind the scene, mixing the poisoned cup for its destined victim. But the actors on the public stage of the trial were, at the same time, wreaking their own vengeance on a political opponent; and the more exasperated against him, in proportion as, by his imperturbable demeanour and real inoffensiveness, he seemed to defy their assaults, and to throw them back on the consciousness of their injustice and ingratitude towards him.

Nor can there be any doubt, that there were many individuals, whose pride he had hurt, whose ignorance he had exposed, whose ill-humour he had irritated, and who, such is the infirmity of human nature, would rejoice in the opportunity of revenge by the verdict of a public condemnation of his doctrine. In affronting the sophists by his free discussions of their pretensions, he had excited, doubtless, the hostility of many of the higher order of citizens, their patrons and disciples. Many fathers of families too must then have been suffering from that corruption of public morals which, under the teaching of the sophists, had clothed itself with plausibilities of argument, and impudently arrogated, for its vain pretensions, the importance of philosophy. Disobedient, profligate sons, lifting their hands against their fathers, and adding bitterness to their unnatural rebellion, by the hollow false-hearted principles upon which they had learned to justify it,—forward, petulant youths, insulting the dignity of age by their pretensions to superior wisdom, and their turbulence,—these were the fruits of sophistical education, which came home to every family at Athens. Few that felt the evil in their own homes, would stop to inquire whether Socrates was the teacher whom they had to blame for their suffering. Most would hastily conclude, that all such instruction of the young was pernicious, and their offence at the mischievous doctrine of the sophists would become a disgust to philosophy and philosophers.

Some, indeed, would distinctly trace to Socrates the annoyance which they had experienced from particular individuals. There were many who had frequented the society of Socrates, with no sincere intention of profiting by his lessons,—who observed his inquisitive manner, and its effect in convicting and refuting the errors of those with whom he conversed, and who endeavoured, for their own wanton gratification, to imitate him in their intercourse with others. These would take delight in confounding and perplexing others, and exposing and ridiculing their pretensions to wisdom. It is easy to conceive, that the superficial resemblance to the manner of Socrates in these persons, and the vexation produced by it, would excite angry objection against the real method of Socrates.[1] These persons would be pointed at as his disciples. These would be referred to as instances of the evil tendency of the teaching of the philosopher himself; the discredit of the spurious disciples being reflected on the master, to whom it belonged not in any degree.

It appears, further, as might have been expected, that the doctrines of Socrates were studiously misrepresented at the time. Allusions or illustrations employed by him in his reasonings were construed into positive opinions on the subjects to which he thus referred. For example, when, inculcating honest industry, he quoted Hesiod,[2] saying, "Work there is none that is a scandal, inaction is the scandal," the captious absurdly but maliciously interpreted him, as applying the words of the poet to sanction the doing every thing, whether right or wrong, for the sake of gain. When he quoted from Homer the account of Ulysses silencing the uproar of the people, against the practice of employing worthless persons in the public service, it was represented, that he approved the coercing the common people and the poor by harshness and violence.[3] Again, in urging the necessity of looking to the qualification of those who should be appointed to office, and illustrating this by the fact, that no one would choose, by lot, a pilot, or carpenter, or flute-player, or any one, indeed, in matters where error was far less mischievous than in politics,—he was charged with encouraging contempt of the established laws, and exciting the young to acts of violence.[4] And, (which is the most invidious form of misrepresentation), a general charge of corrupting the young was thrown out against him, unsupported by any specific statements of the means of corruption which he employed. As in the polemics of later days, so in the controversy between Socrates and his assailants, the obloquy of general hackneyed terms of reproach was resorted to as the substitute for definite grounds of imputation. Thus were the off-hand allegations against all philosophers,—"that they searched into the things in the air and the things under the earth, and rejected all belief in the gods, and made the worse appear the better reason,"[5]—used as a cover, on this occasion, to the envy and malignity which shrank from the light and the evidence of facts.

The accusation of Meletus, it will be observed, was distributed into three heads: 1. Contempt of the established religion. 2. The introduction of new divinities.[6] 3. The corruption of the young. The second of these charges requires to be more particularly noticed, because it has reference to a peculiarity in the conduct of Socrates which gave it a colour of truth.

The mind of Socrates appears to have been deeply imbued with religious feeling. The observation of final causes particularly excited his interest; so much so, as to lead him to think that no other account should be attempted to be given of the phenomena of the world, but as they are the results of a wise and benevolent design. He delighted thus in contemplating every thing in a moral and religious point of view. He thought that the introduction of physical and mechanical causes into the study of nature, only perplexed and misled the mind. He had at first been greatly attracted by the speculations of Anaxagoras. What won his attention in the system of this philosopher, was its distinguished merit beyond all previous systems, in assigning mind as the master principle of the universe. But when he came to study the writings of Anaxagoras more closely, he was grievously disappointed, and threw up the system in disgust. For he found that it lost sight of the grand and true principle with which it set out, and, after all, constructed the universe out of mere material and mechanical elements.[7]

[1] Xenophon speaks of persons who were pointedly corrected by Socrates, *μὴ μόνον ἃ ἐκεῖνος κολαστηρίου ἕνεκα τοὺς πάντ' οἰομένους εἰδέναι ἐρωτῶν ἤλεγχεν.* Mem. i. 4. Such persons would bear a grudge against him, as Anytus in particular appears to have done, and would not be very scrupulous, with this angry feeling dwelling in their minds, as to the mode of resenting the affront.

[2] Op. 311. *ἀεργείη δέ τ' ὄνειδος.*

[3] Xenoph. Mem. i. 2.

[4] Plato, Euthyphro, 3, 6. *ὥστ οὖν καινοτομοῦντος σοῦ περὶ τὰ θεῖα, γέγραπται ταύτην τὴν γραφήν· καὶ ὡς διαβαλῶν δὴ ἔρχεται εἰς τὸ δικαστήριον, εἰδὼς ὅτι εὐδιάβολα τὰ τοιαῦτα πρὸς τοὺς πολλούς.* Op. i. p. 6.—Xenoph. Mem. i. 2, 9.

[5] Plat. Apol. 23, p. 54.

[6] Athenians preserved the same character at the time of St. Paul in this respect, also, as well in their eagerness after news; as is seen in their accusing him of setting forth strange gods. (Acts xvii. 18.) *ξένων δαιμονίων δοκεῖ καταγγελεὺς εἶναι.*

[7] Plato, Phædo.—Apolog.

Socrates.

He saw, indeed, how futile, as to any real knowledge of the universe, had been the inquiries of the early philosophers. As an Athenian, he participated in that general prejudice against physical science, which Athenians had ignorantly imbibed against all philosophy, when they characterized it as idle talk and drivelling dotage. But as a genuine philosopher, in spite of his Athenian prejudices, he saw and felt that there was a real moral agency pervading the world; and he judged that, by observation of this, principles of real use for the right direction of human life might be discovered. Tinctured too, as an Athenian, with the superstition of his countrymen, and at the same time correcting it by his superior judgment and feeling, he was disposed to draw every phenomenon into his moral and religious theory of the universe. To stop to inquire into any thing whether it might be explained on simple natural causes, or to doubt its moral design, would appear to his mind as sceptical and profane. Hence, we see at once displayed in him the common character of the Athenian, in his dislike of physical science, and his susceptibility of superstitious influences from the most trivial things; and, on the other hand, the wisdom and religiousness of the true philosopher, in his constant devout disposition to refer all things to a providential design and moral agency.

It is well known how anxiously the heathens watched the most minute circumstances, not only in their religious rites, but in the actions of daily life, as intimations of the will of the gods. Not only dreams and visions, but flights of birds, the meeting any particular object, sneezing, a voice, or any sound, and the like trivial things, were regarded with seriousness and awe. Socrates felt the mystic influence of such incidents; only he thought more deeply on them than the generality, and that,—not with the vulgar emotions of fear or of hope, according as the omen might be interpreted,—but with calm and pious reference to the benevolent design which he attributed to them as divine intimations. Further, not only did he apply this sentiment to the outward circumstances of daily life; but he also took into his view the state of his own mind. He conceived that he received at times mysterious signs distinctly perceptible to himself, not indeed of any positive good to be expected from a particular course of conduct, but of precaution,—warnings against evil concerning others as well as himself. These presages he interpreted,—or others perhaps, taking his account of his impressions in too literal a manner, have so represented it,—as a voice addressed to him on each occasion. Instances too, are alleged in which this divine voice was the means of saving him and those who obeyed its direction, from danger. In the retreat of the Athenians after the unfortunate battle at Delium, it is said to have prevented his taking a particular road, and thus saved him, together with Alcibiades and Laches, from being pursued and overtaken by the enemy; whilst others taking another way were overtaken and slain.[1] This circumstance, according to Plutarch, was a great occasion of the fame at Athens of the "demonion,"—or "genius," as it was called by Latin writers,—of Socrates.[2] To this voice is attributed his active devotion of his life to the moral reform of his countrymen by private and personal addresses to them, and his refraining at the same time from all political exertion.

The name of a particular dæmonion, or genius, was evidently not assigned by Socrates himself to these extraordinary presages, while he confidently declared their reality. It was rather the misconstruction of the vulgar, and of his assailants, interpreting what he affirmed generally of divine intimations, as assertions of the presence of some particular divinity ascertained by his own convictions, and distinct from the gods worshipped at Athens. Heathens were incapable of forming a notion of the Deity, but as a local and tutelary god. They could not rise to the sublime conception of the one universal Being, τὸ δαιμόνιον, the God in all the world, than whom there is none else. In the view of Socrates, this belief in a presaging voice addressed to his private ear, was nothing more than an extension of the prophetic science, or divination of the heathen world, to practical purposes, and to the cultivation of religious feelings.

It must be remembered, that the Athenians had their augurs or prophets among the regular officers of the republic, without whose presence no matter of public counsel or of war was ever transacted. These were the recognized interpreters of the divine will. But Socrates claimed a special authority for the presages with which he was peculiarly favoured, and thus seemed to innovate on the science, and encroach on the established forms, of divination. He enjoined, indeed, a devout reference to the Delphic oracle, in all questions of hazardous conduct, teaching that, whilst human reason was the guide in all matters of human power, in those, on the contrary, which were out of human power, as the future event of actions, resort should be had to every means offered for exploring the will of the gods. He professed to have adopted his own course of life on the evidence of such communications. He advised Xenophon to consult the Delphic oracle, as to whether he should do well in accepting the invitation of Proxenus to join the expedition of Cyrus.[3] But with this reverence for the recognized sources of divine information, he combined a suspicion of the pretenders to prophecy, who were countenanced by the popular superstition,—the θεομάντεις and χρησμῳδοί,—who abounded at Athens.[4] He relied rather on the sagacious auguries of his own mind, drawn from observation of some passing incident, or some rapid conclusion respecting the consequences of actions—a kind of intuitive judgment and forecaste, mingling and confounding itself with his religious impressions,—a second hearing, as it were,—a perception of a voice unperceived by the common ear, mysteriously telling of danger to come from some particular course of conduct. Thus was a pretext given to his enemies to say, that he introduced "new divinities;" whilst public opinion tolerated the grossest pretensions to divine revelations, and a system of mercenary imposture founded on them. Public opinion upheld the system of divination as it existed, with its external array of augurs, and prophets, and ceremonial. Socrates, on the contrary, led every man to consult the will of the Deity, not without devout preparation in the inward recesses of his own mind, nor without reference to his own obedience and moral improvement.[5] Superstition, doubtless, strongly tinctured his notions of religious duty. This made him construe many things into divine intimations, which were frivolous and irrelevant. Still he rose above the superstition of the popular divination, in the personal piety which laid hold of each occasion for its exercise and cultivation, and taught men to regard the Divinity as interested in the protection of the good, and ever present to the words, and actions, and even the silent thoughts of men.[6]

Xenophon appears to have faithfully stated the difference between the popular divination and that professed by Socrates, in the following account: "He introduced nothing new beyond others who, acknowledging the reality of divination, make use of omens, and voices, and objects pre-

[1] Plutarch. de Socr. Gen. 298. Cicer. de Divin. i. 54.

[2] Ibid. p. 299.

[3] Xenoph. Anab. iii. 1, 4.

[4] Plato, Apol. 22. c. p. 51.

[5] Plato, Alcib. ii. 150, p. 99. Καὶ γὰρ δεινὸν εἴη, ἐι προς τὰ δῶρα και θυσιας ἀποβλέπουσιν ἡμῶν ὁι θεοὶ, ἀλλὰ μὴ πρὸς τὴν ψυχὴν, ἂν τις ὅσιος καὶ δίκαιος, κ. τ. λ.

[6] Xen. Mem. i. 1, 19. Καὶ γὰρ ἐπιμελεῖσθαι θεοὺς ἐνόμιζεν ἀνθρώπων, ὀυχ ὃν τρόπον οἵ πολλὸι νομιζουσιν, κ.τ.λ.

sented on the way, and sacrifices. For these do not conceive, that the birds, and the persons that meet them, know what is expedient to those who divine by them, but that the gods, by means of them, signify this. And so he held. But the generality say, that they are dissuaded and persuaded by the birds, and the objects that meet them; whereas Socrates spoke of it as he thought. For he said that it was the Divinity, *τὸ δαιμόνιον*, that gave signs to him. And to many of his intimates he prescribed to do some things,[1] to forbear other things, on the ground, that the Divinity had presignified it to him; and it was to the advantage of those who took his advice, whilst those who rejected his advice had to repent it."[2]

But how great was the change from the practical devotion of the mind here taught by Socrates, from that popularly entertained at Athens! The history of divination, as it was regarded, not at Athens only, but throughout Greece, is but a picture of the invidiousness and malignity of the human heart transformed into attributes of the Divine Being. Let us only hear Solon, as he is described by Herodotus, speaking of the Deity as a principle of envy and turbulence, and as guided by no fixed course in the disposition of human affairs; and we may judge what a task he had enterprized, who entered into conflict with this inward and subtile idolatry of human passions, established by the heathen system of divination. It was indeed teaching divinities new to Athenian ears, when Socrates inculcated an inward reformation of the character of those who would look for the favour of the gods, or expect a special interposition and direction from the benevolent principle which guided the course of the moral world.

Whereas, too, the popular divination was employed on the most trivial occasions, and made the substitute for the proper exertion of men's faculties on matters cognizable by them, Socrates differed from this prevalent notion of the subject. He contended, that, where the line of conduct was plain, men should use the best of their judgment in acting,—that they should use their experience and reason in learning what the gods had given them to learn by such means, and only have resort to consultation of the Divine will by the extraordinary means of divination, where the results of conduct were uncertain. Thus might he be construed as dissuading men from the use of divination, when he only dissuaded from an improper use of it, and exhorted to a rational activity.

We may see from the story of Aristodicus of Cyme, how the practice existed among the Greeks, of endeavouring to obtain from the oracles sanctions even to iniquities and impieties. Aristodicus consults the oracle whether he may surrender an unhappy fugitive; and the oracle permits him, dexterously reproving, by the very permission, the attempt to cast the burthen of personal responsibility on the oracle itself, and to cover an immoral act with the veil of religious duty.[3] Divination, in fact, was indolently resorted to in the heathen world, to relieve the mind of the labour and anxiety of thought, and the searchings of conscience. And Socrates addressed himself to the correction of this practice, by recommending, as we have seen, exertion of the judgment, and the acquisition of information on all matters within the sphere of human reason. He would thus provoke the hostility of many a professed diviner, who made a trade of his art, and would find individuals of this class ready to join in the outcry raised against him, of innovation on the popular theology.

The jealousy of the sophists in particular, the very class with whom the accusation of Meletus identified him, would also swell the popular envy against him on this head. For the sophists, among their pretensions, claimed to be regarded as endued with a predictive sagacity, so as to be expert practical guides respecting the future.[4] Socrates would offend them in this point in two ways,—both as directing persons to have recourse to their own judgment, and the regular means of information on all ordinary questions to which human reason was competent; and as teaching a reference to a secret divine intimation on all other matters beyond the compass of man's understanding. For in both respects would the sophists find their course interfered with. The use of men's own judgment, or the appeal to the signs of the Divine will, would equally lessen the value for those counsels which they pretended to impart.

What added still further to this invidious feeling was, that the reputation of Socrates now eclipsed theirs throughout Greece. And Socrates appears himself confidently to have appealed to this public estimation of his character against the partial censures of his countrymen at the time of his trial. He vindicated his assertion of divine intimations specially granted to him, by referring to the oracle of Delphi as having honoured him with its distinct approbation. Chærephon, in the devoutness of his admiration of his master, had, on some occasion, consulted the oracle respecting him, and obtained an answer that Socrates was the wisest of men. The authenticity of the anecdote has been questioned. But the introduction of it in the two "Apologies,"[5] may be taken as a voucher of its substantial truth. It at any rate shews the favourable opinion which had been conceived of him out of Athens itself; that, as Lycurgus had been complimented by the verdict of an oracle, so the same tribute of public applause might, with equal probability, be assigned to Socrates.

According to Laertius, the sentence of condemnation was carried by a majority consisting of 281 votes. The number was little more than sufficient to decide the question on that side; for it only exceeded the number of votes of acquittal by three. "Had but three votes only fallen differently," says Socrates himself, in the "Apology" of Plato, "I should have been acquitted." Nor, indeed, would Meletus alone, without the aid of Anytus and Lycon, (he is made there confidently to declare) have obtained even a fifth part of the votes to save him the penalty of a thousand drachmas, affixed by the law to an unsustained prosecution. But when the penalty of death was further put to the vote, and he was found unwilling to propose the substitution of any other penalty, such as a fine or exile, but evinced his indignant contempt of their unjust sentence, by asking rather, in his ironical way, instead of even a slight punishment, the highest honour of the state, that of a public maintenance in the Prytaneum, the multitude of the jurors was so exasperated by the unbending spirit thus displayed, that eighty additional votes were given on the hostile side, determining the sentence of death. So evidently was the whole case ruled by passion and the arts of demagogues exciting the people to treat it as a slight on their majesty, rather than as a cause in a court of justice. Otherwise it could not have happened, that when the previous question of guilt had been carried with nearly an equal number of dissentients, the severest penalty should have obtained such an accession of voices in its favour.

We have already remarked the little solicitude shewn by

[1] Xenophon here differs from Plato's Apology, in saying, that Socrates received intimations of what was to be done; whereas Plato expressly says the directions were only negative.

[2] Xenoph. Mem. i. 1, 3, p. 3. Xenoph. Apol. 13, *ἐγὼ δε τοῦτο δαιμόνιον καλῶ.*

[3] Herodotus, Clio. c. 158, 159. The same is illustrated in the story of Glaucus in Erato, c. 86. The oracles were consulted, also, on frivolous matters, such as the petty thefts of Amasis. Euterpe, c. 174.

[4] Isocr. c. Soph. 2, 4, *περὶ τῶν μελλόντων μὲν εἰδέναι προσποιουμένους.*

[5] Xenoph. Apol. p. 249. Plato, Apol. p. 48.

Socrates in regard to his defence from the accusation. As he strongly disapproved the affected artificial rhetoric of his times, and the practice of appealing to the passions against the judgment of the hearer, so neither would he study beforehand what he should say on the occasion of his trial. Twice had he essayed (he observes to Hermogenes) to consider what he should say in his defence, and as often had he been prevented by those secret divine intimations to which he habitually referred his conduct.[1] Nor again would he receive the proferred services of friends in pleading his cause. The celebrated orator Lysias composed an oration for this purpose. On reading it, he expressed his admiration of it, but declined it as unsuitable to him. When Lysias wondered that he could admire it, and yet say it was unsuitable, he observed, in his usual manner of illustration, by an apposite case; "Would not also fine coats and shoes be unsuitable to me?" Plato, however, it is said, could not be restrained from appearing in his behalf, and made an effort to address the court. But the uproar was so great, that on his uttering the words, "ascend the bema," he was met with the cry, "descend," and forced to abandon the attempt.[2]

So neither, again, would he resort to those appliances to the feelings which were usual in the Athenian courts. The Athenian juryman expected that the defendant should come before him in the character of a suppliant, and entreat his clemency rather than claim his justice. He was to be assailed with prayers and tears, no less than with arguments addressed to his understanding. But Socrates would not condescend to these methods of persuasion. He would not produce his wife and children in the court, to excite compassion, or bring forward his connexions and friends to intercede in his behalf. He felt it unbecoming in him at his age, and with his reputation as a philosopher, to supplicate for his life. It would have given to his whole previous demeanour the appearance of insincerity and hypocrisy. It would have shewn that dread of death, against which all his teaching had been directed.[3] It would have been an evidence that he disregarded the sanctity of religion, in trying to influence his jurors to decide by favour against their oaths, and so far would have substantiated the charge of Meletus against him.[4] For the same reason, he had refused to offer to submit to a mitigated penalty, when challenged, according to the practice in the Athenian courts, to propose his own estimate of the offence. Afterwards, indeed, he softened this bold vindication of his merits, by adding, in the same ironical manner, that he could perhaps pay the fine of a mina of silver, and would therefore fix that amount of damages; or that as Plato, Crito, Critobulus, and Apollodorus, suggested the sum of thirty minæ, and would be good sureties for the payment, he would fix the latter amount.[5] To have seriously proposed any such estimate would, in his opinion, have been an admission of his guilt.[6]

He displayed throughout the trial, the same calm and cheerful temper which characterized his ordinary behaviour. There were in his manner, even at that solemn crisis, touches of the same ironical humour, the same half-earnest, half-playful strokes of argumentative attack, which had given so much interest and point to his daily familiar conversations; and when the trial was over, he evinced no further emotion than the indignation of a sincere and honest man, at the malicious and mischievous arts by which the result had been accomplished. He was sustained by the consciousness that no crime had been proved against him; whilst his assailants must feel the reproaches of conscience for the real impiety and iniquity of which they had been guilty; some for having instigated others to bear false witness against him; some for having themselves borne this false witness. The disgrace of the condemnation fell not on him, he asserted, but on those who had passed such a sentence. He consoled himself with the thought, that it was the will of the Deity, and it was best for him now to die; that, though condemned by his present judges, like another Palamedes, he should receive from posterity that verdict of approbation which was withheld from Ulysses, to whose successful plot the life of that chief was sacrificed.[7] Availing himself also of the prophetic power which the popular belief attributed to the words of a dying man, he warned his countrymen, as he left the court, that they were embarked in a course which must involve them in bitter repentance.[8] He concluded his address with the following striking admonition: "I have only this request to make. As for my sons, when they shall have grown up, punish them, I pray you, by troubling them in the same manner in which I have been in the habit of troubling you, if they appear to you to concern themselves either with money or any thing else in preference to virtue. And if they would seem to be something when they are nothing, reproach them as I do you, that they take no concern about what they ought, and think themselves to be something when they are nothing. And if you do this, I shall have suffered justice at your hands, both myself and my sons. But it is now time to depart; for me to die, for you to live; but which of us is going to a better thing is uncertain to every one, except only to the Deity."[9]

In his way from the court to the prison to which he was now consigned, he was observed with eye and mien and step composed, in perfect unison with his previous address. On perceiving some of those who accompanied him, weeping, "Why is this," he said; "is it now that you weep? did you not long ago know, that, from the moment of my birth, the sentence of death had been decreed against me by nature? If, indeed, I were perishing beforehand in the midst of blessings flowing in upon me, it would be plain that I and my kind friends would have to grieve; but if I terminate my life at a time when troubles are expected, for my part I think you ought all to be in good heart, as feeling that I am happy."[10] Apollodorus, whoes admiration of his master amounted to an amiable weakness, complained to him of the great hardship of his suffering by an unjust sentence. Acknowledging the affectionate feeling thus shewn to him in a familiar manner, by passing his hand over the head of his attached disciple, he, at the same time, gently reproved him, saying, "Would you then, my dear Apollodorus, rather see me dying justly than unjustly?" and smiled at the question. On seeing Anytus pass by, he could not forbear, it is said, the expression of a strong censure on the conduct of that individual towards his own son. He foretold, what the unhappy result proved too true, that the heart of Anytus would one day be embittered by the evil fruits of that low and unworthy education to which, with mercenary views, he had subjected his son, a young man with whom the philosopher had formerly conversed, and who had seemed destined for better things.

The execution of Socrates, by the poisoned cup, would have followed immediately on his condemnation, but for the peculiar circumstances under which the trial had taken place. It was after the commencement of the Delian festival; an annual commemoration, of the safe return of Theseus and his devoted companions to Athens, from the fatal labyrinth of Crete, and the acquittal thenceforth of the

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[1] Xenoph. Mem. iv. 8. *Ἔφη γὰρ ἤδη Μελίτου γεγραμμένου αὐτὸν τὴν γραφὴν, αὐτὸς ἀκούων αὐτοῦ πάντα μᾶλλον ἢ περὶ τῆς δίκης διαλεγομένου λέγειν αὐτῷ, ὡς χρὴ σκοπεῖν ὅ τι ἀπολογήσεται, κ. τ. λ.*—and Apol. 2, *et sqq*.

[2] Diog. Laert. in vit. Socr.

[3] Plato, Apol. Op. i. p. 79.

[4] Ibid. p. 82.

[5] Plato, Apol. 38 b. Op. i. p. 88.

[6] Xenoph. Apol. p. 23, *κελευόμενος ὑποτιμᾶσθαι.*

[7] Xenoph. Apol. 24.

[8] Plato, Apol.

[9] Plato Apol. ad fin.

[10] Xenoph. Apol. 27.

bloody tribute exacted by Minos, by the mission of a vessel to Delos with sacrifices to Apollo, and other religious rites. When the priest of Apollo had once crowned the stern of the sacred vessel with the festive garland, it was not lawful to pollute the city by a public execution, until the solemn pomp should have been performed, and the vessel had returned. This ceremony had been performed only the day before the trial of Socrates. Thus he obtained the respite of thirty days between his trial and execution.

These were days of high interest and importance not only to his sorrowing friends, but to the cause of that admirable practical philosophy which all his previous life had inculcated. During this time he employed himself in literary exercises which he had never practised before. He composed a poem in honour of the god Apollo, whose festival was then in course of celebration. And feeling a religious scruple as to whether by the general pursuit of philosophy, he had fully complied with the suggestions of dreams repeatedly urging him, as he said, to "cultivate music," he now applied himself to the fulfilment of this supposed charge, by turning the fables of Æsop into verse.[1] But these were only pastimes illustrative of the serenity of his mind. Now, too, in his prison, with the chains on his body, and the near prospect of a violent death, he could discourse with an unanswerable cogency and eloquence of argument, of the vanity of human things, and the real happiness of man, as consisting in the cultivation of the spiritual and immortal principles of his nature. He had professed his whole life to be a meditation or discipline of death. He now had the opportunity,—which, as a philosopher, (could the voice of natural instinct have been silenced,) he would most have desired,—of realizing, by his own example, that death to which his thoughts and pursuits had been studiously directed. Unlike his successors in the schools of the Stoics, he did not advocate a doctrine of suicide, however he depreciated the importance of human life. With that good sense which restrained his religion and his philosophy from running into fanaticism, he held it to be impious in any one to release himself, by his own hand, from that post of duty in which the Deity had placed him.[2] Though, however, he had not courted death, or rashly placed himself in the way of it, he felt that, in the circumstances in which he was now placed, he was called to go through this last act of his philosophic profession. He seems, indeed, to have rejoiced in the opportunity thus afforded him of summing up his philosophy in one great principle, from which every observation and argument, in the course of previous teaching, had been drawn, by demonstrating, so far as reason could avail to demonstrate the fact, the absolute and eternal existence of the great principles of moral truth. The occasion was one which the genius of Plato would not fail to seize as most felicitous for the development of its own enthusiastic and transcendental view of the philosophy of Socrates. Plato, accordingly, has, in that most exquisite of his Dialogues, the Phædo, invited us to the couch of Socrates, on the last sad morning of his imprisonment, to listen to the philosopher, with the chill of death almost upon him, discoursing on the immortality of the soul. The affectionate and eloquent disciple doubtless shed natural tears over his dying master But he wished also to elevate his own philosophy to the dignity of being the dying confession of the great sage of Athens. And he wished, further, that his own philosophy should speak, as it were, the funeral oration over him to whom it was indebted for its earliest inspirations, and pour its own libation on his tomb. Thus he has especially elaborated the last scene of his master's life, and made us contemplate with the deepest interest the death of Socrates, not only as an act of heroic self-devotion and patient martyrdom to the truth, taught by the great sage himself, but as a splendid episode in the dramatic development of his own philosophy.

During his imprisonment, Socrates was not denied the solace of receiving his friends, and conversing with them day after day. Early each morning might be seen a company of devoted friends, whom nothing could separate from him, assembled at the hall of justice, where the trial had taken place, and which was close to the prison, watching for the jailor to open the gate and admit them. Being admitted, they would commonly remain with him in the prison until evening, engaged in earnest and instructive conversation. His wife and children, too, appear to have been constantly with him.[3] He was importuned by these affectionate followers to suffer them to effect his escape. Crito earnestly entreated him to be allowed to execute a plan which he had concerted for rescuing him. Simmias, the Theban, also brought a sum of money with him to Athens for that purpose. Cebes and others were equally ready with their resources. They argued, that, so far from being at a loss what to do with himself out of Athens, as he had said on his trial, they could ensure him friends in Thessaly, and many other places, who would most gladly welcome him, and protect him. But to none of these importunities would he yield. He answered, that, while he highly estimated their kindness, he was pledged to obey reason only, and that he saw no ground in his present circumstances for taking a different view of his case. As for the duty of providing for his children, by preserving his own life,—a consideration which Crito appears to have strongly pressed on him,—this was not now a matter for him to consider;—it was for those to consider, who, as his Athenian judges, treated life and death as such light concerns; for his part, he must look simply to what was right or wrong to be done.[4] Thus steadily and calmly did he persevere in his resolution of awaiting the utmost extremity.

At length it was announced that the Theoric galley had been seen off Sunium, and might very shortly be expected to arrive at Athens. Crito proceeded in anxious haste to the prison, and being well-known to the jailor from his frequent visits there, obtained admission at a very early hour. He found Socrates asleep, and sat by him in silence, wondering to see him sleep so soundly in so much trouble, until he at length awoke to receive the fatal intelligence. This he received with the same composure as if it had been some ordinary communication. His only answer to Crito was, that he was quite resigned to the will of the gods, if it were so, but that he was persuaded by a dream, from which he had just waked, that the vessel would not come that day, but the following one. His reliance on dreams as divine intimations, has been already mentioned. He told Crito, accordingly, of his having dreamed that a woman of noble form, clothed in white, came to him and called him, and said to him in the words of Homer,[5] "On the third day to deep-soiled Pthia thou shalt come." The event, at any rate, accorded with his expectation from the dream. On the morrow the vessel reached the harbour of Piræus; and the following day was appointed for the execution.

By the dawn of that day, the sorrowing party again met at the accustomed place, and were informed by the jailor, that the Eleven,—the officers who superintended the public executions,—had given orders that the chains should be taken off, and that Socrates should die on that day. After being kept waiting some time, they went in and found the philosopher already loosed from his chains, and sitting on the couch, with Xanthippe and his youngest child in her arms, by his side. By his desire they conduct her home, the kind Crito

[1] Plato, Phædo. p. 60 d. *et sqq.*

[2] Plato, Phædo, p. 61, c. *'Ον μὲν ἴσως βιάσεται ἀυτόν. οὐ γὰρ φασὶ θεμιτὸν ἔιναι.*

[3] Plato, Phædo. p. 60 a. Op. i. p. 135.

[4] Plato Crito, p. 48, c. Op. i. p. 111.

[5] *Ἤματί κεν τριτάτῳ Φθίην ἐρίβωλον ἵκοιο.*

Socrates. entrusting her to the care of his attendants, amidst cries of passionate grief, which had broken forth from her afresh at the sight of them now come to bid their last farewell. The occasion naturally leads to the conversation which follows; a discussion, according to Plato, on the immortality of the soul,—Socrates interrogating and arguing with all his wonted vivacity; whilst the party around him answer and listen with eager interest, and, as may naturally be conceived, with undescribable sensations of mingled delight and pain. Crito would have dissuaded him from this exertion; for he feared, from what he had been told by the executioner, that the heat of the body thus produced, would add to his discomfort in his last moments, by rendering the effects of the poison more lingering. He only observed, that "it mattered not; the executioner should only be ready to do his duty, and mix the draught twice, or even thrice over, if it should be found necessary."[1]

The discourse being brought to a close, he rose to proceed to the bath, as an immediate preparation for his death; when Crito detained him for a while, to ask his last commands about his children, or any other matter in which their services might gratify him. He replied, "that he had nothing new to say beyond what he had ever been saying,—that by attending to themselves, they would most gratify him and his, as well as themselves, in all they might do, though they might even make no promise now; but that if they neglected themselves, and were unwilling to follow in the track pointed out in all that he had said to them up to this last occasion, all that they could do would be of no avail, however much, and however earnestly, they might promise at the present moment."[2] Crito assented to this advice, but in his eagerness still to do some act of kindness to his revered friend, subjoined, "But in what way are we to bury you?" This mode of speaking of his burial, gives occasion to a very characteristic reproof from him, of this solicitude on the part of Crito. "As you please," was his answer; "if at least you can take me, and I do not escape from you." Then gently smiling, and looking off to the surrounding company, he added, "I cannot, my friends, persuade Crito, that I am the Socrates that is now conversing, and ordering every thing that has been said; but he thinks that I am that man whom he will shortly see a corpse, and asks how you should bury me. But what I have all along been talking so much about,—that when I shall have drunk the poison, I shall no longer stay with you, but shall, forsooth, go away to certain felicities of the blest,—this I seem to myself to have been saying in vain, whilst comforting at the same time you and myself. Bail me therefore, to Crito the opposite bail to that which he bailed me to the judges; for he was bail for my staying; but do you be bail for my *not* staying when dead, but going away; that Crito may bear it more easily, and may not feel aggrieved for me, as if I were suffering something dreadful, when he sees my body either burning, or being interred; nor may say at the burial, that he lays out, or carries out, or inters *Socrates*. For," he continued, turning himself again to Crito, "be assured, excellent Crito, that the speaking improperly is not only wrong in itself, but also produces some evil in the soul. However, take courage, and say that you are burying *my body;* and bury it as may be agreeable to you, and in the manner you may hold most lawful."[3]

He then went into another apartment to bathe, Crito following him, whilst the rest of the party awaited his return. After bathing, he received his children,—two of whom were yet little ones, the third a youth,—and the females of his family. Having conversed some time with these in the presence of Crito, and given them his final commands, he dismissed them, and came out again to the assembled friends. This affecting interview had occupied a considerable time, and when he returned, it was near sunset. He had not long sat down, when the officer of the Eleven presented himself, and respectfully intimated to him that the fatal moment was at hand. The noble and gentle demeanour of the philosopher during his imprisonment had won upon this man; and used as he had been to the scenes of execration and horror within those walls, he was struck by the contrast in the case of Socrates, and bursting into tears as he gave his message, turned himself away, and retired. Socrates himself was touched by this demonstration of considerate feeling. He cordially returned the salutation, promising a ready compliance with the order. Then addressing the company, he observed, "How courteous the man is! through all the time he would come to me, and would converse with me sometimes, and was the best of men; and now how generously does he weep for me!" He then called for the poisoned cup. Crito's affection would still have delayed it, for he urged that the sun was not yet gone down, and that others on the like occasions had not used such despatch, but had supped and drunk beforehand as they pleased. Socrates answered that this might be reasonable for others; for him it was reasonable not to do so; and persisted in requiring the cup to be brought. The process of bruising the hemlock took some time; but at length the man who was to administer the poison came with it now ready for the draught. He calmly inquired what he was to do; and, being told that he was only to walk about after drinking it, until he found a heaviness in the legs, and then to lie down, he took the cup into his hand without the slightest change of colour or of countenance. But before he put it to his lips, partly, it seems, from religious feeling, and partly in humour, he further asked whether he might make a libation to any one from the cup. Nor did even his usual quaint manner of putting a question, which he knew would somewhat surprise the hearer, forsake him on this occasion; for he looked at the man, at the same time, with that peculiar glance usual to him, which his contemporaries jocosely designated by a word denoting its resemblance to the manner in which the bull glares around him with the head downward. Learning that the whole draught was not more than sufficient for the fatal purpose, he said, "At any rate one may, and ought to pray to the gods, that the migration hence to those regions may be prosperous; which indeed I do pray, and so may it be!" With these words, he drank off the poison with the most perfect composure and readiness.

At the sight of this, the bystanders could no longer command their emotions. Their tears flowed profusely. Some rose up from their seats,—Crito set the example,—and covered their faces, to give vent to their sorrow. Apollodorus sobbed aloud. He gently expostulated with them for this outbreak of grief, saying, "What are you doing, my friends, so strangely? I indeed sent away the women not least on this account, that they might not offend in such a way; for I have heard that one ought to die amidst auspicious sounds: I pray you, therefore, be tranquil, and bear up." This rebuke had the effect of repressing their tears. The heaviness which he had been led to expect from the working of the poison now began to come on, and he left off walking, and reclined, with his face upward, and covered over. The torpor gradually spread towards the upper regions of the body,—the lower parts becoming, one after the other, congealed, and insensible,—until it reached the heart. In this interval, he uncovered himself, and said, "Crito, we owe a cock to Esculapius; pay it, I pray you, and neglect it not;" intimating probably that now all the diseases of life were healed, and that he was restored to real and pure existence by the death of the body. These were his last words. Crito asked whether he had any thing more to say, but received no answer. There was no further indication of life,

[1] Plato, Phædo, p. 63, d. *et sqq.*

[2] Ibid. p. 115, a. *et sqq.*

[3] Ibid.

but a motion of the body. The executioner uncovered him, and they observed his eyes fixed; upon which Crito, faithful in the last respectful attentions to his beloved friend, the now departed philosopher, closed the mouth and the eyes.

Thus died Socrates, when he had now completed his seventieth year, B.C. 400, or 399, in the full vigour of a healthy old age; happy in his own estimation, and in that of his admiring disciples, in having terminated his life in so glorious a manner, with unimpaired faculties of mind and body, and after a defence sustained with so much truth, and justice, and fortitude.[1]

His death spread dismay at the moment among those who had been most conspicuous in their attachment to the philosopher, as they naturally dreaded the overflowings of that malignant spirit which had swept down their master. The chief of these appear to have fled to Megara, where they could reckon on finding a refuge from Athenian hostility, and a home with their fellow-disciple, the friendly Euclid. It is remarkable, however, that Isocrates, timid as he was by nature, should not have scrupled to remain at Athens, and to testify his affectionate regret for his master, by appearing the next day in public, clothed in mourning.[2] But with the fall of its great victim, the spirit of persecution was sated for a time. An act had been perpetrated, to which the eyes of all Greece would be intently turned; and the greatness of the sacrifice seems at the moment to have absorbed the attention of its agents and instruments, in the contemplation of it and its possible effects. If we may believe the representation of subsequent writers, shame and repentance soon followed the cruel act; and those who were most ostensibly involved in its guilt, were either banished or sentenced to death, or laid violent hands on themselves. Of the banishment of Anytus, and the death of Meletus, we are told by Laertius, that Antisthenes was the immediate cause. In what way he was instrumental to the death of Meletus, is not stated. But with regard to Anytus, Antisthenes is said to have occasioned his banishment, apparently without the intention of doing so, by a stroke of practical humour. For meeting with some young men from Pontus, inquiring for Socrates, whose fame had induced them to visit Athens, he conducted them to Anytus, who, as he observed to them, was "wiser than Socrates;" upon which, the indignation of the bystanders was excited, and they drove Anytus forth from the city.[3] He fled to Heraclea; but there found no peace, being forced by public proclamation to leave the city forthwith.[4] Though, however, these individuals soon after received the retribution due to their offence, it would not follow that they suffered from their countrymen on account of the part they had taken against Socrates. The ascendancy of another political faction, (and Athens was ever fluctuating between contending parties), would be quite sufficient to account for their overthrow and desperation. On the other hand, the testimony of Plutarch is explicit to the point, though he mentions no individuals by name, that the sycophants who had assailed Socrates became the objects of popular hatred to such a degree, that none would associate with them in any way, not even to return them an answer when addressed by them, and that at last they hanged themselves, being no longer able to endure the public execration.[5] His friends, indeed, performed the last obsequies to his remains; but his fellow-citizens afterwards concurred in honouring him, by erecting a brazen statue of him, the work of Lysippus, in the Pompeium, and expressing their sorrow, by closing the public gymnasia for a while.

This at any rate is certain, that persecution, as it ever does, overwrought its part in the case of Socrates. It oppressed, indeed, the individual, but it gave the seal of martyrdom to the cause in which he had been engaged. It produced a temporary intimidation, under which men would hear less of the name and teaching of Socrates openly avowed, but throughout which the admiration and love of the heroic philosopher would be cherished in secret, and his doctrine would be fostered in the shade, to appear in the sunshine of a future day. If the Athenians had desired to plant the root of philosophy in their city, they could not more effectually have done so, than by their violence against Socrates. Such, in fact, was the result. Philosophy henceforth obtained an Athenian naturalization and name; and the schools of Athens may date their period of nearly a thousand years from this memorable act, which, in its intent and spirit, fiercely but blindly endeavoured to extinguish there the very profession of philosophy.[6]

The cause, however, in which Socrates had been engaged, was too true, for any opposition to it, though conducted with the greatest prudence, to have been long successful. It had also already advanced too far, and interested too many persons in the maintenance of it, to be put down by a sudden blow. The burning of a book, or a formal condemnation of the opinions of a writer, are but futile means, as experience shews, of suppressing obnoxious doctrines. How much less could opposition avail, where, as in the case of Socrates, the offending doctrines had been scattered over, not the pages of a book, but the strenuous exertions of a long life,—already engraved in characters which no obliterating hand could reach, and doubtless so worked into many a mind, as not to be distinguishable from its own proper convictions,—doctrines too, so confirmed by the noble example of their teacher, in carrying them out to their full consequences by his death? For the death of Socrates, it should be observed, was not simply a test of his sincerity in his teaching. It was this, and still more. It was the ultimate and decisive opposition to those false principles, against which every action and discourse of his life had been directed. He had been all along exposing the presumptuousness and vanity of the principles on which men ordinarily judged and acted. He was now further to shew, that this opposition on his part was not to be daunted by those principles, when set in formidable array against his own life; and that, professing a low estimate of the present life, he would not disown or shrink from that profession at the moment of greatest trial.

If we inquire, accordingly, what was the substance of the positive teaching of Socrates, we must address ourselves to the contemplation of his active life, and his resigned patient death. He had no design of establishing philosophy as a literary pursuit or intellectual pastime; though he probably foresaw, that that taste for inquiry into truth which he was ever awakening, must soon lead to the formation of a philosophical literature at Athens. He already witnessed, indeed, the commencement of such a literature, the result of this excitement, if it be true that he had read the Lysis of Plato, and observed respecting it, "How much the young man makes me say that I never said!"[7] He wished rather to divert men from the vanity of setting themselves up as philosophers, and make them employ their thoughts in learning and investigating, instead of prematurely commencing

[1] Xenoph. Mem. IV. 8.—Apol. 32.—Plato, Phædo, ad fin.
[2] Pseudo-Plutarch. X Orat. Vit. Plutarch. Op. ix. p. 336.
[3] Diog. Laert. in vit. Antisth. vi. 4, 10.
[4] Ibid. in vit. Socr. ii. 5, 43.
[5] Plutarch. de Invid. et Od. Op. viii. p. 128.—Diodorus Siculus says, ὁ δῆμος μετεμελήθη . . . . καὶ τελος ἀκρίτους ἀπέκτεινε. xiv. 38; also Augustin. de Civ. Dei, viii. 3.
[6] The schools of Athens were closed in the reign of Justinian, A. C. 529.
[7] Diog. Laert. in vit. Plat. xxiv.

at once as well-informed persons and teachers of others, with crude and superficial notions and principles.

If we look, then, to the course of his practical teaching, —to the general tenor of his conversations and actions, and the example throughout of his life and death,—we shall find that his whole labour was directed to the establishment of true moral and religious principles, in opposition to the false and mischievous principles which, he observed, were commonly acted upon and avowed in the world. The excellence and supremacy of self-knowledge was what he was ever inculcating; and of self-knowledge, not as a matter of intellectual curiosity, or for its value as a science, but in order to self-government and to happiness. He found that this was the last kind of knowledge which men ever thought of acquiring; that they had, in fact, no concern about it; or that if they were reminded of its necessity, they presumed on their possession of it already. His first effort, then, was to open the minds of men to a perception of the value of this knowledge, and of their own need of it. The questions which he would put—the refutations which he addressed to the various propositions or conclusions elicited from others in the course of his conversations—the perplexities to which he would reduce them—and the unsatisfied state in which he would commonly leave them, after exciting their doubts—all had a direct tendency to convince men of the insufficiency of their intellectual acquirements, and of their want of some more adequate and availing information.[1] To the same purport was his disparagement of physical science, and of all merely speculative knowledge, in comparison with that which was useful for human life.. For he was far from an utilitarian, in the modern sense of that term. He did not value particular studies, because they ministered to the necessities or conveniences of human life, or undervalue them because they had no such bearing. But he saw that his clever and ingenious countrymen were studious of intellectual refinement—that they delighted in the specious, and the admirable, and the subtile, more than in the solid and the unostentatious qualifications of the good member of a private family and the useful citizen. He was aware, too, from his own acquaintance with the existing physical philosophy, how imperfect that knowledge was, how entirely hypothetical, and incapable of practical application. We must make allowance, therefore, in estimating his objection to speculative science, for the polemical spirit in which he assailed a branch of knowledge then, at once, so barren, and so encroaching in its claims on public attention. We must regard him as preparing the way for the due cultivation of the other, the higher as well as more important knowledge, that of man's own nature, then so little thought of, and so neglected. This seems to be invariably his design on every occasion, whatever may be the immediate purport of his discourse.

When he came to direct the minds of men, once awakened to the importance of moral study, to the subject itself of human nature, he had to encounter on the very threshold the most perverse notions. All their maxims of life were based on the absolute importance of the present life. The body, and its present appetites and desires, were regarded as the whole of man. The tyrant, in the enjoyment of absolute power to gratify every passion without restriction or penalty, was considered as the apt representation of the highest human felicity. All men's plans of life accordingly were directed to the acquisition of power for themselves. They studied to improve their external circumstances, and not themselves. Then their religion was merely the fear of mysterious powers influencing the prosperous or adverse events of the present world, and which were therefore to be conciliated or appeased by offerings and vows. Socrates set himself strenuously to refute these vain presumptions. He argued the folly of supposing, that men really accomplished their own wishes in gratifying each prevailing inclination. He showed, that whilst they did what they pleased at the moment, they did not in fact attain that pleasure which they sought; and led them therefore to surmise, that there must be some end of human pursuit beyond the gratification of the passions, and further, some ultimate end to the whole sum of the active energies of the soul, beyond the present life, and distinct from all bodily associations. But he not only suggested such a thought by shewing the reasonings on the opposite view of human life to be inconsequential and absurd; he further practically refuted the prevailing fallacies on the subject, by his own example on the other side. He proved to the world, by divesting himself of all the worldly accessaries of happiness, and depending exclusively on the internal resources of his mind and character, and by his perpetual cheerfulness under those privations, that happiness did not result from externals, or from the body, but from the internal nature of man, nor from any thing positive and absolute in that nature, so much as from its state of discipline and command over the appetites of the body. Theories of morals were yet to be formed. It remained for Plato to erect the true and sublime standard of human conduct in the perfections of the Divinity, and for Aristotle afterwards to shew the application of the law of habits to the subject. Socrates has the merit of having prepared the way for these developments of the subject, by demonstrating the folly of seeking the ideal of happiness in any enjoyment of the body, or in any thing present.

So also as to religion, though he could not advance, in his conceptions of the retributive justice of the Divine Being, beyond the circle of darkness which limits the natural observation of man, he proved the absurdity of supposing that mere external punishment was the only suffering undergone for offences committed. Secret faults, as he pointed out, did not escape with impunity. He appealed to the remorses of conscience, to shew how surely, however invisibly, wrong doing was visited with its punishment; and whilst in his own mind he concluded that there would be a future state, in which each man would receive the merited consequences of his actions, he must also have excited, in the minds of his hearers, a strong though undefined apprehension of a period of general retribution after death in another world. At least they must have seen that it was not so certain, as they may have once supposed, that though a present punishment may have been evaded, punishment would not follow at a future day. In well-disposed minds, there would thus be a foundation laid of a doctrine of the immortality of the soul. Under the teaching of Socrates himself, this truth, perhaps, would scarcely assume the form of a doctrine, so distinctly as it is stated by Plato. It would be simply a practical conviction. And thus Socrates himself probably scarcely propounded it in formal terms, nor without those qualifying doubts which both his memorialists describe him as joining with its enunciation. But Plato, following him, took up the doctrine as a formal truth, and worked it up into a perfect theory, with the formal array of argument and didactic exposition.

There was nothing, indeed, of system in any part of the teaching of Socrates. In the "Memorabilia" of Xenophon, we have probably a very complete specimen of the substance of what he taught, and, in the desultory manner in which the subjects of the several conversations there given are introduced, of the actual way in which he would throw

[1] Xenoph. Mem. iv. 3. 36. 'Αλλὰ ταῦτα μὲν, ἔφη ὁ Σωκράτης, ἴσως διὰ τὸ σφόδρα πιστεύειν εἰδέναι οὐδ' ἔσκεψαι. . . . . Ib. 39. φροντίζω, μὴ κράτιστον ᾖ μοι σιγᾷν· κινδυνεύω γὰρ ἁπλῶς ὀυδεν ἐιδέναι.

out his questions and reflections on different points, as they happened to suggest themselves on each occasion. There we find the various duties of the good man and the good citizen summarily sketched, without the formality of statement or systematic connexion. He inquires what is just, or pious, or temperate,—and he leads his hearers to consider the true definitions of the several virtues;[1] but it is chiefly with the view of laying open their mistakes and confusion of thought on the subject, and to divert them from sophistical disquisitions on virtue, to the discharge of virtue in all its parts, rather than to give any precise idea of it himself.[2]

Certainly there are grave objections to the morality which he taught. It did not enjoin that perfect purity of sentiment and action, which, judging from its general excellence, we might perhaps have expected. It forbade *excesses* of licentiousness as evil, but it did not also forbid licentious indulgence as altogether vicious, or fix its stigma on those monstrous forms of vice which polluted Grecian society. Nor, again, did it give a right tone to the resentful feelings. It enjoined the requiting of ill to enemies,—placing retaliation as a duty on a par with the return of kindness to friends.[3] With these exceptions, the morality inculcated by Socrates, founded as it was on the indications in man's nature of a destiny beyond the present world, bears strongly the marks of the law written by the finger of God, and proves that the Creator has not left Himself without witness, where the light of his revelation has not shone. Supposing even that those great truths, thus taught, were the broken planks from the wreck of a primitive Faith, floated down on the stream of ages, we must yet believe a providential disposition, in the fact of that ready acceptance which they could obtain with one, brought up, as Socrates was, amidst the grossest corruptions of heathenism. His was an instance, how the unsophisticated heart responds to the notices of divine truth, when once they are duly presented to it; and how, whereever there is a sincere pursuit of right, the moral eye will be enabled to pierce the surrounding gloom, and to discern, for the most part, the true outline and form of right.

It is observable, however, that, whilst Socrates correctly perceived that the laws of religion and morality possessed a sacred importance, independently of all positive enactments of men, he yet appeals to the laws of the state for the particular rules of religious and moral duty. When instructing Euthydemus on the worship of the gods, he cites the Delphic oracle, which enjoined the law of the state as the rule of acceptable worship.[4] When asked by the sophist Hippias what is just, he answers, that it is what the laws prescribe. Such reference was perfectly natural in a Greek, accustomed as Greeks were to view every thing in subordination to politics, and to regard the duty of the citizen as paramount to every other duty. This feeling had its influence with Socrates, and induced him to regard the authority of the state as possessing in itself a moral force of obligation. The respect which he throughout shewed to the laws of his own state, was that of one who not only obeyed what they commanded, but strictly reverenced their authority.[5] We must not, however, suppose, that he thus intended to place positive and moral laws on the same footing. The reference which he gives to the written law of the state, as the directory on questions of religion and morals, is the substitute in his teaching for a systematic development of the moral and religious duties. The law of the state presented, to one who had no thought of systematizing the subject for himself, the best expression of those great truths which he was drawing forth from the higher source of man's eternal nature. He is content to point out to his hearers, in a general way, the wisest and readiest collection of rules for those cases which came under the great comprehensive duties of piety and justice. Evidently he is not treating the subject with the exactness of the theorist, in assigning this importance to the law of the state; but he is enforcing the use of the law of the state as an authoritative practical guide to right conduct. —His internal view of religion, for example, was founded on observation of the signs of benevolent design throughout the material and intellectual world; and he was thus led to the acknowledgment of a pure Theism. But in his conduct, he knew not how to realize the obligations which the perception of this truth imposed on him. With his reverence, accordingly, for the laws of his country, as well as under the influence of that superstition to which his piety habitually verged, he sought a direction to his religious sentiments from the authority of the state, and thus in practice was a polytheist.—His object was further to prevent men from trusting to the conceits of their own judgment in matters of conduct, and to recommend a proper deference to the wisdom and authority of their ancient laws, then so presumptuously slighted by each vain pretender to superior prudence and political sagacity.

In assailing, as Socrates did, the follies of his countrymen by the dexterity of an acute reason, he was ever exposing their ignorance. The impression on his own mind appears to have been, that men erred rather from the want of due information respecting their moral condition, than from the perverseness of their will,—from folly, rather than from vice. Himself an accurate observer of human life, and with a disposition to follow the path of duty wherever it might lead him, he had in his own case felt the importance of intellectual cultivation, in order to right conduct. From his own circumstances, accordingly, and a natural predilection for those exercises of the mind which were his habitual pursuit, he overrated this importance; and, instead of simply regarding the information of the mind as a necessary ingredient in moral improvement, he made it all in all. Thus, according to him, wisdom or philosophy was virtue, and ignorance and folly, vice. He carried this view of morals so far, as to place the knowledge of duty on a footing with the knowledge of arts. Nor was he even startled with the paradox, that if such were the case—if the knowledge of right were the whole of morality—there would be less immorality in intentional wrong conduct, than in unintentional done through ignorance.[6]

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[1] Xenoph. Mem. iv. 8, 11. Ἱκανὸς δὲ καὶ λόγῳ εἰπεῖν τε καὶ διορίσασθαι τὰ τοιαῦτα, κ.τ.λ.

[2] Xenoph. Mem. iv. 4, 9. Ἀλλὰ μὰ Δί', ἔφη, οὐκ ἀκούσῃ, πρίν γ' ἂν αὐτὸς ἀποφήνῃ, ὅ τι νομίζεις τὸ δίκαιον εἶναι. ἀρκεῖ γὰρ, ὅτι τῶν ἄλλων καταγελᾶς, ἐρωτῶν μεν καὶ ἐλέγχων πάντας, αὐτὸς δὲ οὐδενὶ θέλων ὑπέχειν λόγον οὐδὲ γνώμην ἀποφαίνεσθαι περὶ οὐδενὸς, κ τ.λ.

[3] Xenoph. Mem. iv. 2, 16; ii. 6. 35. Aristot. Rhet. ii. 23.

[4] Ibid. iv. 3, 16. Also, i. 3, 1.

[5] See, in the "Crito" of Plato, a beautiful address, put into the mouth of Socrates, from the personified majesty of the laws.

[6] Xenoph. Mem. iv. 2, 20. Δοκεῖ δέ σοι μάθησις καὶ ἐπιστήμη τοῦ δικαίου εἶναι, ὥσπερ τῶν γραμμάτων, κ.τ.λ. Seneca, arguing also the need of moral information for the performance of duty, refers to the same illustration of morality from the arts, as that given by Xenophon, to shew that there is no real analogy between the two subjects. "Vis scire," he says, "quam dissimilis sit harum artium conditio et hujus? In illis excusatius est, voluntate peccare, quam casu: in hac maxima culpa est, sponte delinquere. Quod dico, tale est. Grammaticus non erubescit solecismum, si sciens facit: erubescit, si nesciens. Medicus, si deficere ægrum non intelligit, quantum ad artem, magis peccat, quam si se intelligere dissimulat. At in hac arte vivendi, turpior volentium culpa est." Ep. 95. 8. He seems to have had the argument of Socrates, as given by Xenophon, (Mem. iv. 2, 20.) in his view. So also Aristotle says: Καὶ ἐν μὲν τέχνῃ ὁ ἑκὼν ἁμαρτάνων αἱρετώτερος· περὶ δε φρόνησιν ἧττον, ὥσπερ καὶ περὶ τὰς ἀρετάς. Eth. Nic. vi. 5.

Thus vice was in no case, in the view of Socrates, an act of the will, but of the mistaken judgment. He did not mean by this to assert, that men did not act wrong wilfully in the particular instances of misconduct, so as not to deserve blame for their misconduct; but that the seat of vice was in the perverse understanding,—for that the will was invariably towards good. If, accordingly, vice may be regarded as seated in the understanding, and not in the heart, it would follow, that that man is less vicious in *principle*, who knows what is right and acts wrong, than one who acts wrong without knowing what is right. The former alternative, however, was impossible, according to his theory. For knowledge, by its intrinsic excellence, must prevail over every other principle. So far was Socrates led by the working of his method, and his observation of the ignorance and folly of men, to overlook facts, at least, as evident on the other side,—the plain instances of men acting wrong in spite of their better knowledge, and of greater blame assigned to wrong thus done in spite of knowledge. His error is further to be traced to a confusion of the ideas of right and happiness, in the term "good." That the will is, by the original constitution of man, invariably towards good, if we take good in the sense of real interest or happiness, is quite true; but it is far from true, if we include the notion of right in that of good. Men, when they take even perverted views of their happiness, may be regarded as unconsciously desiring the real happiness of their nature. The will, therefore, in this sense, may be said to be always towards good. But in the latter sense of the term "good,"—that in which it includes right,—the contrary rather is true. Men see the light, but love darkness rather than light; and the seat of vice is, accordingly, not in the understanding, but in the heart. But there is this justification of the language of Socrates on moral subjects, that the ignorance which he attacked, was, in truth, a vicious and blameable ignorance. Men did not take pains to inform themselves on moral subjects. They neglected themselves, pursuing and professing every other kind of knowledge but that which was most at hand for their acquisition, and most concerned them. Seeing, then, the moral errors into which men ran from this neglect, Socrates not unreasonably set his mark of reprobation no ignorance, as the source of immorality. Immediately, indeed, and ostensibly, he attacked the general ignorance of men, holding out philosophy as the remedy of vice and unhappiness. But the ultimate and real object of his attack all the while was, the immoral disposition, the self-neglect, and the irregular habits of life, from which the incapacity and ignorance of men on moral subjects commonly result. Then, further, it was the ignorance of self, chiefly, that he laboured to remove. He found conceit as to themselves, the prevailing fault of the men of his age and country. And he hoped, by exposing their ignorance on various subjects, to make them question their presumptions relating to their own nature, and character, and duties. Thus would he, in effect, be correcting moral error,—the folly of men persuading themselves and others that they knew what they had never cared to examine, much less to know.[1]

As the peculiar aspect under which he presented the subject of morals arose, in a great measure, from his manner of interrogating in conversation, so the general character of his philosophy is to be sought in its intimate connexion with the peculiar method which he pursued. His philosophy, being essentially colloquial, laid down no positive principles in any particular science, or even any general principles for the conduct of the understanding in scientific or moral inquiries. But it sought to rouse the understanding to a perception of its condition of weakness, and defects, and ignorance, previous to its interrogation of itself, and its acquisition of knowledge, and its strengthening by exercise and discipline. Like the great reformer of modern science, he found nothing duly ascertained in the field of philosophy; hypotheses assumed without examination, truth obscured and confounded under the plausible cover of general terms and vague analogies. Yet every one was fully satisfied with the state of knowledge; every one presumed that he was in possession of the truth. So, too, at this period, as at the time when Bacon proposed his new method, there was a dialectical science in use, available only for disputation and victory, and not reaching the truth of things, or imparting any real knowledge. And, in like manner, in the time of Socrates, as in that of Bacon, this imperfect dialectical science was regarded as the key to every kind of knowledge; and he who could discourse fluently on any given subject, was esteemed the accomplished philosopher. "Of nothing," as Bacon himself pointedly observes, "were men so scrupulous as lest they should seem to doubt on any subject."[2]

This state of things formed a strong barrier against any attempt to effect a moral reformation. The way to the heart had to be cleared through a mass of outworks thrown out by the intellect. It only remained, then, for him who would be the moral reformer of his countrymen, to work by means of that very dialectical science which opposed its ramparts and its arms to his progress.

But to have simply used the same method which his contemporaries employed, would have been to revolve in the same perpetual circle. Socrates, indeed, might, by a more skilful use of the same dialectical artifices, have confuted the sophists and others with whom he reasoned. He might have gained the victory in argument, by demonstrating the fallacy of their deductions, or proving the contradictory of their conclusions. But no advance would have been made by such a proceeding towards a detection of the source of the popular errors, the wrong principles themselves, on which men argued and acted. To accomplish this object, then,—to expose the fallacy of wrong principles,—he had to exalt the art of the dialectician to a higher function than that of merely eliciting consequences from given principles.

This attempt accordingly he made. Without instituting any formal method, or teaching any art of discourse,—without, it seems, having any such design in his thoughts,—he yet so far gave a new direction and impulse to dialectical science, as to render it in some measure at least subservient to the investigation of truth. In his hands, it served, if it did nothing more, to raise *doubts* as to the truth of erroneous principles which before had passed without question, and which the very practice of reasoning from them as axioms, had tended to confirm as fixed and indisputable standards of all other truths.

We must not suppose, that definition and induction were unknown as parts of dialectics before Socrates; or that Socrates was absolutely the first to discover and propound their nature and use. The expressions of Aristotle might suggest this supposition. For he says particularly, that there were two things which one might ascribe to Socrates, Definition, and Inductive Reasoning.[3] What Aristotle probably intends to say, is, that Socrates was the first to improve the existing method of dialectics, by employing definition and induction as the principal engines of discussion, and illustrating their nature and use more than ever had been

[1] Xenophon speaks of the refutations employed by Socrates, serving as chastisements of presumptuous folly, κολασηρίου ἕνεκα. Mem. i. 4. 1.

[2] Nov. Org. i. 67.

[3] Aristot. Metaph. xiii. 4. Δύο γὰρ ἐστιν ἅ τις ἂν ἀποδῴη Σωκράτει δικαίως, τούς τ' ἐπακτικοὺς λόγους, καὶ τὸ ὁρίζεσθαι καθόλου. Ibid. i. 6. περὶ ὁρισμῶν ἐπιστήσαντος πρώτου τὴν διάνοιαν.

done before him. He gave them, in fact, a body and a vitality, by applying them to the realities with which men had to do in their daily life.[1] Instead of employing them for the purpose of verbal distinction, or for the expression of some abstract and barren generality, he applied them to limit the vague notions entertained about matters of practical concern, and to bring opinions into harmony with ordinary experience. To the dialecticians before him, Definition and Induction were the commencement of their discussions. They unsuspectingly presumed on the logical processes involved in these instruments of discourse, as already sufficiently accomplished. They attempted, indeed, to define; but they took such definitions as they found at hand,—of course the most superficial.[2] General principles they scarcely thought of establishing; but they assumed such as were the current maxims of the day. And the rest of their discourse proceeded from these crude and unscientific elements. But Socrates did not profess to give definitions, or to have arrived at any positive certain principles, from which, as data, other truths might be demonstrated.

He disclaimed, as has been already pointed out, the design or the ability to teach. He was only an inquirer, himself *knowing nothing.* When pressed, as by the sophist Hippias, to give his own account of the particular subject about which he is importunately questioning, he evades the point, and recurs to his established way of proceeding by interrogatories.[3] He is constantly, that is, endeavouring to rise to a correct definition of the subject under discussion. He presents it as the end to be attained by the whole discussion; leading the person questioned from point to point, until he brings him close to the true and exact idea of the subject. So also does he employ Induction. He cites some instance,—commonly some coarse and very familiar one, from the workshop of the smith or the shoemaker, or from the culinary art, and the like,—as apposite to the point under debate; and thus brings the principle itself, on which the dispute turns, to the test of actual experience. This was so much his manner, that it was made a standing jest by those against whom he so triumphantly employed it. They complained of his ever repeating the same thing; ever talking of "carpenters, and smiths, and fullers, and cooks, and such like nonsense.[4]" But he was not deterred by the scoff, which in reality proved the point and force of his reasonings. He replied, that about the same things, he must persist in saying the same things; unless it could be shewn, that a person being asked, whether twice five were ten, should answer differently at different times.[5] Thus, he would continually recur to his well-known illustrations from common life, hackneyed as they were in his own use, and low and trifling as they might seem.

From this his constant practice of bringing men to the test of definition and familiar instance, on every subject discussed, he had been regarded by the Thirty as the teacher of an "art of discourse," and as therefore obnoxious to a law which they had made (chiefly with a view to him), forbidding the teaching of such an art.[6] Such a restriction, however, could not apply to Socrates; since, as we have seen, he professed no art; he imparted no method of argument; and, to have silenced him, they must, as he shewed them, have absolutely prevented his asking the most simple and familiar question. Here it was the point of an apt illustration that had provoked this sally of resentment from Critias and Charicles, two of the Thirty. It had been reported to them that he had drawn attention to their acts of violence, by asking, what would be thought of the herdsman under whose care an herd should be diminished. On this occasion, Charicles, after vainly remonstrating with him against the practice of his daily conversations, shewed the point of the illustration, by bidding him beware lest he also should make the number of the herd still less.[7]

So far, indeed, was Socrates from instituting any method either of argument or of investigation, that the very definitions and instances which he employed were of a popular character, adapted for refutation of error rather than for conviction of the truth,—such as to place difficulties in the way of a dogmatic opponent, rather than didactic illustrations of any particular subject. He was engaged in repelling dogmatism. And nothing is of more avail for this purpose than analogies; such instances, that is, as test the truth of an assumption in one case, by its application to another of the same kind. Direct instances, shewing experimentally the truth or falsehood of an assumption, may be difficult to be found; and, in their use, they require a particular acquaintance with the subject itself, in order that their application may be seen. For example, if it were desired to expose a false theory of government, some fact of history must be adduced, and its bearing on the theory in question must be distinctly pointed out. But an analogous instance does not require this intimate acquaintance with the subject itself, in illustration of which it is brought. It shews at once that a given hypothesis is either tenable, or not tenable,—that it is verified or not verified in some parallel case, and therefore may be granted or not, in the subject about which the argument is. Only it is necessary, for this purpose, that the analogous instance should be a familiar one,—that the exhibition of the principle in question should be clear and striking in the instances adduced. For example, to set forth the evil of tyranny, it would be quite enough to point out, as Socrates did, the case of a herdsman under whose keeping an herd should be deteriorated; and the inference would be immediate, that a career of confiscation and blood was no evidence of a good government. Again, whether it were wise to choose magistrates by lot, would be a difficult question to be decided by the direct evidence of facts bearing on the point. But when Socrates referred to the absurdity of appointing a steersman by lot, it was at once evident, that there were cases in which this mode of appointing important officers of the state would be mischievous. Such then was the kind of evidence which Socrates was constantly adducing from analogous instances to the point in question;—an evidence, not conveying any positive instruction in the theories of the subjects to which it was applied; but removing false impressions respecting them, and opening the mind to the reception of the truth. It was an admirable method of unteaching prejudices or vain assumptions, and of silencing the dogmatist,—a method, powerful at once for the refutation of error, and the conviction of ordinary minds incapable of being instructed by a more direct and positive evidence. Such, accordingly, was the method practised by Socrates. In pursuing any argument, "he would proceed," as Xenophon observes, "by the most admitted principles; considering this to be the sound basis of discussion. And therefore," adds Xenophon, "he, far beyond all I ever knew, when he spoke, carried conviction to his hearers;" and he would say, "that Homer had ascribed to Ulysses the merit of being a sound orator, on account of his ability to conduct a discussion, by reasoning from such principles as men acknowledged."[8]

It was seldom, however, if ever, that Socrates avowedly

[1] Xenoph. Mem. iii. 3. 11. *Λέγεις, ἔφη, σὺ τὸν ἵππαρχον πρὸς τοῖς ἄλλοις ἐπιμελεῖσθαι δεῖν καὶ τοῦ λέγειν δύνασθαι; κ. τ. λ.*

[2] Aristot. Metaph. i. 5. *Καὶ περὶ τοῦ τί ἐστιν ἤρξαντο μὲν λέγειν καὶ ὁρίζεσθαι, λίαν δ' ἁπλῶς ἐπραγματεύθησαν. ὡρίζοντό τε γὰρ ἐπιπολαίως, κ. τ. λ.*

[3] Xenoph. Mem. iv. 4, 9.

[4] Ibid. i. 2, 37. Plato, Gorgias, p. 491, a. t. iv. p. 96.

[5] Xenoph: Mem. iv. 4, 7. *διὰ τῶν δοκούντων τοῖς ἀνθρώποις.*

[6] Xenoph. Mem. i. 2. 31. 3.—Aristid. t. ii. p. 248.

[7] Xenoph. Mem. i. 2. 37.

[8] Ibid. iv. 6. 15.

argued a point. Professing to know nothing himself, he constantly challenged others as to what they professed to know. He put his questions to each person with whom he conversed, very much as the skilful experimenter in these days does to nature, so as to lead to the affirmative or negative of a particular hypothesis whose truth he would investigate. Having obtained an answer, he proceeds analytically, to found on that another question, studiously directed, in like manner, to elicit the answer which might serve for further inquiry, and so on, until he has reduced the first proposition to some simple elements, clearly shewing the truth or falsehood of the original assumption. It was as truly an experimental process on men's minds, as that which the modern investigator performs on the subject which he examines. Those analogical instances in which he so much delighted, served the purpose of this analysis, no less than direct and proper instances, such as belong to him who investigates experimentally the nature of a particular subject. For analogies detect the state of the mind to which they are addressed. They at once call forth and illustrate its principles and habits of thought, and enable the experimenter to avail himself of the existing resources in that mind for effecting the desired conviction. They furnish him with a clue to the course which he should follow in carrying on his analysis. This was that midwifery of the mind which Socrates used sportively to describe as his peculiar occupation.

In his conversation, for example, with Euthydemus, who prided himself in having cultivated his mind by his own independent study of books, of which he had formed a large collection,—he first drew attention to the singularity of the young man's conceit, by representing him as coming before the public, with high professions of being self-taught, and putting the parallel case of a candidate for some medical office, who should announce that he had studiously avoided even the appearance of having *learned* the art of medicine, and ask for the office on the promise of endeavouring to learn the art by his future practice. Interest being excited by this illustration of the absurdity, he next led his hearers to see the absurdity of entering on political affairs without preparation, by referring to the fact of the severe application and discipline undergone by persons who seek reputation in such accomplishments as flute-playing or riding. Then, having gained over Euthydemus as a more willing listener, he proceeds to question him as to the use for which he had collected so many books. He throws out the presumption that they have been collected with a view to enrich the mind with virtue. Supposing this to be granted, he goes on to interrogate Euthydemus as to the particular excellence of which he is in quest. He enumerates several particulars; and these being rejected, he comes at last to excellence in the art of government, which the young man concedes to be the object of his desire. This gives an opening to inquire into the qualifications necessary for such excellence. He discovers, by the answers of Euthydemus, that he conceives himself master of those moral virtues which he is induced to admit are indispensable to the good citizen. By a series of questions, however, relating to particular actions, he forces Euthydemus to admit, that what is just in one case, is unjust in another, and to contradict himself in his successive statements as to the comparative criminality of voluntary and involuntary acts of injustice. What, then, triumphantly asks the philosopher, think you of a person who is so inconsistent with himself? The conclusion is inevitable; and Euthydemus is constrained to own, that " he knew not what he thought he knew." But Socrates, not yet satisfied, presses him further to explain his notion of that ignorance which he had thus displayed; and finds, that notwithstanding his confession of his want of right instruction, he yet presumes on his possession of self-knowledge. Another question forces him to abandon this position. The young man then asks to be only put in the way of self-examination. Here at once his false presumptions are exposed to the searching analysis of Socrates. The inquiry turns on a knowledge of the goods and evil of life. Euthydemus enumerates one thing after another as good; and Socrates immediately subjoins some counter evil as attending it; until Euthydemus at last gives up his confidence in his own opinion, and declares that he knows not now what he ought to pray for to the gods. Again, Socrates presents before him pointedly the evidence he had thus given of having been diverted from consideration of the subject by the strong presumption of his knowledge of it. But that he may leave no room for escape, he calls on him, in conclusion, to state his opinion as to the nature of democracy, which at least, he conceived, Enthydemus, as a candidate for public office in a popular state, must have studied. And in like manner, he extorts from his successive answers a further proof of his ignorance and incompetence to the duties for which he had designed himself.

The effect thus produced is what Plato compares to the numbing touch of the torpedo.[1] The mental powers of the individual thus tried were for the moment paralyzed. He found that he only committed himself further by renewed efforts; and " began to think," as Euthydemus says of himself at the close of the conversation to which we have just referred, " whether it were not best for him to be silent, as he ran the hazard of appearing absolutely to know nothing."

From the instance just given, it will appear that a current of irony pervaded these experimental argumentations of Socrates. There was irony mingled with earnest conviction, in that very disclaimer of all knowledge with which he set out. It was a mask, behind which he could hurl his weapons of assault on the boasted knowledge of others, whilst at the same time he expressed his serious view of the real ignorance of man, and the necessity of coming with a simple unprejudiced mind to the acquisition of truth. In the prosecution, however, of his method of analysis by interrogation, irony was indispensable for the success of his inquiry. For his object was to obtain the truth from the mouth of the person interrogated, not to state it himself; and where he did state it accordingly, it was necessary to put it in such a form as to try whether it was the opinion or not of that person,—whether he really thought so, or adopted it on the judgment of his questioner. An ironical statement answers this purpose. It conceals the teacher, and enables him to judge, according as the hearer applies it, what the state of the hearer's mind is, and to argue the point in question, not on premises laid down by himself, but the admissions of the other. The hearer, too, is taken by surprise. The air of seriousness which the ironical manner sets out with, and the absurdity involved, on second thought, in carrying out the supposition of a serious intent, in their united effect, provoke the smile of surprise, and win attention. As Socrates was engaged, too, in presenting unacceptable conclusions,—bringing home to the self-conceited evidences of their real ignorance,—it was necessary for him to disguise, as much as possible, the conclusion to which he was tending. He had to assume, therefore, the principles on which those with whom he conversed were reasoning and acting, and reduce these to an absurdity, by applying them as true to some evident case of ordinary experience. The skilful use made by Socrates of this irony was a powerful enforcement, in itself, of the convictions which he desired to leave on the minds of his hearers. He brought the aid of a delicate ridicule to the support of an argument, and thus exhibited the desired conclusion under a form, which, whilst it pleased the hearers, shamed them into an acknowledgment of its truth.

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[1] Plato, Meno., 80 a. t. iv. p. 348.

But this irony, and the analogical instances over which it was thrown, were but approaches to that end which Socrates appears always to have had in view in his conversations,—the ascent to accurate general notions of each object of thought. He was always working his way towards an exact definition of the idea on which the discussion turned. Each instance which he adduced was a step in this progress, diminishing by its light some portion of that obscurity and confusion of thought with which he found the subject invested. He did not, indeed, reach the point which he had in view. Dialectical science was in too rude a state at present for the attainment of its perfect end. Socrates rather set an admirable example of the perseverance and energy with which the end should be pursued, than a perfect model of the method of pursuing it. His very method, indeed, confesses its own imperfection, in stopping just at the point where the way seems to be opened, and leaving the subject negatively, rather than positively defined.

This constant pursuit of exact definition is an indication of the antisceptical bent of the mind of Socrates. The foundations of morals and of all science were shaken by the speculations of his sophistical predecessors. Opinion was exalted to the prerogative of knowledge. Socrates accordingly put opinion to the test. He explored it experimentally, as it existed in different minds; and he proved it deficient from the standard to which it had been vainly exalted. He found that it vanished before the light of investigation; and, in fact, that in proportion as the fancies and errors of opinion were cleared away, advances were made towards more stable and certain knowledge. This knowledge, accordingly, he continually sought after. He had probably but an indistinct conception of the realities towards which he directed his pursuit. Still he appears constantly to have assumed and fully believed their existence, by steadily proceeding, as we find him to have done, through the various opinions which he encounters in discussion, until he arrives at some more definite form of thought. What Socrates only indistinctly apprehended, Plato afterwards realized in his philosophical system, and endued with existence in his celebrated theory of Ideas. But in the view of his master that theory was but dimly seen in shadow. Socrates shaped his course towards it, as he more and more limited the extravagancies of popular opinion on the various subjects which he discussed, and excluded whatever was irrelevant and foreign to the real nature of the thing. He threw doubts on what was doubtful, that there might be the less doubt and uncertainty about what remained when the doubtful was removed from a subject.

What appears to have led Socrates into this sound method of proceeding, was, as Aristotle very justly intimates, the firm moral convictions which were the great elements of his mind and character.[1] He felt that there was a reality in the principles of piety, justice, benevolence, and other moral sentiments, which no sophistry could impugn. He not only felt their reality within himself, but he had observed, that however invisible to the outward eye, they produced real effects in the world; that they were not only evidenced in the constitution of nature, but also recognized in those unwritten laws which were found everywhere the same, independently of positive institution, as well as in the enactments of particular states.[2] He looked for the original of these sentiments to the perfect nature of the Divinity; and he held them accordingly to be invariable and true, as the Divinity is invariable and true. Hence he would allow no proper and adequate power of causation but moral design. Material or mechanical causes were in his view but of instrumental efficacy.[3] It was moral sentiment only, the love and pursuit of good, that possessed real power. This alone, he observed, subsisted unchanged and fixed, whilst every thing else was moved by it, and derived its existence from it. It was the neglect of this primary principle in the detail of the physical theory of Anaxagoras, which had offended him in the system of that philosopher. And agreeably to this, Plato tells us of his accounting for his remaining in his prison, from the simple cause of the moral feeling by which he was actuated.

Fixing his eye accordingly on these stable eternal principles, Socrates pressed forward in every discussion towards their attainment. He would never rest in vague general classifications, which, involving also much that belonged not to the subject in question, left its nature as undefined as ever. But he proceeded to a further limitation of the generalities on each subject, obliging his hearer to distinguish the subordinate genera included in the more general idea first thrown out, and thus gradually to circumscribe the subject within its proper boundaries. This was the intimate connexion of his logic and ethics. He was engaged throughout in an endeavour to remove the vain presumptions of mere opinion, and to substitute for these a real knowledge, as far as it was attainable, of the subjects themselves. He conceived that if men went astray in their conduct, acting on what they mistakenly thought right, and good, and true, it was only necessary to make them *know* the truth, and they would then act on their *knowledge*, as before they acted on mere *opinion*, and by thus acting attain their happiness. This was but a short-sighted view of the origin of human misconduct and unhappiness, as it did not go beyond the fact of the erroneous judgment of men, to the moral perversion which was the primary cause of their failure in action. As the practical error of men arises from this perversion, it is evidently vain to think to improve their conduct, by merely substituting more correct notions of truth and duty; since this remedy does not reach the source of the malady. Such, however, was the view of Socrates. And hence he laboured, whatever might be the subject of his conversations, to lead men to contemplate the nature of the thing discussed, and to seek to define it to themselves; thus blending the perception of the right and the good in the intellectual apprehension of the truth. Xenophon accordingly remarks the importance attributed by Socrates to the ability of distributing things into genera, on the ground, that by means of this talent "men would become most virtuous, most formed for command, and most able in discourse."[4]

Though Socrates thus endeavoured to render his hearers accomplished in the art of discussion, by directing their attention to Definition, he, as might be expected, in that early state of logical science, did little more than point out the great importance of Definition, and mark the direction in which it should proceed. Were we to take our estimate of what Socrates accomplished in this way from the "Dialogues" of Plato, we must suppose Socrates to have been much more methodical in his discussions, than we should infer from the specimens given by Xenophon. Something perhaps should be allowed for the practical turn of Xenophon's mind, and his comparative inattention to the more abstract part of the discussions of his master, whilst his fellow-pupil, on the other hand, who had an eagle-eye for

[1] Aristot. Metaph. i. 6. Σωκράτους δὲ περὶ μὲν τὰ ἠθικὰ πραγματευομένου, κ.τ.λ.

[2] Xenoph. Mem. iv. 4.

[3] Aristotle gives an instance of the manner in which Anaxagoras lost sight of his theory of mind in working out his system. Anaxagoras, he tells us, said "that man was the most intelligent of animals, because he had hands; whereas he should have stated, that man had hands because he was the most intelligent of animals; for that hands were an instrument for taking hold." Aristot. de Part. Anim. iv. 10, p. 1034. Ἀναξαγόρας μὲν οὖν φησὶ, διὰ τὸ χεῖρας ἔχειν, φρονιμώτατον εἶναι τῶν ζώων τὸν ἄνθρωπον· εὔλογον δὲ, διὰ τὸ φρονιμώτατον εἶναι τῶν ζώων, χεῖρας ἔχειν· τοῦ λαμβάνειν γὰρ χεῖρες ὀργανόν εἰσιν. Ed. Duval.

[4] Xenoph. Mem. iv. 5. 12. Ἐκ τούτου γὰρ γίγνεσθαι ἄνδρας ἀρίστους τε καὶ ἡγεμονικωτάτους καὶ διαλεκτικωτάτους.

Socrates.

theory, however remote and dazzling, would seize every hint that dropped from the lips of Socrates for the indulgence of his speculative imagination. Still Xenophon may be regarded as having presented the most natural, as well as most exact, specimens of the method of Socrates. In the simplicity of his honest admiration and grateful recollection of the instructor and guide of his youth, he evidently records what had most impressed his own mind, both as to the substance and the manner of the conversations of Socrates, without any attempt either at dramatic or theoretic effect. From Xenophon we learn how Socrates appeared to the young Athenian, who, without any theories of his own, approached him, simply with the desire of hearing him, and applying what he might learn from the philosopher to his own improvement. Plato, on the other hand, whilst he also has given a faithful portrait of Socrates in the general outline, (and the faithfulness is shown by its close correspondence with that given by Xenophon,) studied to give effect, at the same time, to his own philosophic sketches, by placing the figure of Socrates in such a light as to harmonize with his own sublime and beautiful ideal of truth.

Thus we see how Socrates was the founder of the moral and logical science of the schools of Athens. He taught nothing positively in either branch of philosophy, but he taught men to inquire, and set them on the right track of inquiry. He trained men to think for themselves, to accept no opinion which should be contradicted by the moral and intellectual principles of their own nature, and to rest in no opinion until they had traced it up to these principles.

An exact logic, and a sound ethical system, would in time naturally result from such a direction of men's minds.

In giving account to themselves of their opinions, men would be led to examine into the connexions and dependencies of their ideas. Observations would be made on the relations of ideas, and of words as their signs and representatives. And such observations methodically stated, would at length constitute a system of logic, such as that which Aristotle brought to light about half a century after the death of Socrates. In the mean time, however, the value of ideas in themselves, apart from their expression by words, would engage attention; and a metaphysical logic,—a logic having for its object the determination of the true notion or idea of a thing, and for its business the discussion of the probabilities or appearances of truth surrounding the matter in question,—would naturally be the first to succeed. Such was the Dialectic of Plato,—a science of discourse or discussion, as its name imports; not a particular science; like the logic which grew out of it, but as general in its comprehension as the method itself of Socrates, of which it was the formal development, and equivalent, therefore, to philosophy in the highest sense of that term, as being a search after the nature of things, or, according to Plato, a theory of Ideas.

Again, in giving account to themselves of their opinions, men would be led to trace the connexion of their moral sentiments and actions with an internal standard of right, independent of the variations of opinion. The examination of this relation would suggest, in process of time, a system of rules for bringing the variable—the sentiments and actions of the individual moral agent—into accordance with the invariable principles of his moral nature. The first ethics, identical, like the first logic, with philosophy in general, would be employed in carrying the views of men to those great principles themselves,—discussing and removing obstructions to the pure contemplation of the nature of virtue. But the more mature study of ethics, taking up the subject as a separate branch of philosophy, would develop the application of the doctrine of the fixed standard, by shewing throughout the field of man's moral natue, how every moral sentiment is strictly limited by its reference to such a standard. The former is the chief business of Plato's ethical philosophy; the latter, that of Aristotle's;—the first tending to a contemplative morality, to a love of the transcendent beauty and excellence of virtue,—the latter, to a theory of active virtue,—to a regulated state of the affections in all the offices of life;—both natural consequences in their order, of that awakening of the reason of men, of which Socrates had been the living instrument.

Socrates, at the same time, by the method which he pursued, taught men the beginning of an art of criticism. From an examination of existing opinions, the transition was natural to the systems of philosophers, and the records of the opinions of men of former days. And, in this respect, Socrates may be regarded as the father of the history of philosophy. Even had the criticism of the writings of philosophers formed no part of his conversations, still he must have prompted such an inquiry by his method of interrogating, and exacting from every one an account of his opinions. But he did more than this. Though not properly erudite, in that sense in which Plato and Aristotle were, he had yet acquainted himself with the doctrines of former philosophers. The chief part of his life was spent with his eye, not on books, but on men. Still, as we are informed by Xenophon, he had read, and had selected, in the course of his reading, whatever he thought valuable in the writings of those before him.[1] Plato, accordingly, has made great part of the conversation of Socrates consist of criticism of the theories of philosophers. Much of this criticism evidently belongs to the richly-various and elaborate learning of the disciple, rather than to the master from whose lips it proceeds. But that Plato is not gratuitously ascribing this kind of learning to Socrates, we see from the manner in which the less erudite disciple refers to the discussions by Socrates of the doctrines of former philosophers. Not only does Xenophon mention, in common with Plato, the comments of Socrates on the more recent system of Anaxagoras,[2] but he refers also to his examination of the great antagonist theories of the older schools, of Parmenides, Xenophanes, Melissus, and others, on the one hand; Heraclitus, Empedocles, and their followers, on the other; though without formally introducing their names.[3]

That various and discordant schools of philosophy should have arisen out of the excitement produced by the energetic call of Socrates to his countrymen, was in the natural course of things. Powerful minds, shaking off the yoke of sloth and indifference, and now at length roused to self-exertion, would, however generally docile to the guidance of a leader, be tempted to try their own powers, and strike out a path for themselves. We are not to wonder, then, that Aristippus, the advocate of pleasure, and Antisthenes, the austere cynic, should have been among the hearers of Socrates, or that Plato should have founded a contemplative mysticism on the sober homely philosophy of his master. Socrates, as we have all along shewn, did not propose any precise system of doctrine to his followers. His mission was accomplished in making them exert themselves. He did not desire that they should think alike, but that all should think and judge for themselves. It is no wonder, therefore, that some should have gone into extravagancies, and that, whilst general good resulted from the excitement, partial evil also should have accompanied it. An Aristippus, or an Antisthenes, could not have issued from the school of Pythagoras. But how much evil generally may have resulted from the abject submission to the authoritative opinions of Pythagoras, in the neglect of self-examina-

[1] Xenoph. Mem. i. 6. 14. Καὶ τοὺς θησαυροὺς τῶν πάλαι σοφῶν ἀνδρῶν, οὓς ἐκεῖνοι κατέλιπον ἐν βιβλίοις γράψαντες, ἀνελίττων κοινῇ συν τοις φιλοις διερχομαι, κ.τ. λ.

[2] Xenoph. Mem. iv. 7.

[3] Ibid. i. 1. 1416.

tion and self-knowledge, and disregard of personal responsibility, by those who implicitly received them?

But whilst we ascribe to Socrates the merit of having given at once the impulse and the character to Grecian philosophy, we must yet single out for special commendation, his admirable services in reviving the forgotten theory of natural religion among his countrymen. Of religion, indeed, as an external system of positive laws enforced by the state, they had, as we have before observed, more than enough. But religion, as a system of truth, was scarcely thought of. When Aristophanes[1] brings on the stage Demosthenes asking Nicias, well-known as Nicias was for his superstitious feeling; *ἐτεὸν ἡγεῖ γὰρ θεούς*; "really, then, do you think there are gods?"[2] the allusion is evidently to the real irreligion; which the most rigid and scrupulous worship of the heathen but ill concealed. Resting their belief of a Divine agency in the world on tradition and authority, men omitted to explore the witness of God in their own nature, and in the world around them. Consequently, they were exposed to every objection which the ingenuity of theory, or the folly and wickedness of the world, might suggest to their uninformed credulity, against the positive truth of their religious system. As infidelity in these days finds its refuge in the belief of an infallible church, and is itself in its turn the miserable refuge from the despotism of the very infallibility before which it crouches in silence; so among the votaries of heathen superstition, the doubts and misgivings of the thoughtful intellect, and the troubled heart, were left to prey on themselves, shut up in abject submission to an external authority, and unprepared for their own defence and support. Socrates addressed a great portion of that practical information, which, in spite of his disclaimer of the office of a teacher, he was ever imparting to all around him, to the remedy of this distempered state of the religious feelings. He saw plainly enough that the vulgar theology could not be defended on the ground of rational evidence.[3] This, therefore, in his respect for the ancient laws and customs of his country, he was content to lean on the sanction of positive institution. A great reverence, he justly thought, was due to the wisdom embodied in ancient laws; and he would not encourage persons wantonly to abandon the presumptions of truth and right naturally belonging to established institutions. At least, he would not have men rashly set up their own notions against the presumptions in favour of the wisdom of other men and other days, recommended as these were by some experience of their stability and use, whilst each man's private opinions had no such sanction, or no equivalent sanction. But he felt also, that the internal sense of religion wanted other support,—that presumptions of human vanity and corruption were, and ever would be, brought to bear against this; and that such assaults could only be repelled by a well-informed reason prepared for the encounter. He therefore provided his hearer with a solid and impregnable argument in favour of the being and providence and moral government of the Deity. The argument was what is now familiarly known as the argument from final causes, or the evidences of almighty design in the fabric and course of nature. For this purpose, he gave an induction of instances from the world without, and from the intellectual and moral constitution of man himself, of admirable design in the adaptation of means to ends. He called upon men, with such evidences of divine benevolence around them, not to wait for any more palpable proof, such as judging from the analogy of nature they had no ground to expect, but to believe in the existence of invisible things from their effects, and from the good received to reverence the Deity its author. The language, indeed, attributed to him by Xenophon, is in remarkable correspondence with that of St. Paul, declaring, that "the invisible things of God are clearly seen, being understood by the things that are made, even his eternal power and Godhead;"[4] and the tenor of his argument throughout illustrates the inspired observation of the apostle. More particularly we may advert to his striking inculcation of the doctrine of the moral government of God. He refers to the sense of responsibility as in itself an evidence of the existence of a Divine Power to reward and punish;[5] and he points to the pleasure and pain, advantage and disadvantage, respectively consequent on virtuous and vicious conduct, in the course of things, as instances of a perfection of government beyond the power of human laws.[6] The stock of instances has been enlarged by the researches of modern science, and strength has been added to them by their arrangement and combination. But Socrates, after all, has the distinguished merit of having given the argument from final causes an explicit statement and due importance in the proof of natural religion.

When we think that truths of such high import and interest were sedulously propagated for so many years in the place of concourse of the civilized world, we naturally turn from the contemplation of the living philosopher, to ask, what was the result—what was the amount of beneficial influence on the people to whom his mission was addressed. We cannot doubt, that on the whole the influence was great,—that the serious errors of many in regard to the conduct of life were corrected,—their minds opened to consider the great purposes for which they had been born into the world, and to look for happiness, not from transitory sensual enjoyments, but from the sober and vigorous exertion of their powers of thought and action. In some conspicuous instances, indeed, his endeavours strikingly failed. Critias and Alcibiades were known wherever the name of Athens was heard. And their wild and guilty career presented to the public eye a splendid mirror, from which the most unjust censure was reflected on the philosopher himself. But the many instances which must have occurred in humbler life, of his success in the work of moral reformation, are passed over in silence. That there were such instances Xenophon has given us to understand, when he observes, in his simple manner, that Socrates dismissed those who resorted to him, improved by their intercourse with him.[7] To expect, however, any decisive and permanent public improvement from the teaching of the philosopher, would be to overlook the extent and the malignity of heathen corruption. The men of that day, as of the present, had the voice of God distinctly speaking within them, "their conscience bearing witness, and their thoughts accusing or excusing them," according to that just description of them which Scripture has set before us. But if they

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[1] Aristoph. Eq. 32. [2] Thucyd. ii. 53, v. 105. *Ἐς τὸ θεῖον νομίσεως*,—and *ἡγούμεθα τὸ θεῖον δόξῃ*,—are expressions of Thucydides, which shew the low ground on which religion was rested in Greece.

[3] Plato, Euthyphro, p. 6. a. *Ἀλλά μοι ἐιπὲ πρὸς φιλίου, σὺ ὡς ἀληθῶς ἡγῇ ταῦτα γεγονεναι ὄντως; κ.τ.λ.* Op. i. 12.

[4] Xenoph. Mem. iv. 3. 14. *Ἃ χρὴ κατανοοῦντα μὴ καταφρονεῖν τῶν ἀοράτων, ἀλλ' ἐκ τῶν γιγνομένων τὴν δύναμιν αὐτῶν καταμανθάνοντα τιμᾶν τὸ δαιμόνιον.*

[5] Ibid. i. 4. 16. *Οἴει δ' ἂν τοὺς θεοὺς τôις ἀνθρώποις δόξαν ἐμφῦσαι, ὡς ἱκανοί ἐισιν εὖ καὶ κακῶς ποιεῖν, ἐι μὴ δυνατοὶ ἦσαν;*

[6] Ibid. iv. 4. 24. *Νὴ τὸν Δία, ὦ Σώκρατες, ἔφη, θείοις ταῦτα πάντα ἔοικε· τὸ γὰρ τοὺς νόμους αὐτοὺς τοῖς παραβαίνουσι τάς τιμωρίας ἔχειν, βελτίονος ἢ κατ' ἄνθρωπον νομοθέτου δοκεῖ μοι ἐἶναι.* So Bishop Butier, in his Analogy, part i. ch. 2, observes, "For if civil magistrates could make the sanctions of their laws take place, without interposing at all, after they had passed them, without a trial, and the formalities of an execution; if they were able to make the laws execute themselves, or every offender to execute them upon himself; we should be just in the same sense under their government then, as we are now; but in a much higher degree, and more perfect manner." P. 51. [7] Xenoph. Mem. i. 2. 61. *βελτίους γὰρ ποιῶν τοὺς συγγιγνομένους ἀπέπεμπεν.* Also ib. 4. 19; iv. 5. 24.

shut their ears, and hardened their hearts against this divine instruction, how would they listen to one who was ever upbraiding them with their dulness and inattention to its lessons and admonitions? Rather, they would feel towards him, according to that apposite illustration of Plato, as persons dozing towards one that should wake them up, and, after ridding themselves of his disturbance, think quietly to compose themselves to sleep again.[1] For he did not disguise that his mission to them was one of reproof and expostulation,—a mission, in fact, from the Deity; and that his real concern, accordingly, was not for himself, but for the success of his mission, lest they should incur the guilt of rejecting a divine gift.[2]

And truly we may regard that energetic call which he was ever sounding in the ears of his countrymen, as a providential warning to the heathen world of the sin and misery of the natural man, trusting to his own imaginations,—how, "changing the truth of God into a lie," he "gives himself over unto lasciviousness, to work all uncleanness with greediness." As God sent his prophets to his chosen people, to tell them of their transgressions, and bid them "remember the law of Moses his servant;" so in his dealings with the nations of the world, He appears to have raised up, from time to time, individuals from among themselves, heathens still, yet gifted with a purity of moral vision beyond their contemporaries, to retrace the divine outline of their fallen nature, amidst its ruins, and to declare almost authoritatively the indelible but forgotten law of right. Israel rejected its prophets; but through all the perverseness of the people, those prophets prepared the way of the Lord. The heathen world, in like manner, refused to listen to its monitors, its legislators, and philosophers; but in spite of their general obduracy and indifference, we cannot but believe that the call was not utterly fruitless. To the original influence of Socrates especially, brought as this was to bear on the great centre of heathen civilization, it may have been in great measure owing, that the light of religious and moral truth was kept alive, however faintly burning, for successive generations, in many a dark abode of superstition; and that in a later day, the doctrine of grace and truth appealed not without effect to the Areopagite of Athens, the jailor of Philippi, and the Roman proconsul at Paphos. He certainly excited a spirit of eager curiosity on moral subjects; as was evidenced in the rise of the schools of philosophy to meet the demands of that spirit, and in the moral character of the disquisitions pursued in them. But this spirit could not have exhausted itself in mere literary discussion. There were doubtless the waverings of anxious minds beyond the precincts of the schools, to be settled; cravings after more safe direction of personal conduct than such as the world around them presented, to be satisfied. Such a state of things would keep men looking for gospel-truth. Some would feel, as Alcibiades is represented by Plato, after a conversation with Socrates, and Euthydemus by Xenophon, at a loss how to pray. And to such the answer of Socrates, as given by Plato, would very indistinctly perhaps, yet not without earnest hope, suggest the high thought, that they must wait until they could be informed by God himself, as to the proper disposition towards God and men; or until one should come to discipline them,—to remove the darkness from their eyes, and enable them to discern both good and evil.[3]

(R. D. H.)

SOCRATES, the name of an ecclesiastical historian of the fifth century, born at Constantinople in the beginning of the reign of Theodosius: he professed the law and pleaded at the bar, whence he obtained the name of *Scholasticus*, or the advocate. He wrote an ecclesiastical history from the year 309, when Eusebius ended, down to the year 445; and wrote with great exactness and judgment. His *Historia Ecclesiastica* was first published in 1554, by Robert Stephens. It has since been frequently reprinted, and translated into many of the European languages. It has recently been rendered into English, along with the other ecclesiastical historians of the early centuries of the Christian era, London, Bagster, 1844.

SODA. See Chemistry.

SODOM. See Palestine.

SODOR, a name always conjoined with Man, in mentioning the bishop of Man's diocese. Concerning the origin and application of this word, very different opinions have been formed. The most probable derivation of the term, however, seems to be from Sudereys or Southern Islands, a name given by the Northmen to the Hebrides, to distinguish them from the northern islands, Nordereys, or Orkneys. The bishop of the isles had his seat at Rushin, or Castletown, in the Isle of Man, and when that island became united with England in the reign of Edward III., the bishop still retained his title of Bishop of Sodor, or of Sodor and Man, though the isles had withdrawn themselves from his jurisdiction, and elected a bishop of their own.

SOERABAYA, or Surabaya, the capital of a Dutch residency of the same name, in the island of Java, on the N.E. coast, opposite the small island of Madura, 184 miles E. of Samarang, and 416 E. of Batavia. It is defended by several forts, earthen ramparts, and moats. There are here a town-hall, government offices, a Protestant and a Roman Catholic church, several schools, large docks, and a naval arsenal. Besides ship-building and repairing, tanning and weaving are carried on here; and the trade of the place is very important. Rice, sugar, coffee, indigo, hides, &c., are exported; and European goods are imported. Soerabaya occupies a very healthy situation, and is at present the most flourishing town in Java. The harbour is good, but somewhat difficult of entrance. Pop. 100,000.

The residency of Soerabaya is about 60 miles in length by 40 in breadth. It consists of a low level tract along the shore, rising inland to a chain of well-wooded hills, attaining in some places the height of 11,000 feet. The soil is generally fertile, yielding rice, coffee, cotton, sugar, and indigo. Pop. 970,000.

SOERKARTA, or Surakarta, a town of Java, capital of a Dutch residency of the same name, near the centre of the island, on the Solo, 140 miles W.S.W. of Soerabaya. It has a Dutch fort, a palace of a native prince, a Protestant church, and several schools. The inhabitants are actively employed in weaving and working in leather. Pop. 100,000. The residency has a fertile soil and salubrious climate. Most of the inhabitants are employed in agriculture. Pop. 400,000.

SOEST, a town of the Prussian kingdom, province of Westphalia, government and 13 miles N.N.E. of Arnsberg, on a hill near the Sösterbach, an affluent of the Lippe. It is a curious old town, surrounded with lofty walls and moats, and entered by five ancient stately gates. The streets are generally narrow, crooked, and gloomy. Soest is remarkable for its old churches, of which there are no

[1] Plato, Apol. Socr. 31. a. Op. i. 72.

[2] Ibid. Πολλοῦ δεῶ ἐγὼ ὑπὲρ εμαυτοῦ ἀπολογεῖσθαι, ὥς τις ἂν οἴοιτο, ἀλλ' ὑπὲρ ὑμῶν, μὴ ἐξαμάρτητε περὶ τὴν τοῦ θεοῦ δόσιν ὑμῖν, ἐμοῦ καταψηφισάμενοι. P. 71.

[3] Alcib. ii. p. 150, d. Πότε οὖν παρέσται ὁ χρόνος οὗτος, ὦ Σωκράτες; καὶ τίς ὁ παιδεύσων; ἥδιστα γὰρ ἂν μοι δοκῶ ἰδεῖν τοῦτον τὸν ἄνθρωπον τίς ἐστιν. Σ. Οὗτος ἐστιν ᾧ μελει περὶ σοῦ, κ.τ.λ. Op. v. p. 160.

fewer than ten; many of them in a very neglected condition. Three especially have much interest; the cathedral, an unaltered Romanesque edifice of the eleventh and twelfth centuries; the *Wiesen-kirche*, in the Gothic style, founded in 1314, completed in the fifteenth and sixteenth centuries, and restored in 1850; and the church of St Peter, partially Romanesque and partially Gothic in its architecture. Soest has also a gymnasium, normal seminary, orphan hospital, courts of law, and public offices. Linen cloth, hats, hosiery, paper, and leather, are manufactured here; and a considerable trade is carried on in corn. Soest was in the middle ages the largest and most important town in Westphalia. Wealthy and strongly fortified, it was one of the chief members of the Hanseatic league. It was subject to the archbishops of Cologne, until it was incorporated in 1449 with the county of Mark. Soest was the birth-place of the celebrated painter, Sir Peter Lely. Pop. 9648.

SOFALA, a country on the east coast of Africa, lying between S. Lat. 19. and 25., between Mozambique on the N. and Caffraria on the S., extending from the southern arm of the Zambesi to Delagoa Bay, a distance of about 850 miles. It consists of a low flat sandy or swampy tract along the coast, and of a loftier mountainous region in the interior. Several considerable rivers water the country. Of these the most important are the Boozy or Jarra, the Sofala, and the Inhamban. The rivers annually overflow large tracts of country, and some of them are connected by branches with the Manica in the south, and with the Zambesi on the north. Some of the rivers are partially navigable, and form good harbours at their mouths. The coasts of Sofala are low and beset with shoals, sand-banks, and small islands. The land along the coast is on the whole good, producing abundance of rice, and pasture for flocks and herds. Ivory and bees' wax are the chief articles of export; and these are, for the most part, sent to Mozambique. The native inhabitants of this region belong to several different tribes. In the interior, near the borders of the Trans Vaal Republic, which lies to the S.W. of Sofala, dwell the Matibele. To the S.E. of them, extending as far as the sea, are a number of tribes designated by the Portuguese under the general name of Barbariri. The coasts towards the south are occupied by the Shembi and Botonga, and further north by the kingdom of Sabia, which occupies the land about the delta of the river Sabia. In the interior an elevated plateau, about the middle of the country is occupied by the kingdom of Quiteve; and a mountainous region further west by that of Quissanga. The former of these countries produces gold, topazes, and rubies, while the latter has rich mines of iron and copper. The most northerly kingdom of Sofala is that of Matuka, formerly a portion of the extensive empire of Monomotapa. A great number of the Portuguese settlements in Eastern Africa lie in different parts of Sofala. They have a total area of 10,384 square miles, and contain a population of 287,000. The districts of Quilimane, Sena, and Tete, have an area of 2330 square miles, that of Chikowa 4390, and that of Zumbo 4664. The Portuguese governor of these possessions, who is under the general governor at Mozambique, resides at Sena, a wretched place on the right bank of the Zambesi, with only 200 inhabitants. At the distance of 207 miles to the S.W. of this stands Sofala, formerly the capital of a kingdom and a flourishing commercial town. It has a fort and a church, but consists now of only about twenty straw-huts.

SOFFITA. See *Glossary* to ARCHITECTURE.

SOFIA. See SOPHIA.

SOGDIANA, a name given by the ancients to an extensive tract in Central Asia, whose limits were not very distinctly fixed, but which was separated on the south by the Oxus from Bactriana and Ariana, and by the Jaxartes on the north from Scythia. It thus nearly corresponded with the modern Bokhara in Turkestan, part of which is still known by the name of Sogd. The district is partly mountainous, but contains many fertile valleys and extensive wastes. In the time of Alexander, who visited the country, there were large forests abounding in game. The inhabitants resembled those of Bactriana, and were probably of Indian descent. There is no good ground for believing that Sogdiana contained many large towns. Those mentioned in the accounts of Alexander's expedition were in all likelihood merely forts erected to defend the country against the barbarians on its borders.

SOHRAU, a fortified town of the Prussian monarchy, in the province of Silesia, government and 51 miles S.E. of Oppeln, on a hill in the midst of a marshy but well-wooded region. It has manufactories of woollen and cotton cloth, linen and damask. Pop. 3950.

SOIGNIES, a town of Belgium, in the province of Hainault, on the Senne, 9 miles N. of Mons, on the road from that town to Brussels. The church of St Vincent in this town was built in the tenth century, and still retains portions of the original fabric. The houses of Soignies are, for the most part, well and regularly built. There are a town-hall, two hospitals, an alms-house, and several schools. Beer, spirits, leather and soap, are made here; limestone is extensively quarried in the vicinity, and a considerable trade is carried on in it and in chalk. Pop. 6727. The forest of Soignies lies between Brussels and Waterloo, and is 15 miles in length by 6 in breadth.

SOIL. See AGRICULTURE.

SOISSONS, an ancient city of France, capital of an arrondissement in the department of Aisne, on the left bank of the Aisne, 60 miles N.E. of Paris. The town, along with its suburb St Vaast, on the other side of the river, is inclosed with fortifications; and these two portions are connected by a handsome stone-bridge. The streets are straight and regular, and the houses generally well built of stone. Among the public buildings, the most remarkable is the old cathedral, a dilapidated edifice, partially repaired. The Abbey of St Jean-des-Vignes, which afforded a retreat to Thomas à Becket when in exile, has been all destroyed, except the west end of the church and its two towers and spires. Soissons contains also a good public library, a college, ecclesiastical seminary, courts of law, theatre, baths, and public walks. Carpets, woollen and linen cloth, hosiery, twine, leather, paper, beer, &c., are made here; several fairs and markets are held; and a considerable trade is carried on, especially with Paris. Soissons is one of the oldest cities of France. It is the ancient Noviodunum, and obtained its present name from the Suessones, in whose territory it stood. Here Clovis, in 486, by defeating Syagrius, put an end to the Roman power in Gaul, and established that of the Franks. It was for some time the capital of the country, and was the scene of many important events in its mediæval history. In the campaign of 1814 it was twice captured by the allies, and as often recovered by the French. Pop. (1856) 7875.

SOLARIO, ANTONIO DE, generally called "Il Zingaro," or the gipsy, was born about 1382 at Chivita in the Abruzzi. This is Dominici's account of his origin, but others contend that he was born in Venice. At all events, the young gipsy had adopted the trade of a strolling blacksmith, and was admitted in that capacity to the house of Colantonio del Fiore, the Neapolitan painter, on account of his skill, it is said, in making implements of iron. Solario fell in love with the painter's daughter, and Colantonio would only consent to their union on condition that he should renounce the furnace and the hammer for the easel and the brush of the painter, and that he should become distinguished as an artist. The romance of this story closely resembles that of Quintin Matsys. Solario at once

agreed, and set out for Bologna, where he became the pupil of Lippo Dalmasio. Leaving Bologna, he studied with undiminished zeal the works of the best artists in the various schools of Italy. He made exquisite heads, executed respectable compositions in historical subjects, drew drapery with care, but was very clumsy in the handling of his hands and feet. Nine years after he left the studio of Colantonio, he again presented himself; but on this occasion he did not appear in the blacksmith's apron, but in the purple gown of the artist. Colantonio had now forgotten the young gipsy. Solario discovered himself, and became the son-in-law of the artist. He is afterwards said to have painted and taught art in Naples, under King Alphonso, till 1455, when he died. The school of Zingaro afterwards made considerable noise in Italy. (See the works of Dominici, Moschini, and Lanzi.)

SOLDER, SODDER, or SODER, a metallic or mineral composition used in soldering or joining together other metals. Solders are made of gold, silver, copper, tin, bismuth, and lead. In the composition there must commonly be some of the metal that is to be soldered mixed with some higher and finer metals. Goldsmiths usually make four kinds—viz., solder of eight, where to seven parts of silver there is one of brass or copper; solder of six, where only a sixth part is copper; solder of four and of three.

SOLDIN, a town of Prussia, on the shore of a lake of the same name, in the province of Brandenburg, government and 42 miles N.N.E. of Frankfurt-on-the-Oder. It is walled, and entered by three gates; and it has a fine market-place and several churches. Extensive manufactures, chiefly of cloth, are carried on here; and pearl mussels are obtained in the lake. The town is said to have been founded in 1212, and was at one time the capital of the Neumark, a division of Brandenburg. Pop. 5518.

SOLECISM, a false manner of speaking, contrary to the rules of grammar, either in respect of declension, conjugation, or syntax. The word is Greek, (σολοικισμός,) derived from the *Soli*, a people of Attica, who, being transplanted to Cilicia, lost the purity of their ancient tongue, and became ridiculous to the Athenians for the improprieties into which they fell.

SOLENT, THE, the western part of the strait which separates the Isle of Wight from England. Its western extremity, where it opens into the English Channel, is between Hurst Point and the Needles; its eastern, where it joins with Southampton Water to the north, and Spithead to the east, between Fort Monckton and West Cowes. Its length is 18 miles, and its average breadth 3. Though its navigation is somewhat intricate, the Solent affords a good anchorage and sheltered roadstead for vessels.

SOLESMES, a town of France, in the department of Nord, arrondissement and 12 miles E. of Cambrai, on the Salle. It has an ancient Benedictine abbey, now again occupied by the monks; and the parish church is a handsome building, with a lofty tower, and some fine statues. Lawn, merino, cotton cloth, leather, beer, soap, and other articles, are manufactured here. Pop. 4868.

SOLEURE. See SOLOTHURN.

SOLFA (*Ital.*), a musical exercise for the voice when learning to sing, in which the syllables *do*, *re*, *mi*, *fa*, *sol*, *la*, *si*, are applied to their respective notes in the exercise.

SOLFERINO, a village of Lombardy, near Castiglione. It was formerly the seat of a prince of the same name, and has an old ruined castle; but it is chiefly remarkable for the victory gained here by the French and Sardinians over the Austrians, June 24, 1859. (See SARDINIA.)

SOLI, an ancient town of Asia Minor, on the coast of Cilicia, between the rivers Lamus and Pyramus, from each of which it was about 62 miles distant. Colonists from Argos in Greece, and Lindus in Rhodes, are described as the founders of the town, which is first mentioned in history at the time of the expedition of the younger Cyrus. In the days of Alexander the Great it was so wealthy that that conqueror exacted from its inhabitants a fine of 200 talents (L.50,000). In the war between Mithridates and the Romans, Soli was destroyed by Tigranes, but subsequently rebuilt by Pompey, who settled there many of the pirates whom he had captured, and called the town after himself, Pompeiopolis. Soli was remarkable as the birth-place of Chrysippus, one of the ablest of the Stoic philosophers; of Philemon and Aratus, celebrated poets. The bad Greek that was spoken there has given rise to the term "Solecism," found in all the modern languages of Europe. Extensive ruins still mark the site of the town.

SOLICITOR. In the article ATTORNEY, the substance of the statute 6 and 7 Vict. c. 73, is stated, relating to the qualifications required for the admission on the rolls of the superior courts in England, as well of solicitors as attorneys, the stamp-duties they have to pay, the service of a clerkship, and the examination to be passed. The practitioners in chancery, or courts of equity, are termed "Solicitors," and in the common law-courts, "Attorneys-at-law." Attorneys were first recognised by the statute of Merton, 20 Henry III., in 1235; but solicitors were not mentioned in any statute till the 3 James I. Formerly, in both classes of courts, the proceedings were taken by clerks in court, a limited body of men, to whom the business of the suitors was brought by attorneys or solicitors, so that in each action or suit there were two agents for each litigant, and the expense was largely increased. In the Queen's Bench and the Common Pleas this was reformed; but it was not till 1830 that the Exchequer of Pleas was thrown open to the attorneys. In the Court of Chancery the offices of six-clerk and sworn-clerk were abolished in 1842, and their duties transferred to the solicitors.

The jurisdiction of the ecclesiastical courts in regard to wills and administrations, and divorce and matrimonial causes, was also abolished in August 1857, and attorneys and solicitors, as well as proctors, enabled to practise in the new courts of probate and divorce, with liberty to the proctors to be admitted within a year on the rolls of the courts of law and equity.

Thus the practitioners in all these courts now consist of barristers or advocates, and of attorneys or solicitors, except in the probate and divorce courts, where proctors also are entitled to practise.

A bill is pending in Parliament to establish further tests of the educational qualifications of attorneys and solicitors, and for their better regulation. (R. M—M.)

SOLIHULL, a town of England, in the county and 12 miles N.W. by N. of Warwick; 103 N.W. by W. of London. It is generally well built, and has two principal streets, several handsome houses, and a town-hall. The parish church is a large cruciform edifice, in the decorated and perpendicular styles, surmounted by an elegant spire; there are also Baptist, Independent, and Roman Catholic churches; a grammar-school, free school, charity school, and others; a public library and reading-room. An annual fair is held here. Pop. of the parish, 3277.

SOLIMAN II., emperor of the Turks, surnamed the *Magnificent*, was the only son of Selim I., whom he succeeded in 1520. He was educated in a manner very different from the Ottoman princes in general; for he was instructed in the maxims of politics and the secrets of government. He began his reign by restoring those persons their possessions whom his father had unjustly plundered. He re-established the authority of the tribunals, which was almost annihilated, and bestowed the government of provinces upon none but persons of wealth and probity. "I would have my viceroys," he used to say, "resemble those rivers that fertilise the field through which they pass, not those torrents which sweep every thing before them."

After concluding a truce with Ishmael Sophy of Persia, and subduing Gozeli Bey, who had raised a rebellion in Syria, he turned his arms against Europe. Belgrade was taken in 1522, and Rhodes fell into his hands the year following after an obstinate and enthusiastic defence. In 1526 he defeated and slew the king of Hungary in the famous battle of Mohatz. Three years afterwards he conquered Buda, and immediately laid siege to Vienna; but after continuing twenty days before that city, and assaulting it twenty times, he was obliged to retreat with the loss of 80,000 men. Some time after he was defeated by the Persians, and disappointed in his hopes of taking Malta. He succeeded, however, in dispossessing the Genoese of Chio, an island which had belonged to that republic for more than two hundred years. He died at the age of seventy-six, while he was besieging Sigeth, a town in Hungary, on the 30th August 1566.

SOLINGEN, a town of the Prussian monarchy, province of the Rhine, government and 13 miles E.S.E. of Düsseldorf, on a hill above the Wupper. It is an ancient place, and has long been celebrated for the manufacture of cutlery; the art of making sword-blades, as practised at Damascus, having been introduced here, as it is said, in the twelfth century. The manufacture of all sorts of hardware still flourishes here; and the cutlery of Solingen is not only highly prized in Europe, but largely exported to Asia and America. It is estimated that there are prepared here annually about 300,000 sword-blades, 500,000 dozen knives and forks, and 200,000 dozen pairs of scissors. Solingen contains Protestant and Roman Catholic churches, a synagogue, and a commercial school. Pop. 7949.

SOLIS, ANTONIO DE, an eminent Spanish historian and poet, was born on the 18th of July 1610, in Alcàlà de Henares, the birth-place of Cervantes, and completed his studies at the University of Salamanca. He began early to write, having produced a drama at the age of seventeen. He had just reached his majority when he gave to the theatre his *Gitanilla, or the Pretty Gipsy Girl*, founded on a story by Cervantes, which by skilful management in the plot, and by purity and harmony in the versification, secured it a place on the Spanish stage, and has caused its reproduction since by Rowley and Middleton in the *Spanish Gipsy*, and its imitation in some parts of Longfellow's *Spanish Student*. This gained for him the friendship of Calderon, with whom he remained on terms of intimacy, occasionally writing for him the preludes to his dramas. Solis was not so successful in his *One Fool makes a Hundred*, but he regained his place by his *Love à la Mode*. In 1642 he prepared for a festival at Pamplona, a dramatic entertainment of no great merit, on the story of Orpheus and Eurydice. Solis was now made one of the royal secretaries, and he continued to write for the king's private theatre, and for the public dramatic entertainments of the capital. In the former capacity he produced his *Triumphs of Love and Fortune*, a wild, poetical drama, written on occasion of the birth of a prince. Tired of the hollow splendour of courts, and longing for religious retirement, he withdrew from his secretaryship, submitted to the tonsure, and, in 1677, as the official historiographer of the Indies, he laid down the plan of his *Conquest of Mexico*. The period it embraces is less than three years, but a period of greater brilliancy and atrocity has seldom fallen to the lot of annalist. Solis, aged as he was, seems to have had his old blood made young again as he contemplated, with his artist's eye and with his human heart, the daring and the crimes of his historical heroes. His style is altogether his own. It is rich and beautiful, and largely tinctured with the racy old idiom of Castile. "In boldness of manner," says Ticknor (*Hist. of Span. Lit.*, vol. iii., 152), "he falls below Mendoza, and in dignity is not equal to Mariana; but for copious and sustained eloquence he may be placed by the side of either of them." The work attained to a great popularity, which it has maintained down to our own time. The *Conquista* was published at Madrid in 1684. The best edition is in 2 vols., Madrid, 1783. The author, however, was now a poor old man; and the sale of his book, although remarkable for the time, did not do much to enrich him. "I have many creditors," says Solis, "who would stop me in the street, if they saw I had new shoes on;" and again, this brilliant historian is found asking a friend for a warm garment to protect him from the cold of winter. It is the old story. He died at Madrid on the 19th of April 1686, in his seventy-sixth year. An edition of the *Varias Poësias* of Solis was published in 1692.

SOLITARIES, a denomination of nuns of St Peter of Alcantara, instituted in 1676. The design of the institution was to imitate the severe penitent life of that saint. Thus they were to keep a continual silence; never to open their mouths to a stranger; to employ their time wholly in spiritual exercises, and leave their temporal concerns to a number of maids, who had a particular superior in a separate part of the monastery. They were always to go barefooted, without sandals; gird themselves with a thick cord, and wear no linen.

SOLLER, a seaport town of Spain, in the island of Majorca, 14 miles N. of Palma. It has narrow, well-paved streets; and contains a church, several schools, an hospital, a suppressed convent, and linen and cotton factories. The harbour is unprotected, and exposed occasionally to a heavy sea; but a considerable trade is carried on in oranges, oil, and linen. Pop. 7034.

SOLO (*Ital.*), a term used in musical compositions of several parts, to mark those voices or instruments that are to perform alone or in a more prominent manner—as *soprano solo*, *violino solo*, &c. The plural is used when two or more voices or instruments of the same name are to perform alone. *Solo* is also a name given to a composition written for a single instrument, such as a violin, an oboe, a flute, &c., which is accompanied by a bass for the violoncello, or a thorough-bass for the pianoforte.

SOLOFRA, a town of the kingdom of Naples, in the province of Principato Ultra, 7 miles S.E. of Avellino. It is well built, and contains many fine churches, monasteries, and nunneries. Woollen cloth, leather, parchment, and jewellery are made here. Pop. 6300.

SOLOMON, the son of David king of Israel, renowned in Scripture for his wisdom, riches, and magnificent temple, was born B.C. 1033. Towards the end of his life he sullied his former glory by his apostacy from God; from which cause vengeance was denounced against his house and nation. He died about 975 B.C.

SOLOMON, SONG OF. See CANTICLES.

SOLOMON'S ISLANDS. See AUSTRALASIA.

SOLON, one of the seven wise men of Greece, was born at Salamis, about B.C. 638, of Athenian parents, who were descended from Codrus. His father leaving little patrimony, he had recourse to merchandise for his subsistence. He had, however, a greater thirst after knowledge and fame than after riches, and made his mercantile voyages subservient to the increase of his intellectual treasures. He very early cultivated the art of poetry, and applied himself to the study of moral and civil wisdom. When the Athenians, tired out with a long and troublesome war with the Megarensians, for the recovery of the isle of Salamis, prohibited any one, under pain of death, to propose the renewal of their claim to that island, Solon thinking the prohibition dishonourable to the state, and finding many of the younger citizens desirous to revive the war, feigned himself mad, and took care to have the report of his insanity spread through the city. In the meantime he composed an elegy adapted to the state of public affairs, and committed it to memory. Everything being thus prepared, he sallied forth

into the market-place with the kind of cap on his head which was commonly worn by sick persons, and ascending the herald's stand, he delivered to a numerous crowd his lamentation for the desertion of Salamis. The verses were heard with general applause; Pisistratus seconded his advice, and urged the people to renew the war. The decree was immediately repealed; the claim to Salamis was resumed; and the conduct of the war was committed to Solon and Pisistratus, who by means of a stratagem defeated the Megarensians and recovered the island.

His popularity was extended through Greece in consequence of a successful alliance which he formed among the states in defence of the temple at Delphi against the Cirrhæans. When dissensions had arisen at Athens between the rich creditors and their poor debtors, Solon was created archon, with the united power of supreme legislator and magistrate. He soon restored harmony between the rich and poor. He cancelled the debts which had proved the occasion of so much oppression; and ordained that in future no creditor should be allowed to seize the body of the debtor for his security. He made a new distribution of the people, instituted new courts of judicature, and framed a judicious code of laws, which afterwards became the basis of the laws of the Twelve Tables in Rome. Among his criminal laws are many wise and excellent regulations; but the code is necessarily defective with respect to those principles which must be derived from the knowledge of the true God and of pure morality, as the certain foundations of national happiness. Two of them in particular were very exceptionable—the permission of a voluntary exile to persons that had been guilty of a premeditated murder, and the appointment of a less severe punishment for a rape than for seduction. Those who wish to see accurately stated the comparative excellence of the laws of Moses, of Lycurgus, and Solon, may consult the prize *Dissertations* relative to natural and revealed religion, published by the Teylerian Society of Haarlem, vol. ix.

The interview which Solon is said to have had with Crœsus king of Lydia; the solid remarks of the sage after surveying the monarch's wealth; the recollection of those remarks by Crœsus when doomed to die, and the noble conduct of Cyrus on that occasion, are known to every schoolboy; but it is to be feared they are somewhat mythical. Solon died in the island of Cyprus at a very advanced age, probably about 559 B.C. Statues were erected to his memory both at Athens and in Salamis. His thirst after knowledge continued to the last: "I grow old," said he, "learning many things." Among the apophthegms and precepts which have been ascribed to Solon are the following:—"Laws are like cobwebs, that entangle the weak but are broken by the strong." "He who has learned to obey will know how to command." "In all things let reason be your guide." "Diligently contemplate excellent things." "In every thing that you do, consider the end."

The chronology of his life is involved in no small obscurity. His legislation may, with some degree of confidence, be referred to the year 594 before Christ; but, as a very learned and able chronologer has remarked, since both his age and the time of his death are doubtful, nothing can be with certainty affirmed of the year of his birth. (Clinton's *Fasti Hellenici*, vol. ii., p. 301.) According to Lærtius, he died at the age of eighty; but Lucian extends his life to 100 years. Of the poems of Solon, an elaborate edition has been published by Bach, under the title of *Solonis Atheniensis Carmina quæ Supersunt*, Bonnæ, 1825, 8vo. Additional information respecting the life and labours of Solon may be had by consulting the *Grecian Histories* of Thirlwall, vol. ii., and of Grote, vol. iii.

SOLOR, a small island in the Malay archipelago of the eastern extremity of Flores, S. Lat. 47., E. Long. 123. 8. It is 30 miles in length by 15 in breadth, and is partly mountainous and rich in iron. The inhabitants are for the most part Malays. Those on the coast recognise the supremacy of the Dutch, while a portion of the island belongs to the Portuguese.

SOLOTHURN (Fr. *Soleure*), a canton of Switzerland, in the N.W. of the country, lying between N. Lat. 47. 5. and 47. 30., E. Long. 7. 20. and 8.; having on the north the canton of Basel, east that of Aargau, south and west that of Bern. Its form is exceedingly irregular; its length from N.E to S.W. is 36 miles; greatest breadth, 18; area, 290 square miles. The surface consists of two portions, one mountainous, occupied by the Jura range, and the other low, consisting chiefly of the valleys of the Aar and Emmen. The former comprises the north-western and the latter the south-eastern portion of the canton. The Jura Mountains extend from S.W. to N.E., and form a number of distinct parallel ridges, at no great distance from each other. The highest summits within the limits of Solothurn are the Weissenstein and the Hasenmott in the south-west, the latter being 4400 feet above the sea. The ridge nearest the low country is here the loftiest; those further north gradually diminish in height to little more than 1000 feet. In the lower part of the canton the chief river is the Aar, which flows in a somewhat irregular course from S.W. to N.E. Its chief affluent from the mountains is the Dunnern, while on the other side it receives the Emmen. On the north side of the mountains a few small streams take their rise and flow directly into the Rhine; the others swell the current of that river by means of the Aar. The mountain-ridges in the canton are composed of the Jura limestone, and their slopes are covered with numerous large blocks of granite and gneiss. The soil is on the whole fertile, not only in the lower but even in some of the more elevated tracts. In the lowlands all the ordinary kinds of corn are grown in super-abundant quantities. The mountains are partially covered with forests of excellent timber, especially fir and beech; and there are many fine upland pastures and meadows. The canton contained in 1854—45,245 acres of arable land, 57,778 of meadows and pasture land, 445 of vineyards, 52,800 of forests, and 30,329 of uncultivated land. Vines are grown only in a few places, mulberry-trees are cultivated, and silk-worms reared. The inhabitants are employed to a large extent in pastoral pursuits, and especially in breeding cattle. In 1854 there were 4305 horses, 27,109 horned cattle, 8467 sheep, 7259 goats, and 17,409 swine in Solothurn. The number of milch cows was 10,901, producing 4910 cwt. of cheese and 5500 cwt. of butter. Several important mineral deposits are found within the limits of the canton. Extensive beds of iron lie at either base of the mountains; several mines are in operation, and the ore is smelted and worked at Balsthal and Klus, near the middle of the canton. About 1865 tons of iron are annually produced. The country has also valuable quarries of limestone, some kinds of which are susceptible of a high polish, and go by the name of Solothurn marble. Excellent millstones are also obtained from this canton. Manufactures are not carried on to any great extent in Solothurn, and they are rather declining than increasing in importance, leather, paper, and woollen cloth being the principal articles made. Commerce, however, is in a flourishing condition. The horse fair held in the capital is one of the most frequented in Switzerland. The inhabitants are for the most part Roman Catholics, there being in 1850 only 8097 Protestants in the canton. A dialect of German is generally spoken. The means of education are widely diffused, and all children above seven are obliged to attend school. The government, according to the constitution of 1831, is republican. The legislative power belongs to the great council of 109 members,

elected every six years by colleges of electors for each of the ten circles or districts into which the canton is divided. The executive consists of a smaller council of nine, elected by the members of the great council from their own number. The head of the government has the title of Landamman. Solothurn is represented in the Federal Assembly of Switzerland by three, and in the Council of Estates by two members. The total population in 1850 was 69,674, of whom 64,044 were citizens of the canton, 4652 citizens of other cantons, and 933 foreigners.

SOLOTHURN, or *Soleure*, the capital of the above canton, stands at the foot of Mount Jura, on the Aar, here crossed by two bridges, 18 miles north of Bern. It was at one time regularly fortified; but the defences have been in recent times demolished, in pursuance of an order of the great council in 1835. The streets are broad, regular, and well paved, and there is a spacious market-place adorned with a fine fountain. Here stands the Cathedral of St Ursus, one of the finest churches in Switzerland, with a massive square tower 190 feet high. The town-hall is an ancient irregular building, with several turrets; and the government-house, arsenal, museum, theatre, and two churches, are handsome buildings. Solothurn has also a gymnasium with six professors, a lyceum with three, and a town library of 20,000 volumes. A few manufactures of cotton cloth, paper, leather, and hardware are carried on; and there is a small amount of trade. It was at Solothurn where the Polish patriot Kosciusko spent the last two years of his life, and where he died in 1817. Pop. 5370.

SOLSTICE, the time when the sun is in one of the solstitial points, that is, when he is at his greatest distance from the equator. It is thus called because the sun then appears to stand still, and not to change his distance from the equator for some time, owing to the obliquity of our sphere, to which those living under the equator are strangers. The solstices are two in each year; the æstival or summer solstice, and the hyemal or winter solstice. The summer solstice is when the sun seems to describe the tropic of cancer, which is on June 22, when he makes the longest day; the winter solstice is when the sun enters the first degree, or seems to describe the tropic of capricorn, which is on December 22, when he makes the shortest day. This is to be understood of the northern hemisphere; for in the southern the sun's entrance into capricorn makes the summer solstice, and that into cancer the winter solstice. The two points of the ecliptic, at which the sun's greatest ascent above the equator, and his descent below it, are terminated, are called the *solstitial points;* and a circle, supposed to pass through the poles of the world and these points, is called the *solstitial colure.* The summer solstitial point is in the beginning of the first degree of cancer, and is called the *æstival* or *summer point;* and the winter solstitial point is in the beginning of the first degree of capricorn, and is called the *winter point.* These two points are diametrically opposite to each other.

SOLWAY FIRTH, an inlet of the Irish Sea, partially separating England from Scotland, and washing the shores of Kirkcudbrightshire and Dumfriesshire in the latter, and those of Cumberland in the former. It stretches inland, from S.W. to N.E., for 31 miles, and its breadth from the head as far down as the mouth of the Annan is 2 miles; between Southerness Point in Kirkcudbright and Allonby in Cumberland, it expands to 7 miles; and at its mouth, between Rayberry Head and St Bees Head, it is 20 miles across. The chief rivers that fall into the Solway Firth are the Urr, Nith, and Annan from Scotland, and the Derwent, Ellen, Waver, Wampool, and Eden from England. A great part of the firth is occupied by broad sandbanks, which are dry at low water. The tides both ebb and flow here with great rapidity and force; and bores are formed at the mouths of several of the rivers. The Solway Firth is navigable for its whole length for vessels of 100 tons, and for those of 300 tons a considerable distance.

SOLYMANIA, called also SHEHR ZAUR, a town of Kurdistan, the residence of the Pacha. The town had fallen into decay, but was rebuilt by Solyman the Pacha, who, in 1810, having taken up arms against the Pacha of Bagdad, defeated him and put him to death. Pop. 6000; 54 miles east of Kerkook.

SOMALPET, a town of Hindostan, in the Nizam's province of Nandere, 52 miles N.N.E. from the town of Nandere.

SOMAULI, or SOMALI. See AFRICA.

SOMBOR, or Zombor, a city of the kingdom of Hungary, in the province of the hither Danube, in the circle of Kozep Jaras. It contains 2980 houses, with 14,860 inhabitants, whose chief trade is in corn and cattle. Lat. 48. 8. 32., Long. 21. 10. 33. E.

SOMERS, JOHN, *Lord*, high chancellor of England, was born at Worcester about 1650 or 1652. He was educated at Oxford, and afterwards entered himself at the Middle Temple. In 1688 he was one of the counsel for the seven bishops at their trial, and argued with great learning and eloquence against the dispensing power. In the convention which met by the Prince of Orange's summons, January 22, 1689, he represented Worcester, and was one of the managers for the House of Commons at a conference with the House of Lords upon the word "abdicated." Soon after the accession of William and Mary to the throne, he was appointed solicitor-general, and received the honour of knighthood. In 1692 he was made attorney-general, and in 1693 advanced to the post of lord-keeper of the great seal of England. In 1695 he proposed an expedient to prevent the practice of clipping the coin. In 1697 he was created Lord Somers, baron of Evesham, and made lord high chancellor of England. In the beginning of 1700 he was removed from his post of lord chancellor, and the year after was impeached of high crimes and misdemeanours by the House of Commons, of which he was acquitted upon trial by the House of Lords. He then retired to a studious course of life, and was chosen president of the Royal Society. In 1706 he proposed a bill for the regulation of the law, and the same year was one of the principal managers for the union between England and Scotland. In 1708 he was made lord president of the council; from which post he was removed in 1710, upon the change of the ministry. In the latter end of Queen Anne's reign his lordship grew very infirm in his health, which is supposed to be the reason that he held no other post than a seat at the council table after the accession of King George I. He died of an apoplectic fit in 1716. Addison has drawn a flattering view of his character in the *Freeholder*. His life has been carefully written by Lord Campbell, in his *Lives of the Chancellors*.

SOMERSETSHIRE, a county in the west of England, lying between N. Lat. 50. 49. and 51. 30; W. Long. 2. 14. and 3. 50; bounded on the N.W. by the Bristol Channel, N.E. by Gloucestershire, E. by Wiltshire, S. by Dorsetshire and Devonshire, and W. by Devonshire. Its boundary-line has considerable irregularities, and its general form is that of a crescent. Its greatest length from E. to W. is 68 miles; extreme breadth, 43; area, 1645 square miles, or 1,052,800 acres. The county is hilly, and is divided naturally into three parts by two ranges of hills, between which lie wide plains and valleys. The two ranges are the Mendip Hills and the Quantock Hills. The former extend from the hills near Frome, on the borders of Wiltshire, in the direction of W. by N., to the Bristol Channel. Their length is 25 or 30 miles; their breadth, 6 or 7 in some places; and several of their summits exceed 1000 feet in height. In the W. of the county rise the

Quantock Hills, the other principal ridge in Somersetshire. Their direction is nearly parallel to that of the Mendip Hills, and their culminating point is Bagborough Station, or Will's Neck, 1270 feet above the sea. A greater elevation, 1668 feet, is reached by Dunkerry Beacon, still further W. than the Quantock Hills. Besides these hills, there are in the extreme N.E. of Somersetshire several peaks, irregularly grouped, about Bath and Bristol. Such are Lansdown, 813 feet high; Dundry Hill, 790 feet; and several others. The eastern and southern boundaries of the county, from Bath to Yeovil, and from thence to Wellington, are also occupied by detached heights, broken by several transverse valleys. To the N.E. of the Mendip Hills, between them and these about Bristol and Bath, the country is watered by the Avon and the Yeo—the former marking the boundary between Somersetshire and Gloucestershire, and both falling into the Bristol Channel. The central portion of the county, between the Mendip and the Quantock Hills, is watered by the Axe, the Brue, and the Parret, all flowing N.W. into the Bristol Channel. The last of these rivers is joined by the Isle; another Yeo, also called the Ivel; and the Tone, which waters the region to the S.W. of the Quantock Hills. Between the last of these rivers and the Parret, lies an elevated tract about 100 acres in extent, called the Isle of Athelney, where Alfred the Great is said to have fled for refuge from the Danes. It was anciently secluded from the surrounding country, not only by these rivers, but by a marsh which has been long since drained. In some parts of the county there are still extensive marshes—as about the mouths of the Yeo and other rivers in the N.E.—and also between the Mendip and the Quantock Hills. The coast is indented by several bays of small, and by one of considerable size. The last is Bridgewater Bay, about the middle of the coast, where its direction changes from a southerly to a westerly one. Of much smaller size are Sand Bay, and Uphill Bay to the N., and the shallow Bay of Porlock to the W. of that of Bridgewater. The greater part of the shore of Somersetshire is lined with sands, but these are in general of no great breadth; and the country immediately behind them is either occupied with hills, more or less lofty and steep, or with low marshy tracts of ground. Indeed, hilly as Somersetshire is, there is in it a larger extent of marshes and fens than in most of the counties of England. The geological formation of the country is various. Oolitic strata prevail in the N.E.; and it is of these that the hills in this quarter are formed; and from these is obtained the stone generally known as Bath stone. The oolite is quarried at Dundry Hill and other places. Beneath these deposits beds of lias are generally found. New red sandstone occupies the valley of the Avon, and is surmounted in some places by limestone. There are several beds of coal in this region, as well as strata of old red sandstone and mountain limestone. The former of the two last forms the central ridge of the Mendip Hills, flanked on either side with bands of mountain limestone. The hills on the eastern and southern boundary of the county are of the same geological formation as those in the N.E. The western part of Somersetshire consists chiefly of old red sandstone and slate; the latter, which is similar to the slaty rocks of Devonshire, forming the wild region called Exmoor Forest, W. of the Quantock Hills. The hills themselves consist of a coarse gritstone, belonging also to the slate formation in the N. of Devonshire. The climate of Somersetshire is healthy, and well suited to the production of the crops usual in England. The soil, too, is in general good, though presenting a considerable variety in different places.. On the Mendip and Quantock Hills, as well as in Exmoor Forest, the country is very bleak and barren; and is valuable more for the minerals beneath the surface, than for any productions of the soil. These hilly and barren portions of the county, however, bear but a small proportion to the whole; and between them are to be seen the richest meadows and arable land, the value of which more than counterbalances the sterility of the hills. In the better parts of the county, it may rather be described as rich than beautiful. The wide vale of Taunton has a very rich soil, and produces large crops of excellent wheat. There are no extensive forests, but upwards of 20,000 acres in various parts are covered with wood; which is, in many places, of a large and stately description. The extent of orchards, especially when in full bloom, produces a pleasing effect, and in some measure compensates for the want of woods. Wheat, oats, and barley are the kinds of corn most extensively raised. Next to them come potatoes, beans, flax, and hemp. Many improvements in agriculture have been recently introduced; although, even yet, the county cannot be said to be distinguished for the excellence of its farming.

As Somersetshire contains, on the banks of its rivers, large tracts of the richest meadow lands, the most valuable branch of its rural economy is the fattening of cattle and the management of the numerous dairies. The oxen, bred chiefly in the less fertile pastures of Devonshire, when grazed in this county, afford the best beef; and furnish, in great numbers, the markets of the metropolis, as well as those of Bristol and Bath, in their immediate vicinity. Sheep of the Leicester or Southdown breeds are fed in large numbers on the more elevated pastures of the county. Large numbers of hogs are fattened, and the bacon of Somersetshire is of excellent quality. The produce of the dairy is of the best kind. The cheese of Cheddar has obtained great celebrity, but that made in many other parts, and frequently sold as Gloucester, is equal to any in the world. The next agricultural product is cider, which forms almost the universal beverage of the working classes. The consumption of it within the county is very large, and some is sent to distant parts. The county also contains a few hop gardens.

The mineral resources of Somersetshire are very considerable. Of metals, the most important found here is iron, which is obtained in various places, near Bristol, in the Mendip Hills, and in the Brendon Hills, in the extreme west of the county. The total quantity of ore raised in Somersetshire, in 1858, was 26,041 tons; valued at L.13,021. Lead and silver are also obtained from the Mendip Hills. Of the former, there were raised in 1858 1000 tons of ore, yielding 435 tons of metal; and of the latter, 1295 ounces were obtained. The existence of coal in some places has already been noticed. There are in all thirty-five collieries. No separate return is given of the coal produced in this county; but the total for Gloucestershire, Somersetshire, and Devonshire, in 1858, was 1,125,250 tons. Other valuable minerals are obtained in the county, such as building-stone, slate, gypsum, &c.; zinc, calamine, and copper exist, but are not worked to any great extent.

This is a manufacturing district for various productions. The manufacture of fine woollen cloth is extensive, chiefly at Frome, where it employs a large number of hands; and it is also carried on at Road, at Beckington, Charter-Henton, Twerton, near Bath, Lyncombe and Wedcombe, and at Freshford. In another part of the county, at Wellington and Milverton, cloth of an inferior description is manufactured. A considerable number of men are employed in making sail-cloth, sacking, and girth-web, at Crewkerne and the parishes of East Coker, Merriot, West Hatch, and North Perrot. At Chard and at Ilminston, silk and lace, and the machinery for those fabrics, are made; and the same trades afford considerable occupation at Bruton and Taunton. At Yeovil, and some of the towns and villages near it, the chief trade is glove-making, which

gives employment to a great number of people. Edge tools are made at Wells, and also at Whately, Emborrow, and some other places. At Nailsea the manufacture of glass is carried on; paper-making and tanning at Cheddar; and there are also in the county an iron-work, and a furnace in blast.

The foreign commerce of Somersetshire passes chiefly through Bristol, which is the mart for such goods as are required in distant countries. Some of the woollen goods which are manufactured at Taunton and Wellington are shipped from Exeter. The far greater portion of the productions of the county are, however, destined to supply the demand for internal consumption. The cattle, butter, and cheese are chiefly sent to London; the linen and woollen goods are distributed through the western and Welsh counties, and, in general, are destined more for the home than for foreign markets.

The means of internal communication are roads, railways, and canals, all of excellent construction. There are two roads from London to Bristol, uniting near Bath; another from Bristol to Bridgewater, and thence to Taunton and Exeter; one from London through Salisbury and Yeovil to Exeter; and many others. The Great Western Railway enters the county near Bath, and extends to Bristol. From this place the Bristol and Exeter Railway traverses the county, and passes Bridgewater and Taunton. Short branches connect this line with Cleveden, Weston-super-Mare, and Gastonbury. The Wilts, Somerset, and Weymouth Railway diverges from the Great Western, and passes Frome, Castle Cary, and Yeovil. There is also another line from the last of these towns to the Bristol and Exeter Railway. All these lines are on the broad guage, being connected with the Great Western. The chief canals in Somersetshire are a small part of the Kennet and Avon Canal, which connects the Avon with the Thames; the Somersetshire Coal Canal, a branch of the former, extending to Paulton; the canal from Glastonbury to the lower part of the Brue; and that from Bridgewater to Taunton. The civil divisions of the county are the eastern and the western, each of which contains 2000. Almost the whole of it belongs to the diocese of Bath and Walls; which is subdivided into the arch-deaconries of Bath, Wells, and Taunton. According to the census of 1851 Somersetshire contained, in all, 1129 places of worship, with 288,333 sittings. Of the former, 553 belonged to the Church of England, 309 to Wesleyan Methodists, 110 to Independents, 89 to Baptists, 15 to Quakers, 12 to Brethren, 8 each to Unitarians and Roman Catholics, 6 to Mormonites, &c. The whole number of day-schools, at the same period, was 1381, with 53,720 scholars. Of these 490 were public schools, with 36,512 scholars; and 891 private schools, with 17,208 scholars. There were also 719 Sunday-schools, attended by 56,090 pupils; and 19 evening schools for adults, attended by 272. Of the last, however, 17 were also used as day-schools.

The titles derived from this county are those of the Dukes of Somerset and Wellington; the marquises of Lansdowne, Bath, and Bristol; the Earls of Poulett and Ilchester; and the Baron Mendip. Since the reform bill each division of the county has returned two members to the House of Commons. The seats of the nobility and gentry, especially of the latter, near Bath and Bristol, are numerous; and our limits allow only of noticing the most distinguished of them, viz., Longleet, the seat of the Marquis of Bath; Hinton, the seat of Earl Poulett; and the houses of the Earl of Carnarvon, Sir Alexander Hood, Mr Miles, and Colonel Gore Langton.

Two members are chosen for each of the cities of Bath and Wells, and two for each of the boroughs, Taunton and Bridgewater. Bristol, which is partly in this county, returns two members. The boroughs of Minehead, Ilchester, and Milburn-Port, which chose two members each, have been disfranchised, and the town of Frome has been made a parliamentary borough, returning one member. Ilchester contains the jail and county court, but the assizes in the spring are held at Taunton; and in the summer at Wells and Bridgewater alternately.

Somersetshire contains antiquities belonging to almost every period of English history. There is a druidical circle at Stanton Drew, near Bristol; Roman camps at Bath, Ilchester, and several other places; Saxon camps at Wiveliscombe, Porlock, and elsewhere; ancient abbeys at Glastonbury, and Muchelney; several ruined priories; cathedrals at Bath and Wells, and numerous old churches. Among the illustrious natives of this county are Roger Bacon, born at Ilchester, Blake at Bridgewater, Cudworth at Aller, Fielding at Sharpam, and Locke at Wrington. Some important historical events are connected with Somersetshire. It was anciently inhabited by a tribe called the Hedui, in the east, and by the Cimbri in the west. Under the Romans it was included in the province of Britannia Prima. At the time of the Saxon invasion this county was the scene of sharp conflicts between the invaders and the Britons; and King Arthur defeated the Saxons under Cerdic, at Mount Baden, supposed to be in the vicinity of Bath. This occurred in 520; and it was not till about 658 that Somersetshire was finally conquered by the Saxons. There were also several conflicts in this county at a later era between the English and the Danes. From this time onwards, however, no important events took place here till the great civil war of the seventeenth century. In 1643, the parliamentary forces were defeated at Lansdown Hill, near Bath; and Taunton was defended for a long time by Blake against 10,000 Royalist troops, until it was relieved by Fairfax in 1645. Somersetshire was also the scene of the unfortunate expedition of Monmouth against Charles II. in 1685. He landed in Dorsetshire on the 11th of June; and after taking Bridport by storm, proceeded through Taunton to Bridgewater and Glastonbury. After an unsuccessful attack on Bristol, he was defeated by the king's forces, and obliged to fall back on Bridgewater. Here he made a last effort to gain a victory by surprise, but was totally defeated at Sedgemoor, 4 miles S.E. of Bridgewater. This was, according to Lord Macaulay, the last fight deserving the name of a battle that has been fought on English ground. The county suffered severely from the severities of the victorious party after the suppression of the rebellion. The population of Somersetshire, at the several periods of the census, has been as follows:—(1801) 273,577; (1811) 302,836; (1821) 355,789; (1831) 403,795; (1841) 435,599; (1851) 443,916.

SOMERTON, a market-town of England, Somersetshire, on the left bank of the Cary, 28 miles S.W. of Bath. It has several very narrow streets; an old church, with an octagonal tower; a county jail, occupying the site of an old castle; places of worship for Independents and Wesleyan Methodists, schools, and almshouses. Many of the people are employed in glove-making. Pop. of the parish 2140.

SOMERVILE, William, an English poet, said by Johnson to have been born in 1692, but from a note furnished by Johnson's latest editor, Cunningham, it would appear that he was born as early as 1677, at Edstone, a country seat of his family in Warwickshire. He was educated at Westminster School, and at New College, Oxford. He gave no great proofs of genius while he was at College, but on leaving it he went to reside at the family mansion, where he cultivated poetry, sought pleasure as a sportsman, was hospitable, was a justice of the peace, and, in short, was generally esteemed an easy, careless, cultivated country gentleman. Somervile inherited an estate worth L.1500 a-year, out of which he allowed his mother L.600, but he was too heedless of economy, and perhaps a little too much

addicted to the pleasures of the table, so that in his later years he became involved in debt, from which he was only relieved by death on the 19th of July 1742. Shenstone, the poet, says of him, that he was "forced to drink himself into pains of the body, in order to get rid of the pains of the mind." He was buried at Wotton, near Henley-in-Arden, Warwickshire.

Somervile tried many kinds of poetry; but his best success is attained in his poem of the *Chase*, 1735, which is written in blank verse, with sufficient knowledge of his subject, and with very considerable acquaintance with the requirements of the species of verse which he had selected. He has done all that transition and variety could easily effect to interest the common reader, but the versification frequently drags heavily, and the poem only escapes dulness by the novelty of its passing events, and by the efforts at originality which the writer so obviously puts forth. He wrote, besides other poems, the *Two Springs*, 1725; *Hobbinol, or the Rural Games*, 1740; and *Field Sports*, 1742. His poetical excellence may be fitly summed up in the words of Johnson, "he writes very well for a gentleman."

SOMMA, a town of Italy, Lombardy, not far from the Ticino, near the foot of Lake Maggiore, 27 miles N.W. of Milan. It is an ancient, well-built town, containing a handsome palace, a court of law, and two parish churches. There are also here some remains of antiquity; and a cypress-tree of gigantic size and great age. It was near Somma that Hannibal gained his first victory on Italian ground, completely defeating the Romans under Scipio, B.C. 218. The town has some trade in wine and silk, and a population of 4000.

SOMMA, a town of the kingdom of Naples, in the province, and 9 miles E. of Naples, at the north foot of Mount Vesuvius. It contains a castle, several churches and monasteries, a college and an hospital. The northern summit of Vesuvius, anciently known as Mons Summanus, is now called Monte Somma. Some trade is carried on at Somma in wine and fruit. Pop. 7000.

SOMME, a department of France, bounded on the N. by that of Pas-de-Calais; E. by that of Aisne; S. by that of Oise; W. by Seine Inférieure and the English Channel. Its length from E. to W. is about 80 miles, its greatest breadth 47, and its area 2379 square miles. The surface is for the most part flat and monotonous; but is diversified in some places with low hills, gentle slopes, and pleasant vales. The general inclination of the country is towards the north-west; and in this direction all the rivers flow. Of these the largest is the Somme, which gives its name to the department, and flows through its centre. Its source is in the department of Aisne, not far from St Quentin; and after flowing for about 20 miles to the south-west, it enters this department near Ham, and pursues a north-westerly course to the sea. Its whole length is 115 miles, and it is navigable as far as Abbeville for vessels of 150 tons. From the left it receives the Ayre and the Celle; from the right the Miraumont, Nieve, and Maie. The Authie and the Bresle, the only other important rivers, flow nearly parallel to the Somme; the one forming the northern, and the other the southern boundary of the department. The coast, which is about 25 miles in length, is divided by the mouth of the Somme into two nearly equal parts, of very different character. To the north of the river the sea is kept back from the low lying country by a series of low sand-hills; to the south it washes a line of cliffs of chalk, clay, and marl, whose yielding substance has been in many places worn away by the violence of the waves. The line of coast has undergone considerable change, even within a historical period; for, in the ninth century, the sea covered the low ground north of the Somme for several miles inland. This tract was afterwards occupied by a large lake, and now forms one of the most fertile portions of the department. There are no considerable bays or indentations on the coast. The whole of the department consists in its geological structure of cretaceous strata, covered in general with a sandy clay. The country has a climate resembling that of the south of England, moist, variable, and temperate. It is exposed to all the winds, and those from the north-west are injurious to vegetation. Although the soil is not by nature very fertile, and the scenery by no means striking or romantic, the country everywhere presents an appearance of solid prosperity and quiet happiness. Its well-cultivated ground affords to the traveller the prospect of meadows and corn-fields stretching almost beyond the reach of sight, orchards laden with fruit, extensive farms, and numerous villages, whose inhabitants, though poor, are not miserable. Of the whole surface, 1,190,000 acres are occupied by arable land, 37,650 by meadows, 127,500 by forests, and 20,000 by waste land. Agriculture has made much progress recently, so that the country is considered one of the granaries of France. Besides corn, pulse, beet-root, hemp, and flax are the chief crops raised. The forests are not very extensive, but yield a valuable supply of timber. Horses, cattle, and sheep are reared in large numbers. The number of horned cattle in the department is estimated at 120,000, that of horses at 80,000, that of mules at 3200, of asses at 8000, of sheep at 500,000, of pigs at 70,000, and of goats at 5000. There are no important minerals in the department, except peat, of which a large quantity is annually obtained. Building-stones and paving-stones are quarried to a small extent; and clay for brickmaking is found in abundance. Although most of the inhabitants are employed in agriculture, manufactures are also carried on to a considerable extent. Amiens and Abbeville are the chief manufacturing towns, and woollen and cotton fabrics are their staple produce; cloth, lace, velvet, gauze, muslin, &c., being made. Besides these, Somme has also bleachfields, dye-works, tanneries, paper-mills, breweries, distilleries, oil-works, &c. The chief articles of trade are the rural produce of the country, and the manufactured goods. Numerous roads and several railways traverse the department; by means of the latter Amiens is connected with Paris, Boulogne, and Lille. There is also a canal, which stretches along the side of the Somme nearly to its source; and, by a junction with that of St Quentin, connects it with the Schelde, Oise, and Seine. Somme forms the diocese of Amiens; and contains several courts of law, subject to a court of appeal in that town. Education is provided for by a lyceum, a secondary school of medicine, two communal colleges, a normal seminary, and 1100 elementary schools. The capital is Amiens; and the department is subdivided as follows:—

Arrondissements.	Cantons.	Communes.	Pop. (1856).
Amiens	13	253	191,413
Abbeville	11	171	137,596
Doullens	4	49	59,447
Montdidier	5	144	68,124
Peronne	8	184	110,039
Total	41	850	566,619

SOMMERFELD, a town of the Prussian monarchy, in the province of Brandenburg, in the government and 45 miles S.S.E. of Frankfurt-on-the-Oder. It is surrounded by walls; and has a church and a castle, manufactures of woollen and linen cloth, and some trade. Pop. 5672.

SOMMIÈRES, a town of France, in the department of Gard, 15 miles S.W. of Nismes, on a hill near the left bank of the Vidourie. It was formerly fortified; and was a place of some importance in the civil wars of the sixteenth century, being frequently held by the Protestants. The walls are all destroyed; but the castle still remains. Woollen cloth, leather, brandy, &c., are manufactured; and there is some trade in wine and wool. Pop. 3697.

SOMNAMBULISM,

MAGNETIC OR ARTIFICIAL.

Somnambulism.

UNDER the title Somnambulism it is proposed in the following article to give a brief history of the various phenomena which have at different times been described under the names of Mesmerism, Animal Magnetism, Magnetic Somnambulism, Hypnotism, &c. In the last edition of the *Encyclopædia Britannica*, the first class only of these phenomena received a full treatment.

Neither of the appellations "Animal Magnetism" and "Somnambulism" are free from serious objections, inasmuch as they express theoretical views as to the nature of the subject which many reject as altogether untenable. But long usage has given them too strong a hold upon the public mind to warrant their rejection now, and the other names which have been suggested are not less objectionable than those now mentioned. The different writers on these phenomena have advanced very various theories as to the nature of the mysterious and occult agency engaged in their production, but there has been an all but uniform tendency to connect them with magnetic and electrical forces. It is only in more recent times that attempts have been made to dissever them from this connection, and to explain them upon purely nervous and subjective principles. Though the introduction of the phenomena of somnambulism by the Marquis de Puysegur was extremely distasteful to Mesmer, caused no inconsiderable revolution in the doctrines and practice of animal magnetism, and exercised a permanent and powerful influence upon its subsequent fortunes and development, it was not considered, either by Mesmer or Puysegur, to be an essential departure from the fundamental principles of the mesmeric theory. The influence or energy at the foundation of both was considered to be identical. The phenomena of somnambulism were believed to have been abundantly manifested in the operations of Mesmer, and to have frequently occurred in the magnetic crisis; but it was only in the practice of Puysegur that they were prominently brought forward and made the subject of special observation. It is in the same way that many phenomena, daily seen and casually observed, are found to have an importance and significance which was scarcely even suspected till they have been made the subject of special research and earnest observation. The connection between mesmerism as propounded by its founder, and somnambulism as developed by his pupil, is so intimate both in their historic and intrinsic relations, and the one is so directly the sequel and consequence of the other, that they cannot with justice be dissociated from each other. It is on this ground, therefore, that we propose to treat them both together, and, inasmuch as magnetic somnambulism is that form of the mesmeric theory which has descended almost without change to our own time, and has entirely superseded the original phase of the doctrine, we have thought it right to treat of the whole subject under this designation.

The term Animal Magnetism has been employed to denote an agency or influence to which certain singular phenomena, occurring, or said to occur, in the economy of particular individuals, have been supposed to be attributable. The phenomena which this agency has been conceived to produce in those who are under its influence, may be comprehended under two distinct classes: those which occur whilst the person operated upon remains awake, and those which take place whilst the patient is in a state of sleep, or in a state resembling it. To the former class of effects belong—*first*, various sensations, more or less painful, experienced particularly in those parts of the body that are the seat of disease, and which enable the practitioner to detect what that seat actually is; *secondly*, convulsive and other nervous affections, which have been regarded by the advocates of animal magnetism as salutary crises; and, *thirdly*, the removal of any diseases with which the persons magnetised may be affected, the magnetic influence proving in this respect an universal curative of disease and preservative of health. Under the latter class of effects, or those occurring while the persons magnetised are in the state of magnetic sleep, may be included the power they acquire of carrying on a continued conversation with their magnetiser, without being at all sensible of the presence or conversation of others, and sometimes in a language and upon matters with which, in their natural or waking state, they are little if at all acquainted; the power of discovering the secret thoughts of others; the power of receiving, through the medium of the epigastrium, or other parts of the circumference of the body, those impressions of external objects which, in ordinary circumstances, are received only through the peculiar organs of external sensation, or that power which, in the technical language of magnetism, is shortly termed the transference of the senses; the power of detecting the internal alterations which have been produced by disease in their own bodies, or in those of others with whom they may be placed in animal-magnetic relation; the power of foretelling the nature of the changes which are to occur in their own maladies, or in the maladies of others; the power of instinctively suggesting the remedies by which these changes may be best promoted, and the cure of the diseases accomplished; together with various other extraordinary, or, as they have usually been deemed where they have been supposed to occur, preternatural powers of a similar kind. These two classes of phenomena belong to different periods of the history of animal magnetism. To those of the first class chiefly the early practitioners of this mysterious art confined their pretensions, and it was only at a later period that the magnetisers laid claim to the power of producing the wonderful manifestations included under the second class. At the outset we shall make a few remarks on Mesmerism before Mesmer.

Mesmerism before Mesmer.

It seldom happens that any great discovery has been made without its appearing that some traces and indications, more or less distinct, of the phenomena to which it relates have been manifested at some time or other, anterior to the period of its publication. We see this illustrated with respect to the application of steam-power, the electric telegraph, and many other important discoveries. Moreover, if we go back to periods of remote antiquity, and examine the records, scanty and imperfect though they may be, of nations and races who possessed a more ancient civilization than our own, we shall find frequent evidence of the existence of sciences and arts, which we might otherwise suppose had only made their appearance at a much later period in the world's history. We shall find that, in Egypt, in India, and in China, there was much progress made in many of the departments of science and art, at a time when Europe was still in a state of barbarism. The histories of these remote periods are now enveloped in much obscurity, and the traces of the existence of practices analogous to those of mesmerism are very faint. On Egyptian and Assyrian inscriptions and hieroglyphs there are some representations of persons apparently employed in mesmeric manipulations. Artifi-

cial somnambulism is believed to have been practised by the Brahmins and Faquirs of India from a very early period; and there is little doubt that it is not only known and practised by them at the present day, but also that their knowledge has been handed down by tradition from ancient times, and not derived from their intercourse with European nations. The Jesuit missionaries of China also testify to the existence in that empire of modes of treatment analogous to those of mesmerism. To come to times nearer our own, it is believed by some that there are many passages to be found in the writings of Greek and Roman authors which can only be rightly interpreted, on the supposition that there were modes of practice known to the Greek and Roman physicians which did not widely differ from those employed in mesmerism. It was used as an argument against mesmerism by Bailly, in the discussion of the French Academy of Medicine in 1825, that the phenomena exhibited by the mesmerised were in many respects comparable to those manifested in the Eleusinian Mysteries of the temple of Ceres, and to those witnessed in the cave of Trophonius. It was also averred that they bore some analogy to what was witnessed at the rites of the Bona Dea, at the shrine of the Delphic oracle, and in the Forest of Dodona. Whatever may have been the nature of these ancient rites and ceremonies, we know too little of them to use them with effect either for or against any modern system which may be supposed to bear any analogy to them. But it is important to note the existence, throughout all historic ages, of practices which bear some similarity to those of which we are about to treat in this place. In the passages quoted from ancient writers, as in the verses ascribed to Solon, and in the lines from Plautus and Martial, the allusions certainly point strongly to the practice of rubbing with the hands for the purpose of assuaging pain. The miraculous cure by the Emperor Vespasian of a case of blindness by inunction of saliva, at the instance of Serapis, as recorded by Tacitus, seems to have been a very manifest plagiarism of the miracle performed by Christ, and cannot, with any justice be described, as has been done by Mr Colquhoun, to be a "magnetic cure." Setting aside the hypothesis, that mesmerism had certain features in common with the witchcraft and magic of superstitious times, we come to a period not long anterior to the time of Mesmer, when opinions were broached with respect to magnetism which have a very direct and important bearing upon his peculiar views. This portion of the pre-mesmeric history of magnetism has been very well elucidated by Mr Colquhoun, Deleuze, Thouret, and others, who cite numerous authors, writing during the sixteenth and seventeenth centuries, who entertained opinions concerning magnetism extremely analogous, in many respects, to those which were subsequently propounded by Mesmer, as we shall afterwards see. Mesmer, at the outset of his career, and in concert with the astronomer, Father Hell, commenced with the employment of real magnets in the treatment of disease. But at a later period he saw fit to renounce the use of real magnets, and announced the idea that the healing virtue did not reside in the mineral magnet, but emanated from his own person. Even in those cases which at first appeared to be benefited by the application of magnets to different parts of the body, he ascribed the curative power, not to the inherent property of the magnets, but to some quality which he communicated to them by touch. This quality, in contradistinction to that which naturally resides in the magnet, and which has been called mineral magnetism, he designated by the name of animal magnetism. Before the time of Mesmer, the therapeutic power of the magnet, both in powder and entire, had been held from the earliest time; and during two centuries that other so-called magnetical power, which Mesmer imagined he had just discovered to belong to the human frame, was well known and described in terms not very unlike those which Mesmer himself afterwards employed. A brief notice of the history of the use of the mineral magnet in medicine, and of the theory of animal magnetism, which was in vogue before Mesmer promulgated his views, will complete our sketch of the history of mesmerism before the time of Mesmer. We shall just glance at the therapeutic history of the magnet or loadstone. The mysterious attractive property of this inorganic substance, which Reichenbach has recently attempted to show has a counterpart in the organic world—the animal magnetism of Mesmer and his followers, attracted very early attention, and it was not long in being enlisted among the number of therapeutic agencies. It is not necessary to dwell upon the various marvellous and contradictory virtues which were ascribed to it by different professors of the healing art. By some it was looked upon as a noxious, by others as a salutary substance; by some it was regarded as a moral, and by others a physical agent. Powdered, it was given internally as an evacuant for dropsies; and, so late as the sixteenth century, there were few diseases in which the powder was not considered to be beneficial. Externally it was employed in diseases of the eyes, and for burns. As a plaster it was applied to poisoned wounds, in order to exhaust the offending substance. It was termed the divine plaster, and was used generally by surgeons, to purify wounds from all manner of malignity, and to favour the generation of healthy flesh. Although Dr Gilbert of Colchester had shown in 1600 that the properties of the magnet are destroyed by pulverization, practitioners continued to use it up to the beginning of the eighteenth century. Since then it has become obsolete. The history of the powdered magnet is the same with that of a hundred other substances which have figured in therapeutic annals. Of how many of the much-vaunted remedies of our own times the same history will hold good, time alone can reveal.

The use of the entire magnet, or of bodies known to possess genuine magnetic properties, dates from a very early period. A glance at the history of the magnet as a therapeutic agent will conduct us to the discovery of Mesmer, the first development of which sprung from the use of the metallic magnet; a circumstance which contributed more than anything else to give the name of animal magnetism to that class of phenomena with which the name of their discoverer has also become indissolubly united.

Ætius is the first Greek author who mentions the therapeutic virtues of the unpulverized magnet. When held in the hand, it was reported to prove beneficial in allaying the pains of gout, and in curing convulsions. The employment of the magnet for similar purposes is alluded to by other Greek, and by some Arabian physicians, but it was Paracelsus who first brought the virtues of the magnet most prominently into repute. He attributes to it the property of dislodging and attracting towards itself all material diseases. The list of these diseases is very extensive, and it was much increased by his followers, and by several medical authors of the eighteenth century, more especially by Van Helmont, Borel, Reichel, Klarich, and Kircher. It was employed in the treatment of mania, epilepsy, tetanus, hernia, dropsy, jaundice, ulcers, hysteria, spasms, and a host of other diseases too numerous to mention.

After the discovery of the artificial magnet, an attempt was made by M. le Noble, a French abbé, to introduce this agent into medical practice. He employed these magnets sometimes temporarily, and of great size and power, upon different parts of the body; but for more general and permanent use he had them formed into different pieces of ornamental and useful dress, such as caps or bandeaux for the head, necklaces, crosses, bracelets, girdles, and garters. By frequent and numerous trials he convinced himself that his magnetic dresses and ornaments were often speedy and effectual means of cure in a great variety of diseases. In

1777 he applied to the Royal Society of Medicine of Paris to appoint a committee of investigation, in order to make an experimental trial of the medicinal virtue of his magnets. The society acceded to his request, and appointed MM. Andry and Thouret to undertake the task, and report to them the result of their investigation. The commissioners devoted themselves assiduously to the task, and reported very favourably of the effects which they had observed to follow the use of magnets and magnetic dresses. Notwithstanding the very favourable report of MM. Andry and Thouret, the artificial magnet did not prosper as a therapeutic agent. Its virtues, however, continued to be mentioned with favour by such men as Alibert, Laennec, Recamier, and Chomel.

In reviewing this laborious and most minute investigation of the numerous and greatly varied effects which were observed to occur after the application of artificial magnets, we cannot but feel some degree of surprise that no suspicion should have arisen in the minds of the experimenters, that some of these effects might be the result of those spontaneous operations of the economy itself, which, from the earliest periods of medical science, have been known under the appellation of the *Vires Conservatrices et Medicatrices Naturæ;* that others were the effect of a proper and stricter attention perhaps to clothing, diet, and regimen than had been previously employed; and that the greater part of the sudden cures were probably the result of hope, engendered by belief in the efficacy of the remedy and confidence in those who applied it, or of other mental impressions, the influence of which, in producing remarkable and sudden effects upon the corporeal and mental functions of the human economy, and in promoting the operation of remedial agents, has long been recognized by medical men under the general, but not always accurately defined, term of the power of imagination.

Though somewhat later in point of time than the first announcement of the discoveries of Mesmer, we may here notice shortly, in connection with the use of magnets, the metallic tractors of Mr Perkins, which were introduced from America about the end of last century, and obtained considerable repute both in England and on the continent. They consisted of an alloy of different metals. They were rounded at one extremity, and pointed at the other. The diseased parts were directed to be rubbed or touched by the sharp point, which was also to be drawn over them in different directions, according to circumstances. The introduction of these tractors into England excited a great degree of attention. It occurred to Dr Haygarth, of Bath, to test their intrinsic value by a series of experiments, in which tractors, made of lead, wood, and old nails, covered with wax so as to resemble as near as possible the tractors of Perkins, were employed. It was found that effects as remarkable as those which had been observed to follow the use of the genuine tractors were produced by the factitious articles.

The nature of the facts elicited by the experiments of Dr Haygarth, Mr Smith, and others, was such as to prove, to the satisfaction of every one, that the metallic tractors of Mr Perkins did not produce their effects upon the human system by any action peculiar to themselves, but by some influence or agency altogether independent of the particular materials of which the instruments were composed, and common to them with every other substance, mineral and vegetable, that was employed in the same manner. Dr Haygarth himself had no hesitation in ascribing these effects to the influence of the imagination. "I have long been aware," says he, "of the great importance of medical faith. Daily experience has constantly confirmed and increased my opinion of its efficacy. On numerous occasions I have declared that I never wished to have a patient who did not possess a sufficient portion of it. The trials with the false tractors place its efficacy in a very conspicuous point of view, and must even astonish persons who have particularly attended to this subject; they clearly prove what wonderful effects the passions of hope and faith, excited by mere imagination, can produce upon diseases. On this principle we may account for the marvellous recoveries frequently ascribed to empirical remedies, which are commonly inert drugs, and generally applied by the ignorant patient in disorders totally different from what the quack himself pretends that they can cure. Magnificent and unqualified promises inspire weak minds with implicit confidence."

These experiments are worthy of being recalled to the attention of the public, and of being kept in mind by those who are at present endeavouring to revive the use of natural or artificial magnets as therapeutic agents, the more so that it does not appear to have occurred to MM. Andry and Thouret, nor to those who have since employed the magnet, to put the results which they obtained from the use of that agent to the test, by a comparative series of trials of the description suggested by Dr Haygarth.

However conclusive the experiments of Haygarth may have been against the intrinsic merits of Perkins' tractors, they are claimed as corroborating the reality and value of animal magnetism, inasmuch as it is maintained that the effects, though not proceeding from the tractors themselves, emanated from the person of the operator, just as they proceeded from the persons of Mesmer and Puysegur, through the intervention of the iron-rods, buckets, and trees which they employed in their practice.

We shall now glance briefly at the theories prevalent for two centuries before the time of Mesmer, in which we shall find not merely obscure foreshadowings, but an almost complete development of those peculiar doctrines which have rendered his name famous. It is true that we shall not find any trace of the paraphernalia which he employed in the practical application of his doctrines to the cure of disease, but it is sufficiently admitted that his buckets and rods were not essential elements, but merely subsidiary appliances fitted to produce a suitable impression on the minds of his pupils and patients. It will be sufficient, therefore, if we demonstrate an identity of principle without insisting upon an identity of practice.

The belief in the efficacy of the magnet, whether administered internally or applied externally, in curing diseases, seems, with most of those who adopted it, to have constituted only a part of a great system, in which they recognised magnetism as a general power or principle pervading the whole universe, and establishing particular connections between all its various parts. To these mutual relations of the different parts of the universe, material and animated, they give the names, sometimes of attraction and repulsion, and sometimes of sympathy and antipathy. Gilbert, to whose work upon the magnet reference has already been made, conceived that the earth is a great magnet, which acts and is acted upon by the other planets in the universe; and that this planetary influence operates upon all the bodies, animate and inanimate, which exist upon the surface of our globe. Fludd, in his *Philosophia Moysaica*, published in 1638, developed a theory of the universe, in which its phenomena were mainly accounted for by the attractive or magnetic virtue, and the antipathy of bodies. Man, considered as the microcosm, he held to be endowed with a magnetic virtue, subject to the same laws as that of the great world; having his poles like the earth, and his favourable and contrary winds. He describes the circumstances which produce negative or positive magnetism between different persons, and states that, when the latter subsists, not only the diseases and particular affections, but even the moral affections, are communicated from one person to the other. Kircher, in his work on the magnet, published at Rome in 1641, describes the influence of

magnetism, not only as it is universally diffused throughout the planetary system, but also as acting upon and existing in minerals, plants, and animals. He seems to have been the first author who made the distinction between, and employed the terms of mineral, vegetable, and animal magnetism. Similar ideas are to be found in the *Nova Medicina Spirituum* of Wirdig, published in 1673; in the *Medicina Magnetica* of Alexander Maxwell, a Scotch physician, published in 1679; and in the *Philosophia Recondita, sive Magicæ Magneticæ Mumialis Scientiæ Explanatio* of Santanelli, published in 1723. It was, it may be remarked, upon this general doctrine of the sympathy pervading all parts of the universe, that the sympathetic treatment of wounds and diseases practised by Paracelsus, Sir Kenelm Digby, and others, was founded.

Besides the theories more immediately founded on magnetism, we shall find that the power of the human will or volition is called upon to play an important part in the system of Mesmer, as propounded by himself and developed by his followers. These two elements are mixed up and confounded with one another in a most unsatisfactory way by mesmerists. At one time they appear to be considered identical, while at another they are represented as complimentary,—at one time, the phenomena are referred to the operation of magnetism, while at another they are referred to the influence of the will. In like manner, in the premesmeric period, one writer will be found to ascribe great power to human volition, while another will explain everything by magnetism,—with them, as with Mesmer and his disciples, we shall find that a cloud of mysticism obscures all these theories.

The power of volition may be employed to produce some influence or effect, either upon the person who exercises it, or upon some other person. Many remarkable cases of the former kind of influence have been observed and recorded by men every way worthy of credit. The celebrated Kant wrote an article (*Vermisch. Schrift.*, vol. iii., p. 389) on the power which the will can exert to overcome pain. Cases of this kind are related by Passavant, Brandis, and Boerhaave; but the most remarkable case of the seeming power of the will over the body, is that of Colonel Townsend, related by Dr Cheyne. Like the Faquirs of India, this man could at will simulate death for a lengthened period. It may prove a warning to others, who, from vanity or any other cause, may venture on such rash experiments, to state that this unfortunate man died, not seemingly, but really in the course of his last experiment. Of the latter kind of effects, those which human volition can produce upon others, analogous and antecedent to those of Mesmer, many singular instances have been recorded. The reality of this power was maintained by many eminent writers of the sixteenth and seventeenth centuries. A list of these authors, the most remarkable of whom were Pomponatius, Van Helmont, and William Maxwell, will be found in Colquhoun's *Report on Animal Magnetism*, p. 23. The following are some of the more remarkable effects said by these authors to be produced by the operation of the will, and the imagination acting upon the organization of others.

1. It is assumed as a fact generally acknowledged, that there are men endowed with the faculty of curing certain diseases, by means of an emanation directed through the will and imagination towards the patient. This is a principle which will be found to lie at the foundation of all the mesmeric theories.

2. This force affects the blood and the spirits, which produce the intended effects by means of an evaporation thrown outwards.—(Pomponatius.)

3. The person operating should have great faith, strong imagination, and a firm desire to cure the patient; and the confidence of the patient contributes to the efficacy of the remedy.—(Pomponatius.)

4. It is further maintained, that this power may render the very elements and matter itself subject to the command of man.—(Pomponatius.) Mesmer asserted that he magnetized the sun.

5. It is maintained that there is an ethereal vital spirit or essence which penetrates all bodies, and acts upon the mass of the universe. In man this influence resides in the blood, and is worked and directed by volition.—(Van Helmont.)

6. This virtue in man may be impressed on external bodies, such as vegetable substances, which derive additional virtue from the imagination of the man who gathers them.—(Van Helmont.)

7. The effect produced is in proportion to the energy of the will in the operator, and the weakness of the person operated on.—(Van Helmont.)

We might adduce many more instances of doctrines maintained by these older writers, in all of which, as well as in those quoted above, the most superficial observer will perceive the striking similarity to, if not complete identity with, the doctrines taught by Mesmer, Puysegur, and their followers. Besides the works of Colquhoun, the *Histoire Critique du Magnétisme Animal* of M. Deleuze, and the *Researches and Doubts on Animal Magnetism* of M. Thouret, may be consulted with advantage. Our space will not permit us to enter farther into the subject here. We shall, therefore, proceed to the consideration of the History of Mesmer and his Doctrines.

Mesmer and his Doctrines.

The personal history of a man like Mesmer, whose views have given rise to so much speculation, is intimately interwoven with the credibility of his discoveries. We shall, therefore, give some account of the more remarkable events of his career.

With respect to the time and place of the birth of Frederick Antony Mesmer our information is imperfect. According to some authorities, he was born on the 23d May 1734; according to others not till 1740. By some he was stated to be a native of Switzerland; while others maintained that he was born at Merseburg, in Swabia. Those who make 1740 the year of his birth, hold that he was born in Vienna. According to his own account (*Précis de la découverte du Magnétism*, p. 1), he was born at Weiler, near Stein, on the Rhine, in 1734. He was in poor circumstances, and went to Vienna to study medicine. He attended the lectures of Van Swieten and de Haen, and after graduating in medicine, he is said to have made an advantageous marriage, and commenced practice in Vienna. His mind had early evinced a strong tendency to the study of the marvellous and mystical. His first dissertation, published in 1766, *On the Influence of the Planets on the Human Body*, is an evidence that he was addicted to the study of astrology. In this work he attempted to show that the heavenly bodies, in virtue of the same law which produces their mutual attraction, exercise an influence on living beings, and particularly on the nervous system, by means of an universal fluid; and that there exists in nature a principle universally active, which, independently of our will, produces those effects which are vaguely ascribed to medical skill.

The first published account of Mesmer's application of his peculiar views to remedial purposes is contained in a letter addressed to Dr Unzer of Altona, of date 5th January 1775. In this letter, which was widely circulated, he relates the case of Mademoiselle Oesterline, an hysterical female, whom he had had under treatment in his own house for two years. This patient exhibited, as might be expected, a very extensive train of symptoms, which only yielded temporarily to the ordinary modes of treatment. Mesmer conceived the idea of establishing in the body of his patient a kind of *artificial tide*, by means of the magnet. He communicated his project to Father Hell, the

imperial astronomer, who assisted him with the magnets which he possessed, and which he got made to fit the different parts of the body. The magnets were attached to her feet and chest, and appear to have caused painful currents to pass through her body, and terminate in the crown of her head. After causing much disturbance in her system, all the symptoms gradually disappeared, the patient became insensible to the action of the magnet, and was cured of the attack. She had relapses as before, but was now easily relieved of them. It is worthy of notice, that at this time Mesmer ascribed all the merit of the treatment to the magnets employed, while at a subsequent period, we find, in his memoir on the discovery of animal magnetism, published at Paris in 1789, that his opinions in regard to the nature of the curative agency had undergone a complete revolution. Besides giving a very different account of the symptoms and effects produced by the magnets, he found that another principle caused the magnet to act, it being itself incapable of this action upon the nerves. Of this *principle* Mesmer never gave any clear explanation; and it appears to have constituted the secret which he sedulously kept concealed from the world and his disciples, by some of whom it was supposed to be no other than the power of volition. In order to preserve the consistency of his views, he had recourse to the expedient of charging those who derived their information from his letter to Unzer with confounding animal with mineral magnetism. He accused the Academy of Berlin, and those philosophers and physicians who had corresponded with him, and whom he suspected of attempting to penetrate his secret, of having fallen into this error. The desire of setting aside for ever such errors, and of completely establishing his claim to an independent discovery, made him resolve from 1776 no longer to make any use of electricity or of the magnet. Both at this period and afterwards he seems to have been keenly alive to the importance of keeping his secret, whatever that may have been. He quarrelled with Father Hell for attempting, as he alleges, to claim the merits of the magnetic treatment for his magnets, but in appealing to the public, the Jesuit appears to have had the advantage. No unprejudiced mind can fail to observe, that Mesmer had now completely departed from his original views; and it is extremely improbable that a body like the Academy of Berlin, and the philosophers and physicians to whom he refers, could have been mistaken as to what was the meaning of his published opinions in so egregious a manner as Mesmer would lead us to suppose. Amongst others with whom he came into collision at Vienna, there were two whom he endeavoured to convince, though without success, of the value and importance of his doctrines. These were M. de Stoërk, President of the Faculty of Medicine at Vienna, and M. Ingenhousz, the Imperial Vaccinator. Baron Stoërk was a countryman of his own, with whom he was well acquainted. Mesmer laboured hard to entangle him in his magnetic theories, to get permission to try experiments in the hospitals, and to get a commission of the faculty to investigate his doctrines. Stoërk seems to have been cautious and politic in his intercourse with Mesmer, who, thus deprived of the distinction which he claimed for his discovery, charges him with fickleness and vacillation. Ingenhousz acceded to Mesmer's invitation to witness his experiments with Mademoiselle Oesterline, which Mesmer avers had been, by the confession of Ingenhousz himself, quite conclusive. The experiments had been conducted with cups, one of which Mesmer had touched, and it appeared that none of them had any effect on the patient, except the one which had been touched. Mesmer, it ought to be observed, had now discovered that almost any substance could be impressed with magnetic virtues by touch. He flattered himself that he had made a convert of Ingenhousz, but he found that, like all the world besides, as he imagined, his new disciple proved unfaithful, and treated his experiments as mere jugglery.

So little had been his success in Vienna, that, during the the same year, 1775, in which he had published his letter to Dr Unzer, he left that city in disgust at the deceit and misrepresentations of which he had been made the object. Towards the end of 1775 he made a journey through Swabia, Bavaria, and Switzerland, and performed many supposed cures, both in public and private, in the presence of medical men. At Munich he was consulted by the Elector of Bavaria regarding the cures performed by Gassner at Ratisbon, which had caused great commotion. Gassner ascribed diseases to demoniacal possession, which he obviated by adjurations and commands in the name of Jesus Christ. In 1774 and 1775 Gassner's cures excited great attention; thousands flocked to him, whom he threw into convulsions by his exorcisms and imprecations. De Haen, at the desire of the Empress Maria Theresa, and her son the Emperor Joseph II., investigated some of these cases of reputed demoniacal possession; but in no case could he find any thing but the most manifest deceit and imposition, and he demonstrated undeniably the total groundlessness and absurdity of Gassner's pretensions. His proceedings were, therefore, put a stop to, and he was shut up in a fraternity of priests, when his miraculous powers completely deserted him. Mesmer's opinion of Gassner was, that he produced real effects, but was ignorant of their cause. He leads us to infer that this convicted impostor was an unconscious, though powerful magnetiser. About this time Mesmer was admitted a member of the Academy of Sciences of Munich.

The following year, 1776, he again travelled in Bavaria, where he is reported to have cured M. d'Osterval, director of the Academy of Sciences, of incomplete gutta serena and paralysis of the limbs. It was at this period that he gave up entirely the use of the magnet and electricity.

On his return to Vienna he undertook, on the 20th January 1777, the treatment of Mlle. Paradis, a girl of eighteen, and afflicted since her childhood with complete amaurosis, accompanied with convulsions, which made her eyes start from their orbits. According to the partisans of Mesmer, his treatment of this case produced the most astonishing effects, which were attested by the two presidents of the Faculty of Medicine, one of whom was M. de Stoërk. His opponents, however, it is said, by exciting the fears of the father of his patient lest the Empress should withdraw the pension which she had granted to her on account of her infirmity, succeeded in inducing him to withdraw her from his care before the cure was completely effected, and in consequence of which his directions for her cure being no longer followed, she became completely blind. Mesmer's attempt to retain her under his care, in spite of her father's wish to the contrary, was defeated by an order of the court physician to give her up, and put an end to his trickery. It is also said that he was ordered to leave Vienna; but this is denied by Mesmer, who alleged that he received a recommendation from the minister of foreign affairs to the Austrian ambassador in Paris, who never disavowed him.

Another and a different account of this affair is given by Sprengel (*Sendschreiben über Thierishen Magnetismum mit Zusätzen*, Halle, 1788, p. 104), on the authority of a work, entitled *Magnetist*, published by C. L. Hoffman, at Frankfort, in 1787. According to this account, a commission was named by the Empress, Maria Theresa, for the investigation of magnetism, and the alleged cure of the girl Paradis. Before an assemblage of 800 persons, medical men and others, the girl was found to distinguish bright colours correctly; but when it was observed that Mesmer made certain signals to her, he was ordered to withdraw, which he did reluctantly, after which she could no longer distin-

guish colours. It is said, that when the commissioners had given in their report, Mesmer received an imperial order to leave Vienna within twenty-four hours. It is now impossible to decide which of these accounts may be correct. It is certain, however, that he left Vienna early in 1778, and arrived in Paris in February of that year.

At this period Paris was the most likely place in the world where mesmerism would take root and flourish. In addition to the naturally lively imagination of the French people, their love of novelty, and the power of fashion, of which Paris was at that time the centre, and the influence of a dissolute court, if its countenance could be obtained, together with an unsettled and excited state of public opinion, were all peculiarly favourable for the admission of the new and startling doctrines of which Mesmer was the apostle.

Mesmer's account of his proceedings in Paris is contained in his *Mémoire sur la Découverte du Magnétisme Animal*, published in 1779; and in his *Precis Historique des faits relatifs au Magnétisme Animal*, published in 1781. According to his own account, he did not enter upon the practice of animal magnetism in Paris until solicited by the French *savants* to make experiments. The first encouragement he received was from M. le Roi, director, and M. le Comte Maillebois, member, of the Academy of Sciences. He also formed the acquaintance of Messrs Mauduit, Andry, Desperrières, and the Abbê Tessier, members of the Academy of Medicine. After performing some experiments, he entered into a kind of agreement with them, though not in their official capacity, to undertake the treatment of certain patients, whom they had previously examined. The arrangement broke down at the very outset, Messrs Mauduit and Andry not being satisfied as to the condition of the first patient proposed to be operated upon; a more particular examination was refused, and he sent no more patients to be examined by them. In consequence of this failure on the part of Mesmer to fulfil the terms of the agreement, he was informed, on the 6th of May, by M. Vicq. d'Azyr, the secretary, who returned to him his certificates unopened, that the commission was withdrawn. Mesmer informed the academy that he had not sought a commission; and, on the contrary, had repeatedly rejected it.

After this he collected a number of patients and retired to the village of Créteuil, two leagues distant from Paris, where he treated them in his own way, without the too critical surveillance of the scientific men of the metropolis. On the 20th and 22d August he wrote to the Academies of Medicine and Science, inviting them to examine his patients, and compare their then condition with the certificates of their state at the time of their coming under his treatment. This rather barefaced proposal was at once rejected.

Shortly after this he returned to Paris, and in September 1778 he formed the acquaintance of M. D'Eslon, physician to the Count d'Artois, brother of the king. D'Eslon soon became a convert, and a partisan of the new views, and by his great influence assisted to secure for him the patronage of the great and powerful, and enabled him to realize the fortune with which he afterwards retired from the capital. He endeavoured, also, to interest the Academy of Medicine in Mesmer's discoveries, but without success. He could only get three members, MM. Bertrand, Malloet, and Sollier, to witness the magnetic treatment, who, after seven months' observation, declined to adopt the mesmeric doctrines.

In 1779 he published his *Memoir* relative to the discovery of animal magnetism, which gave rise to some controversy, and was critically examined by M. Thouret four years afterwards.

In 1780 M. D'Eslon published his *Observations* on animal magnetism, and avowed his adoption of Mesmer's opinions, in consequence of which he incurred the displeasure of his colleagues in the medical faculty. He solicited their intervention in order to secure an impartial examination of Mesmer's doctrines. In reply, he was enjoined to be more circumspect for the future; he was suspended from his deliberative functions for a year, and was threatened that he would have his name erased from the list of members if he did not recant within a year; and the proposals of Mesmer were at the same time rejected.

Mesmer's only hope was now in the government, whose support he had the prospect of obtaining through the assistance of M. de Lassone, first physician to their Majesties, who had become convinced of the reality and utility of his discovery. The conditions under which he was willing to perform his experiments before a commission named by the government were agreed upon, when M. D'Eslon was informed by M. de Lassone that the persons named declined the commission. Mesmer states, that he afterwards ascertained that the proposed commissioners had never been spoken to on the subject. This was for him only another instance of the bad faith with which it appeared all his proposals had hitherto been treated.

"I now," says Mesmer, "no longer hesitated to announce to my patients, that as I was to quit France immediately, my practice would be terminated on the 15th of April following (1781)." So great, however, was the impression that his experiments had produced upon the mind of the queen, with whom a communication had been opened up, that negotiations were re-opened through M. D'Eslon, in order to avert the threatened calamity; an arrangement was made by which a government commission of five persons, two of whom were to be medical men, was to report finally upon his experiments. If the report proved favourable, the government was to announce officially that Mesmer had made a useful discovery; the king agreed to give him a suitable establishment as a free gift, and a yearly pension of 20,000 livres. He was also to be required to remain in France till his doctrine and practice were completely established, and he was not to quit it without the permission of the king. A few days afterwards the agreement was modified to the extent that the examination by commissioners was to be dispensed with, and in place of an establishment he was to get 10,000 livres annual rent for a house suitable for training pupils, of whom three were to be named by the government and three by himself, if he saw fit. Mesmer declined these proposals on the plea that they were not consistent with his dignity, and that his discovery was above all price. He demanded a territorial possession, and not money. The negotiations having failed, Mesmer addressed a letter to the queen, in which he declared that he renounced all hope of an arrangement with the government, and intimated that he would leave France on the 18th September.

Before quitting France definitively he went to Spa, and whilst there (1782) he learned that M. D'Eslon was deprived of his title of doctor-regent, and had started the practice of animal magnetism on his own account in Paris. He was deeply moved by this intelligence, which caused him great alarm and depression of spirits. He believed that the fruit of his labours was about to pass into other hands; he declared that he was a ruined man; that his confidence had been betrayed; and that he was deprived of the reward that was due to him for his discoveries. In order to console him, his friends and followers, who appear to have been numerous and wealthy, entered into a subscription of 100 louis d'ors each, which was filled up chiefly by men of rank and fashion, and included also several medical men from Lyons and other parts of France. At this time (1783) Mesmer was at Spa, to which place he had returned a second time after a temporary absence. The subscription

of 100 louis d'ors, or 2400 francs, was paid by 100 persons, in order to secure the independence and glory of Mesmer. In the course of a few months he realized 340,000 francs. In 1784 he had returned to Paris, opened a magnetical institution, and commenced his lectures and clinical instructions in the beginning of April. Among his pupils there was one subscriber of 100 louis d'ors, M. Berthollet, physician to the Duke of Orleans, and afterwards renowned as a chemist, upon whom his lectures did not produce the desired effect. After a month's attendance, this refractory pupil, probably more versed than most of the others in the principles of scientific reasoning and in the practice of calm and faithful scientific observation, laid upon Mesmer's table a declaration of his belief that the whole theory and practice of mesmerism was perfectly chimerical.

Another of his pupils was M. Picher-Grandchamp of Lyons, who, along with several other medical men, came from Lyons to Paris, to study mesmerism. He afterwards published a *Mémoire de F. A. Mesmer, sur ses Découvertes*, in a letter prefixed to which, in 1826, he gives some interesting particulars relative to Mesmer's course. He mentions from memory some of the distinguished men who attended it, such as the Duc de Coigni, the Prince de Condé, the Duc de Bourbon, MM. de Montesquieu, de Lafayette, de Puysegur, &c. It lasted two months. It was proposed, in the middle of the second course, that both courses and the doctrine should be published. A decided and successful opposition was made to this proposition, on the ground that, as had happened to medicine, the art of printing, by revealing the whole science, would destroy that consideration and kind of reverence, that public esteem and confidence, with which it was honoured. It was determined, however, that, regardless of expense, the maxims of the science should be engraved on metal plates. This was done, and a copy was given to those who should establish a magnetical institution in certain towns fixed on. M. Picher-Grandchamp possessed a copy, which he presented to M. Bourdois de la Motte, the president of the commission of the academy appointed in 1825, on thin metal plates. This work was never published, but the series of propositions which Mesmer dictated to his disciples was given to the world in 1784 by M. Caullet de Veaumorel, under the title of *Aphorismes de M. Mesmer*. These propositions are arranged under different heads, and treat of cohesion, elasticity, gravity, fire, flux, and reflux, &c., and are as fair a specimen of solemn trifling under the guise of science as we have ever happened to meet with.

Towards the conclusion of his courses a quarrel arose between Mesmer and his pupils (a state of matters which seems to have been quite common on such occasions), who had formed themselves into a Society of Harmony, as to their right of publishing and teaching his doctrines and practices. He affirmed that they had come under an obligation to him not to do so without his consent and approbation (Bertrand's *Hist. of Anim. Magn.*) The result was, that Mesmer endeavoured, without success, to raise subscriptions at half-price for courses of instruction in several towns of France, while the society opened a public course of instruction, through M. Despémenil, and instituted thirty establishments in France and other parts of the continent. A curious case, illustrating Mesmer's mode of practice, is related by Madame Campan, in her journal. The patient was M. Campan, one of his partisans, like every one who moved in high life. "To be magnetised," she says, "was then a fashion. In the drawing-room nothing was talked of but the new discovery; people's heads were turned, and their imaginations heated to the highest degree. To accomplish this object, it was necessary to bewilder the understanding; and Mesmer, with his singular language, produced that effect. To put a stop to the fit of public insanity was the grand difficulty, and it was proposed to have the secret purchased by the court." It has not been in the case of Mesmer alone that the higher classes of society have shown a discreditable facility in listening to those who have pretended to possess extraordinary power in curing diseases. M. Campan was seized with a pulmonary affection, and Mesmer was called in. Madame C., who seems to have been both the wiser and the better half of this weak courtier, demanded to know what was to be the treatment. To insure a speedy and perfect cure, Mesmer coolly proposed that one of three things should be done—either that a young woman of brown complexion, a black hen, or an empty bottle, should be placed at the left side of M. Campan. "Sir," said Madame C., "if the choice be a matter of indifference, pray, bring the empty bottle." The treatment did no good, and Mesmer, taking advantage of Madame's absence, had recourse to the old-fashioned plan of bleeding and blistering, and M. Campan recovered. He asked for a certificate that the cure had been effected by magnetism alone, and M. Campan gave it. This circumstance coming to the knowledge of Madame Campan, she reported it to their Majesties, and expressed her indignation at the conduct of the barefaced quack. It was immediately determined to have nothing more to do with him.

On the 12th March 1784, the king named four members of the Faculty of Medicine—MM. Sallin, d'Arcet, Guillotin, and Majault—to examine and give him an account of animal magnetism as practised by M. D'Eslon. With these his Majesty associated MM. Franklin, Le Roi, Bailly, de Bory, and Lavoisier, of the Academy of Sciences, and on the 5th April MM. Poissonnier, Caille, Mauduit, Andry, and Jussieu, were named by M. de Bréteuil, agreeably to the orders of the king, a commission of the Royal Society of Medicine. Mesmer refused to have any communication with these commissioners, though several of them were men possessed of the highest scientific attainments, and who, if there was any worth in the great discovery which he had made, would have been the first to acknowledge it. They had to content themselves with M. d'Eslon, one of the most considerable of his pupils. At the same time M. Thouret was desired by the Royal Society of Medicine to draw up a history of animal magnetism. Five separate reports were the result of these commissions. The first, by M. Thouret, was given in to the Royal Society of Medicine on the 9th July 1784; the second, a report to the government for publication, by the joint commission of the Royal Academy of Sciences and the Faculty of Medicine, was dated the 4th August; the third, a private report to the king; the fourth, the report of the Royal Society of Medicine to the government, was dated 16th August; and the fifth, the report of M. Jussieu, who held opinions peculiar to himself, was dated the 12th September. The report of the joint commission is understood to have been drawn up by Bailly, whose writings establish his claims to the character of a philosopher, and whose conduct, up to the time of his barbarous execution, entitle him to the appellation of a virtuous patriot. M. Thouret's report was entitled *Researches and Doubts on Animal Magnetism*, in which he undertook to prove that Mesmer's claim of having made a new discovery was untenable, and to show that there existed not only a similarity of doctrine between Mesmer and former writers on magnetic medicine, particularly Kircher, Maxwell, and Santanelli, but also the strictest conformity between them in matters of detail. A similar review of Mesmer's doctrines is to be found in an anonymous work entitled, *Anti-Magnétisme, ou Origine, Progrès, Décadence, Renouvellement, et Refutation du Magnétisme Animal*, published in London in 1784.

It was the duty of the other commissioners to bring the doubts suggested by M. Thouret to the test of practical observation and experiment. It was their duty first to witness the ordinary modes of procedure employed by mag-

netisers; and in the second, to give their judgment upon what they observed. The arrangements were as follows:—

1. There was a vessel of wood, closed above, very large, of an oval form, about two feet in height, which was called the bucket (*baquet*), placed in the middle of the apartment. The lid of the bucket was pierced with holes round the edges, from which arose rods of polished iron, of the thickness of the finger, bent, ending in a rounded point, and alternately a long and a short one. The rods could be plunged into the bucket, drawn back, or entirely removed. To the rods were attached cords, of the same thickness as themselves.

2. The patients were placed round the bucket on chairs, one or more rows deep. The rod was directed towards the seat of the malady, and several coils of the cord were placed round the parts affected with pain. These were considered to be conductors of the magnetic fluid, though no evidence was furnished or observed by the commissioners that any conduction took place. The bucket was not considered essential, but merely accessory.

3. The doors and windows were closed; a soft and feeble light only was admitted through the curtains; silence was observed. The air became heated and vitiated. The appearance of the apartment predisposed to reflection and meditation, which was only interrupted by yawning, sighs, sobbings, convulsions, lamentations, signs of impatience, &c. Towards the end of the sitting a pianoforte was sometimes played.

4. The patients were supplied, when they asked for drink, with water in which cream of tartar had been dissolved.

Having acquainted themselves with the apparatus and external appliances necessary in carrying out the magnetic processes, the next thing that engaged the attention of the commissioners was the manipulatory part of the mesmeric method of treatment. They found that there were two ways of magnetising: viz., by immediate contact, and by the direction of the finger or of a conductor at some distance.

1*st*. The most ordinary process, magnetising by contact, consists in applying the hands to the hypochondria, the extremities of the fingers being directed towards the umbilicus. Frequently the thumbs, or the extremities of the two forefingers, are applied to the epigastrium. It is also common to place the hands on the region of the kidneys, particularly in magnetising women. The other parts touched are determined by the seat of the disease. Besides simple contact, greater or less friction, particularly on the umbilical and epigastric regions, is resorted to.

2*d*. Magnetising at a distance is performed by directing the finger or conductor to various parts of the head and body, and carrying them along the body and extremities, the hands being shaken as if in the act of sprinkling a fluid.

The next thing which the commissioners had to do was to observe the nature of the effects produced by these processes. They are very varied. Some are calm, and apparently unaffected; others cough, spit, feel pain, heat, and are thrown into perspiration; others are agitated and convulsed. The convulsions are extraordinary for their number, their duration, and their violence. There is expectoration of mucus and blood. The convulsions are accompanied by rapid, involuntary motion of all the extremities and the body, by subsultus of the hypochondrium and epigastrium, by distraction and wildness of the eyes, by piercing cries, weeping, hiccoughing, and immoderate laughter. These are preceded or followed by a state of languor. The slightest noise or music excites their vivacity. "Nothing," says the commissioners, "can be more astonishing than the sight of these convulsions; without having seen it, it is impossible to form an idea of it, and in beholding it one is equally surprised by the profound repose of one portion of these patients, and by the agitation manifested by the other; by the repetition of the various phenomena, and by the sympathies that are developed. Patients are seen seeking each other exclusively, and in precipitating themselves towards one another, smiling, conversing affectionately, and mutually soothing each other's crises. All are under the authority of the magnetiser; and though they may appear to be in a state of extreme drowsiness, his voice, or a look or a sign from him, rouses them from it. It is impossible not to recognise, in these constant effects, a great power, which agitates the patients, and obtains the mastery over them, and of which the magnetiser appears to be the depositary."

The next point which it behoved the commissioners to attend to, was the character of the persons in whom the most decided mesmeric phenomena manifested themselves. The commission of the Society of Medicine made the following important observations on this subject:—

1*st*. That such persons are, either from constitution or the effect of disease, exceedingly sensitive.

2*d*. That the convulsions do not occur till the person has been subjected for a longer or shorter period to the magnetic processes.

3*d*. That persons magnetised separately, even though very sensitive, seldom experience convulsions, while the same persons magnetised in a crowd are sooner or more frequently thrown into convulsions.

4*th*. That women are more susceptible than men, and that women in affluent are more susceptible than those in indigent circumstances.

5*th*. That it is only after remaining a considerable time in the magnetising chamber that the convulsionaries become affected.

Having followed in their experimental investigations the method now delineated, the commissioners arrived at certain results, of which the following is a brief resumé:—

I. It is established in all the reports that the magnetic fluid, if it exists, is incapable of being recognised by any sensible or physical properties; it cannot be seen, heard, smelt, tasted, nor touched. M. D'Eslon admitted that its existence could only be demonstrated by the changes which it produces on animated beings.

II. It is admitted in all the reports that many persons operated on exhibited none of the magnetic phenomena. The cause, therefore, is not *universal*, but partial or exceptional in its effects. Even Jussieu, the most favourably disposed of the commissioners towards mesmerism, expresses his conviction that the magnetic fluid, if it exists, has not, on most men, whether in a state of health or disease, an action that can manifest itself by sensible signs.

III. It is stated in all the reports that many persons who were led to believe that they were under magnetic operation, when they were not actually so, exhibited precisely the same phenomena as those who were magnetised. The best illustration of this statement is the experiment performed by M. D'Eslon, at Passy, before the joint commissioners in Dr Franklin's garden; an apricot-tree, in an isolated situation, was magnetised, and a boy whose susceptibility had been tried by D'Eslon, and after the necessary precautions, was, with his eyes bandaged, made to embrace different trees. He embraced four trees which were not magnetised; nevertheless the magnetic phenomena continued to be developed with increasing effect till he reached the fourth, when he fell into a convulsive crisis, and had to be carried into the house. When he reached the fourth tree he was still 24 feet from the magnetised one. This experiment the commissioners considered to be most conclusive.

IV. It is established in all the reports that many persons who were subjected to magnetic operation without their being aware of it, did not exhibit the usual phenomena, even though these same persons had, on former trials, when they knew they were operated on, been found to be very susceptible of magnetic influence. Some very conclusive

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experiments, in reference to this point, were made by the commissioners, which we have not space to narrate.

V. It is distinctly shown in all the reports that mistakes analogous to those mentioned in the two last articles were committed by many persons as to the seat in which they experienced magnetic sensations; that is, from misconception as to the proceedings of the magnetiser, these persons experienced sensations in parts not operated on, and none in parts against which the magnetic conductor was directed. These mistakes were amply illustrated in the case of a female operated on by M. Jussieu, who, when her eyes were bandaged, felt the same sensations as those which she experienced when magnetic manipulations were going on, even when nothing whatever was being done to her.

VI. The joint commissioners and the commissioners of the Society of Medicine, with the exception of M. Jussieu, considered themselves as authorized to conclude that the effects upon the human economy attributed by Mesmer and his followers to animal magetism, ought to be ascribed to other causes, and particularly to the handlings and frictions practised by the operators, to the influence of imagination, and to the principle of instinctive imitation or sympathy. M. Jussieu only differed from the other commissioners to the extent that he ascribed some of the phenomena to the effect of animal heat, which may pass from one body to another; he did not admit the existence of any magnetic, or, as he describes it, undemonstrated universal fluid. His report was much more opposed than favourable to the pretensions of the magnetisers.

VII. With reference to the curative influence of animal magnetism the two commissions pursued different modes of investigation. The one, the joint commission, confined itself to the proof of the purely physical and instantaneous effects of the fluid on the animal body; while the other extended its observations to the employment and effects of magnetism on the treatment of diseases. They divided the cases which they saw under three heads—*First*, Patients whose affections were evident and had a known cause; *Second*, Those whose slight ailments consisted in indefinite affections, without any determinate cause; and *Third*, Melancholics. In the first class they saw no good effects produced. In the second class, though some patients professed that they were better, there was no evidence that this was really the case, and if it was so, that it had been effected by magnetism alone. The evidence from the third class is dismissed as altogether worthless. M. Jussieu maintained that many of the effects were determined by a physical cause—animal heat.

VIII. The commissioners pointed out two classes of dangers as liable to result from the practice of animal magnetism, one affecting the health, and the other the morals of the persons operated on. The dangers to health arose from the immediate injury liable to result from the violence of the crises or convulsions into which the patients were thrown, and from the liability to a habit of convulsions being established in the economy.

The moral dangers formed the subject of the secret report submitted to the king by the joint commission. Into these we need not enter, but we may remark that there can be no doubt that the suggestions contained in the report were equally proper and necessary. On this subject the reader may consult Hufeland's *Journal der Practischen Arzneikunde* for 1815 and 1820, and Kieser's *System des Tellurismus*, &c., ii., 437.

The effect of these reports on the public mind was exceedingly adverse to the cause of animal magnetism. An attempt was made on the part of Mesmer to set aside the verdict of the commissioners, in so far as it affected himself, however applicable it might be to M. D'Eslon or any of his pupils. The commissioners, however, had fully satisfied themselves that the essential practices of magnetism were known to M. D'Eslon. Mesmer, it is said, appealed from the decision of the commissioners to the parliament of Paris. But when that body ordained that he *should be obliged* to expose his doctrine and methods before a commission appointed by them, he seems to have fallen from his appeal, and to have speedily left Paris.

Answers to the reports of the commissioners were published by MM. D'Eslon, Montjoie, Bonnefoy, and Bergasse. Anonymous replies were also published, among which were —*Doutes d'un Provincial*, said to have been written by M. Servan, of Grenoble; the *Reflections Impartiales*, &c.; the *Observations*, &c., par un Médecin de Province; and the *Supplement aux Deux Rapports*. A reply to these answers was published by M. Deviller, entitled *Le Colosse aux Pieds d'Argile*. Mesmerism would now, in all probability, have fallen into oblivion, had not the discovery of the principle of somnambulism infused new life and vigour into the effete system. This new class of phenomena ascribed to the principle of animal magnetism has been the means of sustaining the system, though the effects are very different from those which Mesmer demonstrated, and of continuing it to our own time.

In 1799, Mesmer published a new work under the title of *Mémoire de F. A. Mesmer sur ses Découvertes*, in which he endeavours to establish a claim to the discovery of somnambulism, which he considered to be a necessary consequence and corollary of his own system.

Little is known of his personal history from the time when he left Paris in 1784 till his death. He seems to have visited England, and is said to have witnessed the execution of Bailly in the Champ de Mars.

He passed the latter years of his life at Frauenfeldt, near the Lake of Constance, when he was visited by Dr Egg in 1808, and by Dr Wolfart of Berlin in 1812. To the latter, who had been a magnetiser since 1808, Mesmer confided his manuscripts, out of which he drew up a system, which he published at Berlin in 1814, entitled *Mesmerism, or System of the Operations, Theory, and Application of Animal Magnetism, as the General Curative for the Preservation of Mankind.*

Mesmer died at Merseborg on the 15th March 1815, at the ripe age of eighty-one years.

Puysegur and his discoveries.

Having concluded the history of mesmerism, in so far as it was directly associated with its author, we now require to retrace our steps from the time when the joint commission was investigating the merits of Mesmer's discovery, to the year 1764, when mesmerism entered on a new phase of its existence, and assumed a form differing in many respects from that which it obtained from the hands of its author. We allude to magnetic somnambulism, the discovery of M. le Marquis de Puysegur. Though it has been attempted to be shown that Mesmer was acquainted with the phenomena of somnambulism, and that they were witnessed by his disciples in the *Salles de Crises*, there can be no doubt that the discovery of the Marquis de Puysegur was as original as it was unexpected on his part, that it revolutionized the mesmeric system so essentially, that while it added much to, it received little from the original scheme of Mesmer. The revolution has been complete and persistent, and there appears little doubt that if the discovery of M. de Puysegur had not been made, animal magnetism would have disappeared with the death of Mesmer. It infused new life into the expiring system; a life so vigorous, indeed, that it has been sufficient to keep it alive till the present time. Mesmerism, strictly so called, died with its author. It may be truly affirmed, that long before the death of Mesmer, somnambulism, which was at first coldly received by him, and afterwards tacitly admitted and claimed as his own discovery, had made rapid advances in public estimation.

In the following pages we propose to adopt a topogra-

phical arrangement, as the simplest method by which we shall be enabled to give a correct and succinct description of the development and history of the theories of magnetic somnambulism. We shall treat, therefore,—

1. *Of somnambulism in France.* 2. *Of somnambulism in Great Britain.* 3. *Of somnambulism in Germany and other countries.*

Somnambulism in France.

1. *Of Somnambulism in France.*—Among the subscribers to Mesmer's course of instruction were the marquis de Puysegur, at that time an officer of artillery, and his two brothers; the Count Chastenet, a naval officer; and the Count Maxime, an officer in a regiment of infantry. In fact, it appears that mesmerism was received and cultivated by military officers more than by any other class of the community. Having much unoccupied time, they seem to have espoused it as an elegant and exciting exercise, to relieve themselves from the *ennui* which a state of comparative idleness usually engenders. Their education and habits were not fitted to raise in their minds any of those difficulties which occur to a Berthollet or a Franklin, while, on the other hand, the easy acquisition (only 100 louis d'ors) of so wonderful a power as that which mesmerism held out for their acceptance, was too tempting a bait to be refused. We cannot wonder, therefore, that the three brothers Puysegur, and many others of their brother officers, soon became believers and experts in the new doctrine and practice. The cure of diseases, more especially if the method contains something wonderful and contrary to the ordinary routine, has always been found to possess an irresistible attraction for the idle, the ignorant, and the noble. The Count Chastenet was the first convert. The marquis, at first attaching little credit to the doctrines taught by Mesmer, when he retired to his estate of Busancy, near Soissons, amused himself with experiments in curing toothache. Encouraged by his success (a marquis could scarcely fail to cure a dependant peasant's toothache), he ventured on the treatment of a chest affection on a peasant named Victor, twenty-three years of age. "What was my surprise," exclaims the marquis (8th May 1784), "to see this man in some seven or eight minutes fall asleep peaceably in my arms, without convulsions or pains! I pushed the crisis, which occasioned him sensations of giddiness. He spoke and talked quite aloud of his affairs. When I thought his ideas must affect him in a disagreeable manner, I stopped them, and endeavoured to inspire him with others of a gayer character." The fame of Victor spread, and brought numerous patients, but the powers of the marquis were limited, and in order to husband his energies, he fell upon the plan laid down by Mesmer, of magnetising a tree and attaching cords to it, which his patients laid hold of; and it was found that, while he saved himself much trouble, the tree was as effectual in curing his patients as his own hands had been. Among the ignoble crowd Victor remains preeminent. He becomes the *alter ego* of the marquis. He is his *agent of nature*, as the marquis expresses it. By nature a boor, a simple man, a large and robust fellow, when in a state of somnambulism, his whole character is changed. "It is with this man," says the marquis, "that I instruct myself—that I enlighten myself. He becomes a being whom I know not how to name." The following is a resumé of the remarkable phenomena exhibited by Victor:—1. The person magnetised falls into a state resembling sleep; 2. He continues to speak and converse while in this state; 3. An influence is exercised over his thoughts by the unexpressed thoughts of his magnetiser; 4. His intellectual faculties are increased; 5. He has a foreknowledge of the progress of his own malady, and to some extent at least of the means necessary for its removal; 6. He has a total oblivion, while not in the state of magnetic sleep, of what he had said or done whilst in that state.

M. de Puysegur regarded the production of somnambulism as an entirely new phenomenon in animal magnetism. M. Wurtz and M. Picher-Grandchamp combated this view, and claimed the discovery for Mesmer. M. Foissac adopted the same view, and merely allowed to M. de Puysegur the merit of giving a precise description of its true characters, &c. Notwithstanding the claims thus advanced in favour of Mesmer, there is no doubt that all the merit attaching to this discovery belongs to M. de Puysegur.

Besides Victor, the marquis soon acquired other assistants in his experiments. Amongst these was Vielet, a schoolmaster; Catherine Montenecourt; a lad named Joly; Agnes Remont, wife of the smith of Busancy, named *la Marechale;* a female named Madeleine, Lehogais one of his farmers; Ribault and Clement, two of his domestic servants. It is little to be wondered at, that with such agencies, the marquis was able to conduct his experiments with the greatest apparent success. It is not likely that any doubts or difficulties would arise in their progress with such facile instruments. It was with reference to one of them, la Marechale, that M. Recamier had some reasons to suspect fraud, as he was refused the means of dissipating his doubts, and he heard her repeating things which he had himself previously said to his patients. "How ridiculous, besides," adds M. Recamier, "to hear a person prescribe, as a transcendental remedy in a case of pulmonary consumption, a drachm of Glauber's salts!"

Of the perfect good faith of the marquis there can be no doubt. His letters and writings show that he was an enthusiastic philanthropist, a class of men remarkably open to self-deception, and to be imposed upon by others; that he was greatly imposed upon by his agents there can be as little doubt as there is of his own disinterested benevolence. The declarations of Victor were very probably only dictated by the wish to flatter his master, to whom he owed everything, and to enhance his own importance. In a letter addressed to the intendant of Soissons, and reprinted by M Montègre in 1814, it is stated that the magnetic manipulations were of an indecorous character, which would be the reverse of objectionable to that class of the population, on whom his magnetic services were so freely lavished; and when we are told, that besides maintaining many of them at his house, the marquis spent more than fifty francs a day in charity, we can be at no loss to understand how his practice became so popular.

Animal magnetism in the hands of Mesmer was simply a curative agent; now, however, we find it not only to be a curative means, but to confer the power of detecting the morbid condition of parts, both in the person operated on and in others, and the instinctive knowledge of the remedies required to effect a cure. M. de Puysegur's magnetic or somnambulic physician finds it equally easy to determine the disease and the remedy. No wonder, therefore, at the tone of superiority over ordinary physicians which is assumed by Vielet in the account of his own case, written in the dark, as we are told, while in the state of magnetic crisis. "I repeat and I say, that by the sight and the sensation which I actually possess, I can distinguish internal diseases as well as external, and thereby judge, pronounce, and obviate immediately; not like those doctors who give prescriptions after they have informed themselves, and that often very ill, by the statements which they make their patients give them; it is not so in the state in which I am; I can define everything, and conclude in the same way." (*Mémoires*, p. 91.)

The change effected by Puysegur from the mesmeric crisis to the state of somnambulism was a great improvement, the *chambres de crises* being, he avers, "un enfer à convulsions" (*Mem.*, p. 80).

In June 1784 the military duties of the marquis called him to Strasburg, where he performed several magnetic cures. In October he returned to Busancy, and resumed

his observations and practice. Towards the end of the year he circulated accounts of the wonderful effects which he had produced. These he afterwards collected and published, in 1786, under the title of *Mémoires pour servir à l'Histoire et à l'Etablissement du Magnétisme Animal.* The motto of his work is, "Believe and will." The apophthegms, "Active volition towards good; firm belief in its power; entire confidence in employing it," are represented by the marquis as the sum and substance of the whole theory of his magnetic practice.

In the end of 1784, the Count Maxime de Puysegur published an account of sixty cases cured by him in six weeks by the magnetised trees. He ascribes all the merits of his cure to Mesmer, and totally ignores his brother.

In 1785 the Count Maxime organized a society at Guienne for the prosecution of animal magnetism.

About the same period, phenomena analogous to those obtained by the marquis were observed at Lyons, but elicited by different means. The Chevalier de Barbarin established the spiritual school of magnetism. Setting aside every mechanical means, he found that all the phenomena of animal magnetism could be produced by purely mental agencies, by volition and faith, and more especially by prayer. The motto of this school is, "Will that which is good; go and cure."

At Lyons, also, patients in a state of magnetic sleep were employed at an early period for detecting the diseases of others. The author of a treatise, entitled *Impartial Reflections on Animal Magnetism,* published in 1784, makes the following illogical statement:—"Till it is explained how a magnetic somnambulist can point out, better than any physician, the seat and the nature of a disease with which another person is affected, I shall be warranted in believing that it is by the magnetic action he detects so promptly and so correctly what passes in the interior of the body." We would have formed a higher opinion of this writer's judgment, if he had suspended his belief altogether till the required explanation had been given, and till it had been satisfactorily proved that any human being could see magnetically what passes in the interior of another body.

In the beginning of 1785 the Marquis de Puysegur, being in Paris, by chance fell in with his original somnambulist, Victor, who, as good luck would have it, was suffering from feverish symptoms, in consequence of a fall. The opportunity was too good to be lost; and he forthwith commenced operations to convince the unbelieving Parisians by ocular demonstration of the truth of his great discovery. He took Victor to Mesmer, but met with a very cold reception, as was naturally to be expected from one who scouted, on all occasions, the pretensions of those who advanced any thing that could be brought into competition with his own sublime discovery. The heartless criticism, and injurious suspicions of the Parisian salons, wounded the spirit of the benevolent, though all too credulous, marquis. Victor predicted that, on a given day, his complete cure would be completed by a bleeding from the nose, and from the right nostril only, between mid-day and one o'clock. On a former occasion, the critical hæmorrhage had taken place during the night, a circumstance which had excited disbelief and ridicule of his pretensions. The expected day arrived, the hour had come, and at half-past twelve blood escaped from the right nostril. Could victory be more complete? Alas! the unbelievers doubted still; and the marquis retired abashed, with the apparent confusion of an unskilful juggler. Victor was cross-questioned, and disappeared for two days. When he re-appeared, it was but too evident that he had been drowning his cares, and comforting his wounded spirit, in generous libations. The marquis was easily satisfied with his explanations, and soon completed his cure.

Notwithstanding the failure of Victor to produce faith in the minds of the incredulous Parisians, the marquis caused one of his female somnambulists, named Madeleine, to be brought to Paris; but his success in the second attempt was not greater than in the first. "The opinion of the disbelievers prevailed over the small number of persons who, trusting to my probity, believed in the somnambulism of Madeleine." The consequence of all this was, that the marquis fell ill, returned to Busancy, put himself under the treatment of his domestics, Ribault and Clement, and the schoolmaster Vielet, and was in a few days restored to health.

At this period numerous papers on this subject, and cases of magnetic somnambulism, were published by different individuals and societies in various parts of France.

In June 1785, the Marquis de Puysegur rejoined his regiment in Strasburg, and received a letter from the Count de Lutzelbourg, inviting him, on the part of a society of freemasons, of which they were both members, to instruct them in the principles of animal magnetism. He readily complied with this invitation. The only condition which he imposed was, that they should first acquire all possible conviction of the reality of the discovery of Mesmer before he communicated to them Mesmer's papers. They were soon convinced, and the exposition commenced. He began by giving an outline of Mesmer's lectures on the formation of the universe, on the celestial bodies, on cohesion, on elasticity, on gravity, on fire, on intension, and remission of the properties of matter, &c. Such, he said, is a succinct exposition of the lectures of Mesmer. His audience stared, and asked what it all meant. They were unmistakably disappointed with the ridiculous trifles which his pompous and elaborate discourse had resulted in. "This is all very well," they exclaimed, "but your valet-de-chambre did not think of chaotic matter, and the aggregation of atoms, when he made somnambulists at Busancy." After some days of delay, to allow them to digest the mesmeric farrago, he proceeded to explain to them the theory of volition, propounded by Barbarin, and accepted by himself. Still dissatisfied, they could extract from him nothing more than the dogma, that to *believe* and *will* contains the whole doctrine of magnetism.

It would almost appear that the marquis, by the solemnity of the conditions imposed at the outset of his lectures, had the design of taking his revenge upon Mesmer for the coldness with which he received the somnambulic theory, by exposing his doctrines in all their native crudity to a somewhat critical audience, and thereby bespeaking a large share of indulgence for the more vulnerable points in his own favourite doctrine.

He delivered a second course of lectures to his fellow-officers of the Metz regiment of royal artillery, which was attended by them, and the officers of other regiments who were not at that time oppressed with military duties. Hence it was that the practice of somnambulism became very prevalent among the officers of the French army.

Two societies were formed in Strasburg; one called the Harmonic, under the direction of the Marquis de Puysegur; and another, under Dr Ostertag, a pupil and follower of Mesmer. As may be supposed, the society of the marquis was the more popular of the two. The Harmonic published various works—1st, *Exposé des differentes Cures,* &c., 1786; 2d, *Suite de Cures,* &c., in 1787; 3d, *Annales de la Société,* &c. The publication of the fourth volume was prevented by the Revolution. The Count de Lutzelbourg was one of the most zealous practitioners of magnetic somnambulism, and published various works on the subject; among which was a systematic work, entitled *Faits et Notions Magnétiques,* in 1788. The count is considered by M. Deleuze to be a temperate and judicious author, the tendency of his writings being to restrain enthusiasm, and prevent the evil consequences of excessive confidence and imprudent precipitation.

In 1787, M. Wurtz, doctor of medicine, a pupil of Mesmer, published, at Strasburg, a prospectus of a new course of animal magnetism, &c., in defence of Mesmer, and hostile to M. de Puysegur. He avers that Mesmer was well acquainted with the phenomena of somnambulism; but that, from motives of prudence, and with a just appreciation of the evil consequences to which it might lead, he abstained from giving to it that publicity which it had obtained under the auspices of M. de Puysegur.

Among the military practitioners of magnetism, one of the most zealous was M. Tardy de Montravel, a captain of artillery. He published an essay on the *Theory of Magnetic Somnambulism*, in Nov. 1785. The magnetic treatment of Mlle. N. he published in 1786, and that of Madame B. in 1787. The case of the former is remarkable as the first recorded instance of the transference of the senses; for, with her eyes firmly bound, she read foreign, and to her unknown, writings, as soon as they were laid close upon the epigastrium. M. Deleuze states that this girl, of a simple and illiterate character, could not read, even when in the ordinary possession of her senses; a statement which, if true, might have rendered the bandaging of the eyes a superfluous precaution. About the same period, other cases of the same remarkable phenomenon were published. One of these was the case of Mlle. L. by M. Picher-Grandchamp of Lyons. A case was communicated to M. de Puysegur by M. Vialeter d'Aignan, a merchant at Montauban, in which the patient asserted that, in the somnambulic state, she saw by the solar plexus, and not by the eyes. Mlle. L., a patient of Captain Masson d'Autun (whose case is published in M. de Puysegur's *Researches*, p. 160), is mentioned as pointing to the stomachic plexus as the seat of the feelings which informed her of her state.

But the case which seems first to have attracted particular attention to the phenomenon of transference of the senses, was one published in 1787 by M. Petetin, professor to the College of Physicians in Lyons, and not a practitioner of, nor even, at that time at least, a believer in animal magnetism. The subject of it was a young married lady of a very hysterical temperament, whose health had been impaired by anxiety and fatigue. At first she sung incessantly till hæmoptysis was brought on, which interrupted the singing. No effort could make her hear by the auditory organ; but it was found that her attention was arrested, and replies vouchsafed when addressed near the epigastrium, or when the person communicating with her spoke into one of his hands, while the other was applied to her epigastrium. She could discriminate playing cards by feeling them with her hands. She could decipher writing with the points of her fingers. She could tell the time by feeling a watch through the glass. She could recognize an object laid on her stomach, even if held in the shut hand when the back of it was laid upon the epigastrium. If a letter was enclosed in a box and held in the hand, she could read the address on it. She could recognize an object placed under the clothes of a person who stood at some distance from her stomach, and say to whom it belonged. If an article of food was laid on the upper part of the abdomen, she could immediately perceive its *taste*, even when enclosed in a glass vessel; and if an aromatic substance was placed on her stomach, she immediately recognised its *odour*, and she could distinguish mixed substances in the same way.

M. Petetin attempted to explain these remarkable phenomena by the idea of a fine elastic matter in the stomach, possessing all the properties of the electrical fluid, and he attempted to show by experiments that the interposition of non-conductors of electricity was completely destructive of his patient's extraordinary powers. This explanation is purely hypothetical and somewhat inconsistent, inasmuch as it is averred that she could tell the hour through the *glass* of a watch, and perceive the taste of a substance contained in a *glass* vessel: a more rational explanation is within our reach, founded upon psychological and pathological principles; upon which, however, at present we abstain from entering. Somnambulic cases similar to this, and to those of M. Tardy, were published in Lyons two years afterwards.

The phenomena observed in M. Petetin's case, occurring as they did without any magnetic process whatever, are extremely valuable, as showing incontestably that the most wonderful powers which magnetism can claim as its products in the human organism, can arise spontaneously or naturally from ordinary morbific causes.

A work, entitled *An Essay on the Probabilities of Magnetic Somnambulism*, written by M. Fournel, an advocate, in 1785, attempted to establish an analogy between the phenomena of magnetic somnambulism and other extraordinary phenomena, well known and admitted by medical men and natural philosophers.

Besides the numerous scientific memoirs, reports of cases, and philosophical treatises which appeared from the time of Mesmer till the breaking out of the Revolution in 1788, there was one singular production, a work of fiction, *Le Magnétiseur Amoureux*, by M. V., or M. Charles Villers, a member of the Harmonic Society of the Metz regiment, an officer of the royal artillery, which, though in the form of a romance, is described by M. Deleuze as at once a very ingenious book of metaphysics, and one of the best treatises which we possess on magnetism. If this criticism is just, the work of M. Villers must have been a very bad work of fiction. This is not the only instance in which magnetic somnambulism has been made the principal feature in a work of imagination. The *Diary of a Physician*, by Alex. Dumas, or one of the collaborateurs of his numerous novels, depends chiefly on the phenomena of somnambulism for the farrago of astounding and improbable incidents of which it is made up. Besides being a very dreary novel, it is neither ingenious as a book of metaphysics, nor valuable as a treatise on magnetism.

With the commencement of the French revolution disappeared for a time all traces of the proceedings of the cultivators of animal magnetism and magnetic somnambulism. In the meantime, however, the latter state became familiarly known in Germany, where, as we shall afterwards see, it has since been made the subject of much experimental investigation, historical research, and philosophical speculation.

In 1807 we find that M. de Puysegur attempted to call the attention of his countrymen to this subject, by the publication of his work, entitled, *Du Magnétisme Animal considéré dans ses rapports avec diverses branches de la Physique Générale.*

In 1808 there appeared a posthumous work of M. Petetin on animal electricity, containing several new cases of natural somnambulism observed by him. Encouraged by these cases, M. de Puysegur, now a veteran in the cause, brought out, in 1809, a second edition of his *Memoirs*, and of the work published in 1807. In 1811 he published his *Physiological Researches, Experiments, and Observations on Man in the State of Natural Somnambulism, and in the Somnambulism induced by Magnetic Action.* In this work, as its title sufficiently indicates, the phenomena of natural somnambulism are assumed to demonstrate that induced somnambulism is in accordance with the laws of nature, and that the magnetic action is the artificial method of producing this state, instead of, as would most naturally occur to the mind of any one who was not the partisan of a particular theory, being considered as the results of the ordinary psychological and pathological laws which govern the human constitution.

In 1813 M. de Montegre published a collection of articles which had appeared in the *Journal de Paris*, under the

title, *Du Magnétisme Animal et de ses Partisans,* in order to show, in reply to M. Hoffman, one of the editors of the *Journal de l'Empire*, that no system had ever been submitted to a more attentive and more authentic examination than that of animal magnetism had been.

But of all the writers on animal magnetism who had hitherto appeared, there is no one whose influence upon its future destinies can be compared with that of M. Deleuze, whose *Histoire Critique du Magnétisme Animal,* the result of twenty-five years' researches and meditations, was published in 1813.

Of the three different schools in existence at this period, viz., those of Mesmer, Puysegur, and Barbarin, M. Deleuze attached himself to that of Puysegur, though he believed, at the same time, that, notwithstanding the diversity of theory, the same results were obtained in all of them. He became a zealous advocate of the doctrine of a physical agent as the cause on which the various phenomena depended. He believed in the existence of a fluid filling all space, and penetrating all bodies; a modification of which was recognised by Mesmer as capable of being directed by the will, though he had no facts to prove its existence till somnambulism had brought them to light. This fluid, which is under the control of the will, is not the universal fluid, but a magnetic one, continually escaping from our bodies, and forming around them an atmosphere, which, having no determinate current, does not act sensibly on the persons near us; but when urged and directed by our volition, it moves with all the force which we impress on it; it is moved like the luminous rays emitted by substances in a state of combustion. The chief difference between M. Deleuze and M. de Puysegur has reference to the various modes in which the magnetic fluid should be brought into action, and the suitable occasions for its employment. M. Deleuze, full of caution, and having respect to the prejudices prevalent against magnetism, was dissatisfied with the imprudent revelations made in published cases, which were calculated more to repel than to conciliate the favour of sober thinking men. He would have avoided offensive and extravagant details, and accommodated himself more fully to the temper of his readers, by omitting the exaggérations of enthusiastic disciples. This excessive caution, if carried out, would have deprived us of one of the most valuable means of estimating the value of the testimony of the witnesses. Deleuze, in the interest of somnambulism, would give only garbled statements of the cases recorded, but impartial men, in the interest of truth, demand that the whole mass of the evidence, with all its minutest details, should be produced, as the only means by which its value as a whole may be strictly and fairly estimated.

"The wise and moderate tone of the author," says M. Bertrand, "his attainments in the natural sciences, his character for morality, which even his most violent adversaries have never thought of attacking, all concurred to give to this book a success which works on the same subject had been, up to that time, very far from obtaining. This history was not only useful to the cause of animal magnetism in procuring for it a great number of proselytes, it helped it likewise by encouraging those who practised magnetism in secret openly to declare themselves its partisans; people were no longer ashamed to avow opinions which had been defended by a writer so respectable."

In the first part of his work, M. Deleuze, after some introductory remarks on the discovery of animal magnetism, its publication and propagation, and the obstacles by which it had been opposed, proceeded to an exposition of the proofs of magnetism, and the means of convincing one's self of its reality. He then treated, in successive chapters, of the magnetic fluid, and the means by which magnetism acts; of the processes employed in magnetism; of the difference of force among magnetisers; of the influence which the confidence of patients may have on the efficacy of the magnetic treatment; of the application of magnetism to the cure of diseases; of magnetic somnambulism; of the inconveniences, abuses, and dangers of magnetism; of some remarkable circumstances which had presented themselves to his observation in the practice of the art; of the mystical doctrines, and their association with magnetism. This work may be regarded as the most systematic treatise on the subject which had at that time appeared in France, though one still more complete had been published in Germany two years before, by Professor Kluge, of Berlin, under the title, *Versuch einer Darstellung des Animalischen Magnetismus, als Heilmittel;* of which a second and a third unchanged edition have since appeared. The following short statement, by Deleuze, of the somnambulic effect of magnetism, will show what was the state of belief on this subject which prevailed, at that period, among a large portion of magnetisers in France:—

"When magnetism produces somnambulism," says he, "the being who finds himself in this state acquires a prodigious extension in the faculty of feeling. Several of his exterior organs, usually those of sight and hearing, are rendered torpid, and all the sensations which depend on them are performed interiorly. There is in this state an infinite number of shades and varieties; but to form a correct judgment respecting it, it must be examined in its greatest remoteness from the state of waking, passing over in silence everything that experience has not established. The somnambulist has his eyes closed, and does not see by the eyes, nor hear by the ears; but he sees and hears better than a waking man. He sees and hears only those with whom he is in relation. He sees only that which he looks at, and he usually looks only at those objects to which his attention is directed. He is subject to the will of his magnetiser for everything that cannot harm him, and for everything that is not opposed to his ideas of justice and truth. He feels the will of his magnetiser; he perceives the magnetic fluid; he sees, or rather he feels, the interior of his own body, and those of others; but he usually remarks only the parts which are not in the natural state, and which disturb the harmony of the economy; he refinds in his memory the remembrance of things which he had forgotten while awake; he has pre-visions and pre-sensations, which may be erroneous in several circumstances, and which are limited in their extent; he expresses himself with a surprising facility; he is not exempt from vanity; he improves of himself, for a certain length of time, if he is wisely managed; he spoils if he is ill directed. When he re-enters into the natural state, he loses absolutely the recollection of all sensations, and of all ideas which he has had in the state of somnambulism, so that these two states are as unconnected with one another, as if the somnambulist and the waking man were two different beings."

In the year 1813 there appeared, in the sixth volume of the *Dictionnaire des Sciences Médicales,* an article entitled "Convulsionnaires," by M. de Montegre, having special reference to the scenes which occurred at the tomb of Deacon Paris, where many sick persons, who went to pray at the tomb, were seized with convulsions. In comparing these phenomena with those produced by mesmerism, he regards both as depending, not on any special agent, like magnetism, but upon the great law of the mutual and reciprocal influence of the moral upon our physical, and of our physical upon our moral, constitution. He also insists, strongly and justly, on the influence of hysteria in the production of these various phenomena.

In the same year a society of amateurs commenced to meet in the house of M. de Commun, in Paris, for experiments on somnambulism, reading of cases, and conversation. This led to the establishment of the Magnetic Society of Paris in July 1815. M. de Puysegur was made president, and M. Deleuze vice-president. Another consequence of the reunions of M. de Commun was the publication of a periodical journal, entitled *Annales du Magnétisme Animal.* From 1814 to 1816 eight volumes were brought out. In 1817 the journal was revived, under the title *Bibliothèque du Magnétisme Animal.* It was edited by the Baron d'Henin, secretary to the Magnetic Society, and was subject to the control of M. Deleuze.

This journal, like the *Annales,* of which it was a continua-

tion, extended to eight volumes. Of the many curious and remarkable cases contained in the sixteen volumes, the following brief notes of some may be taken as a sample :—

1. The case of Clothilde Lemeunier, who was able to trace, from a very early period, the development of her own offspring, of the progress of the different parts of which she furnished most minute details, though the German reviewer in Eschenmayer's *Archiv* rather ungallantly detects some awkward blunders in her anatomical statements, a circumstance the less calculated to excite surprise when it is known that her magnetiser was a military officer. Had he been a Bäer or a Burdach, we doubt not her anatomy of fœtal development would have set all criticism at defiance.

2. The case of an apparently healthy girl, who, falling at once into the state of self-intuition, saw the marks of an injury of her spleen, which had occurred some years before.

3. The case of a woman, who saw in a child six months old the germs of smallpox, which were to occur twelve months afterwards, and which bore at the time a striking resemblance to paternoster balls or rosary beads.

4. The somewhat romantic case of Major Pittman's maid-servant, whose master, being obliged to sail for India before having completed her cure, left her a white pocket handkerchief, which should secure her falling into the state of somnambulism when he thought of her. Nor would it be proper to omit

5. The *far sight in time* of a somnambulist who foresaw the entrance of the allies into Paris in 1814 a considerable time before it happened, and who walked in the somnambulic state from Paris to Orleans, a distance of 70 miles; nor

6. The *far sight in space* of the somnambulist who, in the depth of winter, saw that a plant which had been prescribed for her, but which was at a distance of many miles, was not frozen.

Nor is the *Bibliothèque* deficient in cases rivaling those of the *Annales* in marvel; as for instance—

7. The case of Madame Vernot, who was made several times to see that the child of which she was at the time pregnant was a boy, and foretold when she should feel its motion.

8. That of Dr Rouillier, into whose interior a somnambulist saw sufficiently distinctly, in 1788, to be able to assure him that he had not had the smallpox; and

9. That of Mademoiselle L., who foresaw that, but for the use of certain decoctions which she prescribed for herself, she would have died of five ulcers in the womb.

The Baron d'Henin attempted to continue the *Bibliothèque* under the title of *Journal of Animal Magnétism*, in 1818, but only one number appeared. In May 1820 he brought out the *Archives du Magnétisme Animal*, of which eight volumes appeared in that and the following years. The first two numbers, consisting of an introductory address by the editor, were afterwards brought out as a separate work, under the title *Le Magnétisme Eclairé*. From this work, and subsequent volumes of the *Archives*, we find that considerable difference of opinion existed among the members of the Magnetic Society of Paris. M. Deleuze, and a portion of the members, held the view that there is a particular magnetic fluid; while the baron, and some others, dissented from that doctrine. It would appear that the majority of the society were intolerant of the opposition which he offered, and he complains bitterly of its degeneration from its original purpose, which was to investigate the nature of magnetism, and ascertain its effects. Instead of this, he maintains that the society adopted a system (that of Deleuze) on too slight grounds; that it did not attempt to verify the phenomena on which such a system might be founded; that it had not the support of a single rigorous experiment, and that it did not permit contradictory experiments. It has admitted, he asserts, without judgment and without criticism, all the facts which have been addressed to it; and if it has seemed to verify them, it has been only to give countenance to their improbability and absurdity. It has rejected all the observations that have been made to it upon this subject; and, in place of returning to the path of truth, has plunged itself deeper and deeper in the abyss of error. The magicians of animal magnetism have never chosen to undergo the proof of a public discussion, but have contented themselves, in their conversations, with relating to one another, without permitting contradictions, the marvels, prodigies, and miracles, to which they accorded their admiration. The society, in short, has adopted as its principle, that it ought to consolidate itself, and preserve its harmony, only by the unity of all its members in the belief, or rather in the most lively faith, in the facultative magnetic fluid of man.

"Almost all the relations of magnetic cures," says the Baron at another place (p. 127), "present circumstances that are assuredly improbable. The marvellous slides in at every page. There is scarcely a somnambulist who is not represented as more or less endowed with miraculous powers, and principally that of seeing, so to speak, materially, and without change of place, real effective events happening at very remote distances, and of giving an account of them as if he had been an eye-witness. What I have expressed, the magnetists in general allege; and several attest it, and say they have positively verified it. I am not to be told that these are false allegations on my part; to be convinced of them one has only to read any of the relations, printed or in manuscript, which contain instances of animal magnetism. It is in vain to object to me, that I have not been well acquainted with the processes of magnetism, that I have not put them in practice, that I have not seen remarkable facts, or that I have observed them badly; I shall not allow myself to be imposed upon by such denials. I have read, or run over, almost all the books which treat of magnetism; I have lived among magnetisers; I have seen them magnetise, and I have magnetised with them. I have restrained my incredulity, the better to allow them to reason, and more frequently to speak nonsense (*déraisonner*), and to push their pretensions to the uttermost. I have often heard the very facts which had occurred before my eyes related in such a way that I could scarcely recognise them, so much were they disfigured by the enthusiasm and exaggeration of those who had been witnesses of them, or who had themselves produced them."

The value of the foregoing criticism on the proceedings of the Magnetic Society of Paris, coming as it did from one who acted as its secretary till its dissolution, in 1820, cannot be too highly estimated. It shows us very clearly how great an amount of caution is required before accepting as true any of the wonderful cases which were at that time published under the auspices of the society, and it applies with equal force to all the subsequent records of somnambulism.

In 1818 appeared the article *Magnétisme Animal*, in the *Dictionnaire des Sciences Médicales*, by M. Virey, in which he attempted to show that the phenomena of animal magnetism, which are well established, are referrible to the principle of the reciprocal dependence of the corporeal and spiritual parts of the human economy on one another. In reply Deleuze published, in the following year, his *Défense du Magnétisme Animal contre les Attaques dont il est l'objet dans le Dict. d. Sc. Med.* Public attention was further directed, at this time, to the magnetic doctrines, by a public course of lectures on the subject by M. Bertrand, to whom we shall shortly have to refer.

In 1820, when the Magnetic Society expired, and M. Bertrand was lecturing, a series of experiments on animal magnetism were performed in the wards of the Hotel Dieu, of Paris, under the authority of M. Husson, physician to the hospital. The principal subject of the experiments was Mlle. Sanson, a girl of eighteen, who, in consequence of a fright, laboured under a menstrual suppression, accompanied with vomiting. M. Dupotet was the operator. Twenty-four separate experiments were made, in most of which something striking was evolved. Without entering into details, as it is to be feared that this young woman most egregiously imposed upon those who had her in charge, we shall only mention a few of the more remarkable phenomena which she exhibited in such profusion. At the *first* trial the vomiting was stopped; at the *third* she fell into the state of somnambulism, out of which it was difficult to rouse her; at the *sixth* she could only hear the questions of M. Dupotet, who was in magnetic relation with her. She was insensible to various loud noises made by the bystanders. At the *eighth* she had not arrived at an exact

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knowledge of the nature of her disease, but she had discovered the remedy for it. "Continue to magnetise me," she said, "and I shall be cured." At the *tenth* she was magnetised through an oaken partition in three minutes; on inquiry she announced that she would become lucid. She felt the slightest touch of M. Dupotet, but not that of any of the spectators. At the end of the sitting she became convulsed, in consequence of the touch of a hand not in relation with her. At the *eleventh* she was again magnetised through a partition; at the *thirteenth* she was pinched by M. Recamier without producing any sensible effect, except convulsions on coming out of the magnetic state; at the *fourteenth* she saw a great light before her eyes, and prophesied that she would see her disease at the next sitting. Accordingly, at the *fifteenth* she declared that she saw her stomach red, and full of red pimples (*boutons*), and that she would never be cured of her disease; at the *sixteenth* she saw five pimples, larger than the others, and a small bag full of blood near her heart, out of which the blood she had vomited proceeded. On this occasion she was charged with deception. She continued to see her disease till the *twenty-fourth* sitting, on the 17th November, when the incredulous M. Geoffroi, who had come into charge of the wards in place of the more credulous M. Husson, gave orders that the magnetic practices should be discontinued. On the occasion of the vomiting returning, M. Geoffroi permitted M. Robouam to magnetise her, when the vomiting ceased.

Among those who were not satisfied that these experiments had been conducted in good faith, on the part of the somnambulist at least, if not on the part of her magnetiser, were M. Bertrand (*Du Magnetisme Animal*, p. 259) and M. Récamier.

Soon after the experiments at the Hotel Dieu, similar trials were made at the Salpetriere Hospital, which had the effect of enlisting in the cause of animal magnetism two physicians, whose adoption of this belief was well calculated to make an impression upon those who were acquainted with their characters and dispositions, viz., MM. Georget and Rostan. The former, in his work on the physiology of the nervous system, published in 1821, observes, that the facts which he has mentioned with respect to somnambulism are for him, as well as for the distinguished physicians who have been witnesses of them, the fruit of an intimate conviction, acquired by a number of trials, and guaranteed by the most rigorous precautions. He did not publish his experiments, but they are recorded in a work, entitled *Cures Operées en France par le Magnetisme Animal.*

Several years later, in an article published in the 13th volume of the *Dictionnaire de Médecine* (Nov. 1825), M. Rostan made confession of his faith in the following terms:—"I repeat, what I am to write of these phenomena I have seen, and I have seen frequently. I have not contented myself with observing it on one single person, but I have submitted several to this kind of investigation. I have taken for the subjects of my observations persons of different classes, of different sexes; persons, several of whom were even ignorant of the name of magnetism; literary characters, students in medicine, epileptics, ladies of fashion, young girls, &c., some of whom were even afraid to subject themselves to my experiments. I have continued this kind of examinations for several years, on account of its inspiring me with great interest." "It was physically impossible that there should be any connivance, or any communication, among the persons upon whom I made my observations."

Notwithstanding the boasted rigour and variety of the experiments made by these eminent men, it is a sad and melancholy fact, as was afterwards sufficiently proved, that they were the dupes of designing females, who, at great personal inconvenience and discomfort, made fun (*s'est moquée de*) of them, as we shall afterwards see. Dr Elliotson, of London, was undoubtedly placed in the same awkward predicament by two clever Irish girls, the O'Keys. Such cases prove to us how little confidence we ought to place in such experiments on the declarations of hysterical and designing females, who seem sometimes to be endowed with all but supernatural powers of endurance and deception. Our readers will easily remember many remarkable cases of females convicted of the most elaborate attempts at imposition in matters totally unconnected with somnambulism, and actuated apparently by a morbid desire of attracting notice.

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On the testimony of M. Londe, the collaborateur of M. Georget, and the witness of all his experiments, we learn that the persons who were the subjects of his experiments afterwards boasted of the deceptions which they had practised. M. Dechambre, in a letter published in the *Gazette Medicale* (12th Sept. 1835), informs us, that having discovered one of the females on whom Georget's experiments had been made (Manoury dite Braquette, since become Veuve Brouillard), he, with some of his companions, completely exposed, by a series of experiments, the hollowness of her pretensions. In a second letter, M. Dechambre informs us that another of Georget's heroines, Petronille by name, died of consumption at the Salpêtriere in 1833. Two house-pupils, M.M. Gorré and Perrochard, of the ward into which she was received, authorised him to declare, that she had frequently stated to them that she never experienced the slightest symptom of somnambulism; that she had always imposed upon (*s'est moquée de*) Georget and the others; and that she and Brouillard had amused themselves in recounting the mystifications of the day, and preparing for those of the succeeding.

In 1823 M. Bertrand published a treatise, entitled *Traité du Somnambulisme et des diverses Modifications qu'il Presente*, in which he showed with how much facility the imagination may produce somnambulism, and that reasonable magnetisers cannot refuse to acknowledge that, in a great number of circumstances, the imagination produces it alone; and that, in all cases, it cannot fail at least to concur powerfully in its production.

In 1825, M. Foissac, a young physician, who had become a convert to animal magnetism, presented memoirs on the subject to the Academies of Science and Medicine (*Rapports et Discussions de l'Acad. Roy. de Med. sur le Mag. An.*), and asked for a commission to examine and report on its merits, chiefly as to the power it gives of detecting the diseases of others, of announcing their future course, and directing their treatment. The Academy of Science did not respond to his call. The Academy of Medicine was still more neglectful, as it did not even acknowledge his communication. He again, however, brought the subject under the attention of the latter body by a letter on the 11th October, and stated that he had a somnambulist at his disposal, whom he offered as the subject of any experiments which it might be thought proper to make. The opinions of the Academy being divided, a middle course was adopted on the motion of the president, and MM. Adélon, Pariset, Marc, Husson, and Burdin, were appointed a committee—M. Renaudin refusing to be placed on it—to report on the question, Whether it was proper for the Academy to occupy itself with animal magnetism? On the 13th December, the report, drawn up by M. Husson, who had been engaged in the experiments at the Hotel Dieu, was laid on the table. Its conclusion was to the effect,—1. That the judgment of the commission of 1784 did not dispense with a new examination of the subject. 2. That the experiments on which that judgment was founded were performed without a general plan, without the simultaneous and necessary concurrence of all the commissioners, and with moral dispositions which must have caused these experiments to miscarry. 3. That the animal magnetism of 1784

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differed entirely from the magnetic somnambulism of 1825. 4. That they should not be behind the German physicians in the study of this subject. 5. That its examination by the Academy would withdraw its use and practice from those who followed it as an object of lucre and speculation. After a discussion of three days, the report was adopted by 35 to 25 voices; and on the 28th February 1826 a commission was named, consisting of MM. Leroux, Bourdois de la Mothe, Double, Magendie, Guersent, Laennec, Thillaye, Marc, Itard, Fouquier, and Guenau de Mussy. On account of the ill health of M. Laennec, M. Husson was named in his stead. On the 7th August M. Husson was appointed the reporter; but from various causes the report was not presented till the 21st June 1831.

Meanwhile, outside the walls of the Academy this subject continued to be prosecuted with zeal.

In 1826 appeared M. Bertrand's work, entitled *Du Magnetisme Animal en France*, &c., *suivi de considérations sur l'apparition de l'Extase dans les Traitements Magnétiques*. The first part of this important work is historical. In the second part the author attacks the very foundation of animal magnetism, and maintains that no physical agent is concerned in the production of artificial somnambulism. Of this work M. Deleuze says (*Hermes*, vol. i.), "of all the attacks directed against magnetism, up to the present day, this is the most powerful, the most imposing, and the most ably combined. The author is a man of genius, &c. He has been occupied with magnetism for some years. He has joined its practice to that of medicine, and he has even taught its doctrines in public lectures. A more attentive examination, and new experiments, have dissuaded him from a belief which he himself propagated; he undertakes to undeceive others, and to prove that magnetism is a mere chimera. Certainly his conviction must be very strong." M. Bertrand, like the Baron d'Henin, was not long in discovering the weak and untenable points of the common theories, and like him also was not slow to point out the exaggerations and misrepresentations of those enthusiasts whose powers of judgment are eclipsed by the force of their imaginations. Instead of calling in the aid of a new hypothetical imponderable, working silently and mysteriously in the human organism, as well as throughout space, he was contented to accept the phenomena as subjective states, presenting themselves under the most diversified forms in all ages, as states not essentially morbid, though certain diseases greatly predispose to them, and never supervening, except under determinate circumstances.

At a meeting of the surgical section of the Academy of Medicine, on the 16th April 1829, M. Jules Cloquet mentioned the case of a lady, a patient of a celebrated Parisian magnetiser, M. Chapelain, whose breast he had extirpated a few days before, on account of a cancerous affection, while she was in a state of magnetic sleep, without her displaying the slightest mark of sensibility during its removal. This case is remarkable as one of the first recorded instances of an operation performed on a patient in the state of anaesthesia. The result of the case was unhappy; on the twelfth day after the operation the patient died of pleurisy, caused by imprudent exposure. This person piqued herself, we learn, on her somnambulic powers; and we have ample evidence to show to what a prodigious extent female endurance can go in bearing pain, without giving expression to the feelings, when actuated by some powerful motive. We frankly admit that, in this case, no feeling of pain was expressed; but no one can tell whether it was felt or not, except the patient herself, who, in the circumstances, was the least likely to do so. On inquiry, it was found that she claimed the power of self-intuition and prevision, and that she had announced the existence of a lesion of the liver. Unfortunately for her credit as a clairvoyante, the scalpel did not reveal any disease of that organ, and disclosed only a purulent effusion into the pleural cavity. As a proof of the little faith that should be attached to the cases reported by professed mesmerists, it will be found (*Hermes*, vol. iv., p. 173 to 204) that M. Pigault Lebrun has made it to appear that, in this case, it was the daughter of the patient who possessed the faculties of lucidity and prevision, and that the *post mortem* appearances found in her mother's body are made fully to confirm her predictions.

As already stated, the report of the commission of the Academy was read by M. Husson on the 21st June 1831. It was continued on the 28th. The report was, on the admission of M. Husson, cooked, in so far as the facts observed by the commission were not reported in the order in which they were observed, but arranged so that the phenomena were made to appear gradually to rise from nullity to a degree of perfect certainty, by an ingenious process of progressive development:—1. From nothing; 2. to something little marked; 3. to a product of ennui, monotony, and imagination; and, 4. to a high degree of probability that they are produced by magnetism alone, independent of the latter causes. The *Examen Historique et Raisonné des Expériences Prétendues Magnétiques* of M. Dubois (d'Amiens) is a most masterly and complete exposure, both of the method and conclusions of this report, and is well worth the attentive perusal of every one who studies this subject. Its contrivance, so as to afford to those disposed to believe a ladder by which they may mount by easy steps from the familiar to the extraordinary, and from the extraordinary to the marvellous; the assumption which it involves of the point at issue, viz., the existence of such a power as magnetism; the absurdity of recognising as one division of their facts null effects of magnetism; the trifling character of their second division of facts, comprehending what they entitle the effects of little consideration; the inconsequence of declaring, in respect of the third class of the so-called effects of magnetism, that they are the effects of ennui, monotony, and imagination, are all pointed out with a vigorous hand; whilst, in respect of the fourth class, in which the phenomena were of a more mysterious character, M. Dubois insists on the total neglect, on the part of the commissioners, of proper precautions against deception and collusion between the magnetisers and their somnambulists. We cannot enter into the details of the cases embodied in M. Husson's report. The most of them were signal failures. M. Foissac's somnambulist, Mlle. Coeline, from whom great things were promised, completely broke down. Mlle. Couturier, produced by M. de Geslin, was also an egregious failure. A female somnambulist of Dr Chapelain, who prophesied that, on a given day and hour, she would discharge a tapeworm as long as her arm, was duly waited on by the commissioners, but the reward of their assiduity was only an ordinary alvine evacuation. The experiments of M. Dupotet also failed. In the case of a man named Chamet, and a female called Lemaitre, he failed to produce convulsions in any part of the body towards which he pointed his finger, as he had promised. The most remarkable case, the one on which the more important conclusion was founded, was in reality more a failure than a success. A man called Cazot, who was an epileptic, predicted the days and hours on which his fits would return. The prediction of events of this kind is not at all wonderful, even though the events should correspond with the prophecy; but in this case the somnambulist did not foresee that he would be killed by a vehicle on the street before the period when the events prophesied were to take place. The explanation that the prevision was only interior and organic, and did not provide against external accidents, is not consistent with the claims of other somnambulists, who pretend that they are able to foretell when their ankle is to be sprained, or when other people are to die. Nevertheless, for every failure there is always a ready excuse, however inconsistent that may be

with the somnambulist's previous promises, or the exaggerated pretensions of others in the same state. Mlle. Coeline, who was first experimented on, and who so signally failed, was taken by M. Foissac to examine the state of a young lady, the daughter of a peer of France, and, after some manipulation, described the pathological condition of her abdominal viscera, and prescribed a somewhat unusual mode of treatment, viz., the milk of a goat which had been rubbed with mercurial ointment—which had already been prescribed and employed by MM. Dupuytren and Husson. The report of this wonderful coincidence was received with a general explosion of marks of incredulity in the Academy. The only other case worthy of note was that of Paul Villagrand, who pretended to be affected with palsy, and who by an elaborate, though very transparent course of deception, also pretended that he was cured by magnetism. This young man came under the observation of M. Velpeau. After many trials of different modes of treatment, the moxa was proposed for his paralytic ailment; but the fear of so painful an ordeal made him abandon his deception.

After M. Husson read his report, the Academy declined to print it, but allowed it to be lithographed. "It was read," says M. Dubois, "but not adopted; heard, but not approved." The silence of the Academy is interpreted by M. Foissac, somewhat contradictorily, to mean an expression of consent.

In 1832 M. Filassier having been cured of a chronic enteritis by M. Chapelain, assisted by a somnambulist, in order to discharge his debt of gratitude, published a graduation thesis, which contained many cases of persons who could see by the epigastrium; who could discover the diseases of others, &c.; who could see what was going on at seventy miles' distance; who, being lame, could be made to walk without crutches; who were relieved of the pains of parturition and the like—all through the power of magnetic somnambulism. (Vide *Magnét. An.*, in *Dict. Pract. de Med. et Chir.*)

Though the academy had waived the discussion of M. Husson's report, it could not prevent the subject from again penetrating within its walls. At its meeting on the 24th January 1837 (Bull. i., 343), a case of painless tooth extraction, in magnetic sleep, was mentioned; and at the meeting of the 14th February a letter was read from M. Berna, apparently a magnetic practitioner, offering to submit certain somnambulists to a commission of the academy. MM. Roux, Bouillaud, Emery, Oudet (the dentist in the case referred to above), Hipp. Cloquet, and Dubois were named a commission, to which were afterwards added MM. Cornac, Pelletier, and Caventou. The report of this commission, drawn up by M. Dubois, was presented to the academy on the 12th August, and read at that and the subsequent meeting. The subject of the experiments, which were performed in M. Roux's parlour, was a nervous girl of about seventeen years of age. The following is the programme of proceedings drawn up by M. Berna:—

1. Somnambulization.
2. Demonstration of insensibility to punctures and to tickling.
3. Restoration of sensibility by mental volition.
4. Obedience to the mental order of losing the power of motion.
5. Obedience to the mental order of ceasing in the midst of a conversation to reply; mental order to reply anew.
6. Repetition of the same experiment, the magnetiser being separated from the somnambulist by a door.
7. Awakening.
8. Conformably with a mental order, which shall have been enjoined during the somnambulic state, persistence of insensibility on awakening, and persistence also of the faculty of losing and recovering this sensibility at the will of the magnetiser.

It will be observed that in this programme there is no allusion made to the higher phenomena of clairvoyance, prevision, transference of the senses, &c. The experiments bearing on the 1st, 2d, and 7th heads were of an undecided character. The results of the experiments illustrating the 4th head were as follows:—When M. Berna mentally paralysed her *right arm* only, she declared that both the *right leg* and the *right arm* were paralysed. He next mentally paralysed her *left leg*, but she affirmed that she could move that leg very well, but not at all the *left arm.* This experiment was repeated with the same result. Inadvertently she *did* move the *left arm* also, though she had declared her inability to do so. The experiments on the 3d and 5th articles also completely failed.

After many objections on his part, M. Berna was induced by the commissioners to exhibit experiments illustrative of vision without the assistance of the eyes. The somnambulist on this occasion was a female, thirty years of age, but every one of the experiments resulted in complete failure. Without having the candour to say that she did not see what was on the cards, she persisted in making guesses, no one of which even approached the truth.

The conclusions of this report were all, therefore, justly condemnatory of the pretended powers of somnambulists. M. Berna protested against it, and M. Husson, who had strong leanings in favour of somnambulism, and advocated the adoption of a resolution to the effect that the only conclusion that can be deduced from the report is, that in the experiments made by M. Berna before the commission, it has not seen any of the phenomena which that physician had announced would be produced. The discussion was continued on the 5th September, and the academy adopted the conclusions of the report. The following year M. Berna published a reply, entitled *Magnétisme Animal, Examen et Réfutation du Rapport par Dubois à l'Academie Royale de Medecine.*

At the meeting of the academy on the 5th September, M. Burdin, a member of the committee of 1825, offered a prize of 3000 francs to any one who could read without the assistance of light, of the eyes, and of touch. The council of administration reported favourably of the proposal of M. Burdin at the next meeting (12th September), and recommended that the time should be limited to two years, if the prize had not previously been merited. The money was lodged, and a commission, consisting of MM. Dubois, Double, Chomel, Husson, Louis, Gerardin, and Moreau, was nominated on the 19th.

The commission, soon after its appointment, published an announcement inviting magnetisers to produce before it any of their somnambulists capable of fulfilling the terms of M. Burdin's offer. (*Bulletin*, i., 944; ii., 17.) Many communications were received, setting forth the most preposterous claims, but there was only one somnambulist produced before the commission, viz., Mlle. Pigeaire, the daughter of a physician at Montpellier. We need not delay to consider the communication of M. Petriconi, magistrate at Calvi, in Corsica (*Bull.* i., 944), concerning the husband who satisfied his paternal feelings by predicting that his wife would bring forth a son; or the clairvoyant who announced the result of an election at Bastia, 40 miles off; nor that of M. Hublier (*Bull.* ii., 126), surgeon-in-chief of the hospitals of Provins, who promised to present to the commission a person capable of reading without the assistance of the eyes, as soon as the necessary training had been completed; nor that of Dr Birmann of Pirna, in Hanover (*Bull.* ii., 127), who knew a young person who was able to read not only German but other languages which she did not know, without the intervention of the eyes; nor that of Dr Bergeron (p. 397), who was acquainted with a young somnambulic girl who had the faculty of seeing in the dark and through opaque bodies; nor that of M. Despine of Aix-les-Bains, in Savoy (p. 631), mentioning two cases of transposition of the senses, one of which he had taken under his own immediate charge in order to study

the phenomena, which he found to consist of hearing, reading, seeing, smelling, tasting, and touching with the feet and hands; as none of the remarkable persons referred to were produced before the commission in Paris in order to have their alleged powers put to the tests necessary to be gone through before the prize could be awarded. We must confine our attention, therefore, to Mlle. Pigeaire, who was brought to Paris in order to be examined by the commission. The terms on which the prize was to be awarded had, in the meantime, been relaxed by M. Burdin, in so far as to allow light to be used as well as the fingers, provided a plate of glass was interposed. This concession was made as Mlle. could not read, it was admitted, without a certain degree of light. The next difficulty which arose between M. Pigeaire and the commissioners was in reference to the apparatus to be used for bandaging the eyes. That offered by the commissioners was rejected by M. Pigeaire, and he insisted on using his own, which they, in their turn, very properly rejected, and gave M. Pigeaire to understand that it belonged to them to determine the form of the mask to be used in the experiments. The president proposed a movable veil to be placed over M. Pigeaire's mask, but this was also rejected, on the pretence that the cheeks required to be uncovered, as he was not disinclined to think, with several persons, that his daughter might read by means of the nerves of the face. To obviate this objection, a member proposed conical tubes to conduct the light to the cheek; but this was also refused by M. Pigeaire. On inquiry it was found that Mlle. Pigeaire could not read for a space of time varying from a quarter of an hour to an hour and a half after the application of the bandage. It was also admitted that she was in the habit of performing a greater or less number of movements with the muscles of the face. Another point to which the commission attached much importance, was the position of the book in which Mlle. Pigeaire was to read. The commission desired the book to be placed directly in front of her, and on a level with her eyes. M. Pigeaire said that the book must be placed on his daughter's knees or on a table, and that she could not read with the book in face of her on a level with her eyes. He also declared that his daughter would be unable to read, and that she would fall into convulsions if one of the commissioners applied his fore-finger on the lower border of the bandage. Towards the conclusion of the sitting, M. Pigeaire said, that at other times his daughter had read words placed in the interior of a box; but, though the commission declared that this experiment would be held decisive if performed in their presence, he declined it.

The commission having been thus resisted on all hands in their endeavours to secure the necessary precautions against the somnambulist reading with the eyes, encumbered it might be with certain obstacles, but yet not altogether prevented from seeing, there is little wonder that it declined to be a party to the experiments at all. Some members of the academy regretted that the commission had not proceeded the length of experiments, but it seems to have been generally acknowledged that the precautions which they had insisted upon were reasonable.

At the meeting of the 7th of August, M. Berna offered, in the name of several magnetisers, 50,000 and 70,000 francs to any person who, in the natural state, should read with the bandage usually employed for covering the eyes of Mlle. Pigeaire. This foolish challenge was not accepted, as it was quite manifest that, if it had, conditions would have been imposed such as the commission had insisted upon, which would have rendered the accomplishment of the feat impossible.

As the period of the *concours* terminated in October 1839, and as no candidate had yet offered himself, M. Burdin, on the 30th July of that year, made further modifications of the conditions on which it might be competed for, in order to induce magnetisers to come forward. He said, "Bring us a person magnetised or not magnetised, asleep or awake; let that person read with the eyes open through an opaque substance, such as tissue of cotton, linen, or silk, placed at six inches from the face, or read even through a simple sheet of paper, and that person shall have the 3000 francs." (*Bull. de l'Acad.*, iii., 1123.) *No candidate appeared*, and the money reverted to its owner.

If such a power as seeing in any other way than by the organ of vision really existed, as was vaunted to be possessed by so many persons both before the prize was offered and since, surely some one of the clairvoyants would have come forward and established a just claim for the prize, but as none appeared, we may conclude with safety that both then and now no such marvellous power exists or is developed in the human constitution.

We have now brought down the history of magnetic somnambulism in France to a period beyond which it did not continue to excite any considerable public interest. So signal and repeated had been the failures on the part of the magnetists to establish the truth of their doctrines before the commissions of the Academy of Medicine, that the whole subject seems to have fallen into merited contempt and oblivion. In more recent times the exciting phenomena of spirit-rapping have superseded those of somnambulism, and spiritual media have recently too much occupied the public attention to leave any room for those who can boast no higher powers than those of which magnetic clairvoyants claim the possession.

Somnambulism in Great Britain.

2. *Somnambulism in Great Britain.*—It is stated by M. Deleuze that Mesmer was desirous to teach his doctrines in England as he had done in France. We have evidence from himself that he visited England, but as to the exact nature of his proceedings there we have no precise information. In a letter written by him to M. Picher-Grandchamp of Lyons, dated Paris, 19th May 1787, he says—"I arrived lately from England, where I had passed a month in amusing myself." We have no other mention of Mesmer's ever having been in England, except that Gorton, in his *Biographical Dictionary*, says that he had lived there for some time subsequently to 1784, under a feigned name. M. Bailly's report was translated into English in 1785, and the impression which it produced upon the public mind probably precluded any hope which Mesmer might have formed of receiving a favourable reception for his views in this country. It does not appear that he made any attempt to propagate his doctrines in London, or formed the acquaintance of any scientific man of eminence on this side the English Channel. England is too rich a field to escape spoliation, and notwithstanding its high pretensions to sound practical sense, it is not averse to receive for a time any scheme, however preposterous and at whatever price, if it puts forth claims sufficiently high, and advertises them widely enough. But in this country a delusion, though it may make a great noise for a season, and seem to flourish, soon disappears and falls into merited oblivion. It may run like wildfire through the land for a few months, but it is soon extinguished, leaving only smoke and ashes behind. Still, though we may repent and be ashamed for a time, we are soon ready to start afresh. Chicanery and deceit do not quench our faith, disappointment and defeat do not extinguish our courage, and pecuniary loss does not damp our enterprise.

Though Mesmer himself did nothing in England, his followers did not lose the golden opportunity of exercising their vocation to some profit on this side the English Channel. About 1788, animal magnetism produced a considerable sensation in this country, and we are informed by Mrs Hannah More, who was keenly alive to the danger of doctrines which emanated from the French metropolis, that

M. Maineduc, a disciple of M. D'Eslon, made L.100,000 by the practice of mesmerism in this country (Dupotet, p. 319). One Holloway also made his fortune by giving lectures, the fee for which was five guineas. The most notable performers, however, were a Mr and Mrs de Lauterbourg, who resided at Hammersmith Terrace. Their house became a great centre of attraction, and they were reported to have cured 2000 people in six months. No disease or infirmity seems to have been capable of resisting their healing virtues, if we can believe their enthusiastic admirers. The deaf and dumb, we are assured, were made to speak by a look of benignity. No wonder that the enthusiastic Mrs Pratt, of 41 Portland Place, Marylebone, announced to the Archbishop of Canterbury that Mr and Mrs Lauterbourg had been rendered by God "proper recipients to receive divine manuduction," and proposed to his lordship a public thanksgiving for the blessings they dispense, and a form of prayer for their continuance. "Let us join," she exclaims, "in prayer and praise to have this most glorious blessing continued, lest our candlestick be removed from us, which I most ardently pray the Lord Jehovah to avert." The miracles of our Saviour in curing the deaf, the dumb, the halt, the lame, and the blind, appear insignificant in number and small in importance when placed side by side with those of Mr and Mrs de Lauterbourg. How great our loss that their candlestick was very speedily removed, and that their names are *not* found in the English Liturgy, not we, but Mrs Pratt, could adequately express.

Various ephemeral publications appeared in London about the same period on the subject of animal magnetism, written, it would appear, more in the interest of particular manipulators than in that of science. These have all passed into a merited oblivion. (*Brit. and For. Med. Rev.*, April 1839, p. 312.)

The outbreak of the French Revolution, and the events which followed that catastrophe till 1815, cut off this country so much from intercourse with France and other continental countries, that the awakened interest about animal magnetism soon died out, and was not easily resuscitated. At the end of last century, as we have seen, Perkins' tractors enjoyed a brief period of notoriety, which was speedily extinguished by the conclusive experiments of Messrs Haygarth and Smith.

A profound ignorance or indifference seems to have prevailed in this country on the subject of animal magnetism, or magnetic somnambulism, which is the modern phase of that doctrine, from the period of the French Revolution till the year 1837.

It appears that little or nothing was known in this country of what was doing on the Continent, more especially in Germany, in reference to this subject. Our experimenters seem to have commenced *de novo*, or probably only with the light which was derived from France in the report of the Commission of the French Academy of Medicine, which originated in the importunity of M. Foissac, and was compiled by M. Husson. In 1831, M. Husson, as we have said, read to the Royal Academy of Medicine the report of the commission which it had appointed so long before as 1826. The report was lithographed for the use of the members, but never discussed or adopted. The Academy of Medicine ignored the report, but M. Foissac nevertheless accepted it as the expressed opinion of the Academy, which it was not. He took silence for consent. The conduct of the Academy was certainly of a more vacillating description, on this the second occasion of its investigation of the phenomena of animal magnetism, than it was on the first, and through this circumstance a great impulse and encouragement were given to the study of these phenomena, as well as increased confidence to those who had already adopted the views as well founded.

It is to be regretted that the London experimenters were not acquainted with the proceedings of the German magnetisers, otherwise they might have avoided numerous extravagances in the phenomena which they evoked, which had already in Germany far exceeded anything that they dared to announce here; as well as many experiments, which placed them in such an attitude of contradiction to their more advanced fellow-workers as to afford convincing proof that one or other of their theories must be false.

At the same time, although generally neglected till the outbreak of the mesmeric mania in 1837, it would be wrong to suppose that animal magnetism had wholly died out in this country. We find traces of its existence, though merely in the hands of obscure adventurers, who were resolved not easily to lose sight of a system which had already proved itself so profitable. It is chiefly at watering-places, and in those localities which are most frequented by the idle, the frivolous, and the fashionable, that it is found still to linger. Dr Elliotson admits that he had been impressed by experiments which he had seen performed at St Thomas's Hospital many years before he commenced his own at the North London, but that he was prevented from prosecuting them on account of the death of the gentleman by whom they were made.

The advent of the Baron Dupotet de Sennevoy, whose success as a magnetic experimentalist before the second French commission had been more than problematical, was the occasion of a renewed interest in the subject of animal magnetism in this country. From the *Medical Gazette* of 16th September 1837 we learn that the Baron was first introduced at the Middlesex Hospital, where, on several successive days, and in presence of the physicians, surgeons, and numerous visitors, he selected a few hysterical girls on whom to try his powers, but entirely in vain. They were scarcely even frightened, and like most of M. Berna's "*l'experience etait manquée.*" Some one laughed and whispered, "Send him to the North London—he'll succeed there." He went to the North London Hospital, where he instituted experiments which were concluded on the 19th September, at the instance of the medical committee of the hospital. Although, according to the testimony of "an eye-witness," the experiments did not fulfil the expectations held out (vid. *Lancet*, Oct. 14, 1837, p. 99), they produced such an effect on the mind of Dr Elliotson, professor of medicine in University College and senior physician to the hospital, that though at first somewhat sceptical, and totally disbelieving such phenomena as seeing with the fingers, smelling with the stomach, &c., he was inclined to believe in the reality of such things as sleep, coma, and somnambulism produced by mesmerism (*Lancet*, Oct. 21, 1837, p. 124). Dr Elliotson, having been so far convinced of the reality of mesmeric phenomena, was induced to continue the experiments himself. This did not excite surprise at first, and it was confidently expected that his experiments would lead to a conclusive refutation of mesmerism. This hope, however, was not realized, and it soon became apparent that he had become a complete convert to all the most marvellous and incredible tenets of the mesmeric faith. Time and space would fail us if we attempted to describe all the windings and turnings of his devious path, till they led to his resignation both of his hospital appointment and his professorial chair. With the blind zeal of a convert to a new faith, he plunged into a series of experiments and exhibitions, at which the learned, the idle, and the noble eagerly assisted; till, urged on step by step, with a credulity and a simplicity which never dreamed of deceit or imposture, he arrived at the brink of a precipice, over which he was hurled, with the ruin of great prospects, the alienation of friends, and the exultation of enemies, but with no word of consolation or support from the noble and curious crowd who had previously assisted at his exhibitions.

The history of the sisters O'Key, in connection with animal magnetism and Dr Elliotson, is in our opinion one of the most melancholy in the whole history of practical medicine. For the particulars of it the reader may consult the *Gazette* and *Lancet* for the years 1837–8, *passim.* That the O'Keys were impostors of the first water, and that Dr Elliotson was their unwitting dupe, there cannot be a shadow of doubt. Into the details of the exhibitions we cannot, nor is it necessary for us to enter. The experiments were conducted with a looseness and total absence of the most necessary precautions for distinguishing between phenomena which were real and those which were pretended. In that department of the investigation which Mr Wakley undertook to sift, the introduction of a little method, and the scientific testing of the phenomena, at once demonstrated the fallacy of the pretended magnetic virtue communicated to nickel, gold, water, &c., by the touch of the human hand. In all the experiments conducted by Dr Elliotson himself, the patients received such manifest indications of what they were expected to do that a very ordinary amount of acuteness was sufficient to carry them through the ordeal with apparent success. Some of the experiments intended to prove new and marvellous powers in the human constitution were as frivolous as they were ridiculous. What can we think of an experiment intended to prove so marvellous a phenomena as the transposition of the senses of vision and smell, consisting merely of presenting, either immediately in front of the face or with a piece of pasteboard interposed, a piece of bread and butter which the patient's tutored hand readily seized, probably assisted by the smell of such an object, which can be felt at a considerable distance?

Though Dr Elliotson devoted himself more to experimenting than theorizing, there is a tacit assumption throughout most of his experiments that the effects are the result of some faculty of one organism acting upon another. The adoption of a system, instead of the verification of the phenomena on which a system might be established, by the Magnetic Society of Paris, was, as we have seen, the rock on which that body split, in spite of the energetic protest of the Baron d'Henin. In so far as he confined himself chiefly to the verification of phenomena, Dr Elliotson adopted a wise course; and though many of the phenomena he witnessed were in strict accordance with the observations of French and German magnetisers, he evoked others in direct opposition to these theories, and which, if true, would have furnished direct proof against their soundness. Such experiments as the following lay the axe at the root of all hitherto recognised systems—"Dr Elliotson, coming in front of the patient, causes her to magnetise herself by desiring her to make bows to her face with one hand." After a few passes she fell into magnetic sleep. Again we are told "that Mr Wood was led to try the effect of magnetising the reflection of Jane O'Key in a looking-glass. Being told to look at herself in an unframed glass, two passes were made at her image, when she fell into the same condition of sleep as when magnetised personally." Upon such inconclusive evidence no person bent upon investigating fairly the existence of the magnetic phenomena could for a moment place the slightest reliance.

The conversation of the O'Keys was not edifying, their sentiments were not refined, their language was not elegant, and their prophecies were not fulfilled. If the phenomena exhibited by these girls in their magnetic state is a true representation of what animal magnetism can do for us in increasing our knowledge, in refining our manners, in improving our medical skill, and in revealing to us the arcana of nature, it will be to the credit and advantage of our race if it is now buried in everlasting oblivion.

Besides Dr Elliotson, Mr Mayo, Dr Macnight, and Dr Sigmond became converts to the magnetic doctrines in London. Of these Mr Mayo is the only one who, by his writings, has exercised an important influence on the fortunes of animal magnetism in this country. Possessed, like Dr Elliotson, of many eminent qualities, both literary and scientific, his adhesion to the cause is no unimportant event in its history. As Dr Elliotson was practical and experimental, so Mr Mayo brought to bear upon the subject theorizing powers of no ordinary kind. We may form an estimate of the length he could go theoretically in discussing the question from the following statement—"By looking upon a mesmerisable body, you may so mesmerise it that another mesmerisable substance laid upon it shall from it be mesmerised sufficiently to produce decided mesmeric effects upon patients sufficiently susceptible of this peculiar agency" (*Medical Gazette*). Of the higher phenomena, such as prevision and transference of the senses, he thinks that "they naturally lead to the supposition that they result from the workings of a spiritual nature, in a certain state of independence of those bodily organs to which it is normally closely tied and bound, from the mind being in part dislocated and displaced from her corporeal tenement, holding on with misplaced attributes to unaccustomed points and corners of the frame" (*Medical Gazette*, vol. xxii., p. 775).

This view of the effect of magnetic sleep is identical with that which prevailed in the most ancient times as to the effect of ordinary sleep. The soul, according to the old theory, withdraws in sleep into the innermost recesses of the human frame, and, in the language of Mr Mayo, "becomes dislocated and displaced from her corporeal tenement." Having retired into the "land of dreams," the soul was relieved from its grosser corporeal impediments, endowed with higher powers, and could then penetrate not merely into the past in time and the distant in space, but could also reach forward into the vistas of futurity. The higher phenomena, therefore, according to Mr Mayo, are but the dreams of artificial sleep, and their revelations convey to us information in every way analogous to that furnished by ordinary dreams. In short, to adopt his form of expression, they are the phenomena of a "dislocated soul" holding on by the corners of the frame.

After a short period of excitement (1837–8), the mesmeric mania subsided, and the public of London generally became content to see with their eyes, taste with their mouths, hear with their ears, and to use the natural means which were provided for the acquisition of all necessary and useful knowledge, instead of seeking for transmigrated faculties in "unaccustomed points" of their frame.

From this period, however, we must date the first beginnings of anything like a school of mesmerism in this country. Though the public excitement passed away, there remained a large number of persons who devoted themselves heart and soul to the investigation of what were to them new and strange doctrines; we shall find that at intervals the public attention could still be aroused to a lively interest in the phenomena of magnetic somnambulism.

Mr Braid, a surgeon in Manchester, was the first (in 1841) who attempted to strike out a new path, and to reform and modify the theory in such a way that, while sufficient to account for all the real phenomena, it could commend itself to the attention of men engaged in the cultivation of the ordinary branches of science. Recognizing the existence of a substratum of truth and facts in the phenomena usually observed at mesmeric meetings, he set about to discover some rational key by which they could be accounted for without shocking our understandings, or making any demand on our powers of credulity. The phenomenon which chiefly arrested his attention, was the loss of voluntary motion in particular parts of the body, which he accepted as real, and explained as follows:—Take

the immobility of the eyelids, for instance, "the continued fixed stare of the patient at any object, by paralysing nervous centres in their appendages, and destroying the equilibrium of the nervous system, produced the phenomenon referred to." This explanation, as put by Mr Braid, is singularly absurd. We have an object at rest—in equilibrio—and we wish to explain why it is at rest. This Mr Braid thinks he has done by stating that the fixed stare destroys the equilibrium of the nervous system. If the equilibrium of the nervous system is destroyed, we have not rest but motion on this hypothesis, therefore the eyelids ought to move, which is the very opposite of what he wished to prove. This criticism does not affect his theory, but only his manner of stating it. He evidently means to state that the continued stare of the patient, by producing (not destroying) the equilibrium of the nervous system, caused the phenomenon referred to. With his theory Mr Braid has invented a new nomenclature; with him mesmerism becomes hypnotism or neurhypnology. "The sole object," he says, "which I had in view in undertaking the experimental investigation of animal magnetism, was to devise a simple and satisfactory mode of demonstrating that the real cause of the phenomena manifested was subjective or personal, and not objective or the result of any magnetic fluid or force passing from the operator to the patient; and as I have succeeded in this attempt in producing all the *ordinary* and useful phenomena (useful in a curative point of view, I mean), more speedily and certainly than by the ordinary mesmerising methods, whilst I never succeeded in producing clairvoyance and the higher phenomena, I thought it better to discuss the phenomena producible by my method under a new name, and adopted the term hypnotism, or nervous sleep." The hypnotising method referred to is described as follows by Mr Braid. He takes any bright object, generally his lancet-case, which he holds ten or twelve inches above the middle of the forehead, so as to require a slight exertion of the attention to enable the patient to maintain a steady fixed gaze on the object, the person being either comfortably seated or standing; stillness is enjoined; and he is requested to engage his attention as much as possible with the simple act of looking at the object, and yield to the tendency to sleep which will steal over him during this apparently simple process. In the course of about three or four minutes, if the eyelids do not close of themselves, the first two fingers of the right hand extended and a little separated, may be quickly, or with a tremulous motion, carried towards the eyes so as to cause the patient involuntarily to close the eyelids, which, if he is highly susceptible, will either remain rigidly closed or assume a vibratory motion, the eyes being turned up, with, in the latter case, a little of the white of the eye visible through the partially closed lids. If the patient is not highly susceptible, this process may be required to be repeated more than once. He found great differences in the susceptibility of different patients; some being affected with difficulty, while others, after a while, became so susceptible as to be affected entirely through the power of imagination, belief, and habit, *i.e.*, the expectant idea produced it in such subjects when no process whatever, whether near or distant, was going forward.

We may notice here, as showing how little is known in France of the progress of science in this country, and how readily discoveries made in one country are, after a lapse of years, reproduced in another as new discoveries, the recent announcement of a method, which is an exact copy of Mr Braid's, of producing a state of anæsthesia, in which a surgical operation was performed. M. Guérinan, surgeon to the hospital of Poitiers, recently amputated a thigh, after the patient had been reduced to the hypnotic state, by means of a bright spatula held about four inches from the root of nose; after about ten minutes the patient was hypnotised, and his leg was removed without the exhibition, on his part, of any symptoms of pain. Thus was the honour of re-discovering hypnotism claimed in France.

The discovery of Mr Braid was one well fitted to excite the hostility of the various classes of mesmerists, who, however much they differed amongst themselves, were at one in the view that the mesmeric phenomena were the result of an influence or power, *ab extra*, which, passing from the operator, was transmitted to the person operated on by means of certain magic passes, fixed stares, and the like. The commission of the French Academy, in 1784, had attempted to explain, on rational principles, the phenomena of mesmerism, as then exhibited; but these explanations, however satisfactory, wanted the convincing evidence of experimental demonstration. This defect has been supplied by Mr Braid, whose experiments have amply confirmed the views then enunciated, by his discovery of a simple method of producing all the credible and authentic phenomena of mesmerism. Besides the simple method described above, there are various auxiliary means which may be employed with success to produce the phenomena in question. It is of advantage if the person to be operated on has witnessed the operation on other persons. The influence of sympathy and imitation is thus brought into play, and increases the susceptibility in a marked degree. The influence of direct auricular suggestion and expectation, excited by the confident tone and deportment of the operator, also contribute to a successful result. Mr Braid is of opinion, that all the mesmerising processes produce their effects from what is essentially the same exciting cause as that which induces hypnotic phenomena—viz., by producing a state of mental concentration, through the attention becoming so engrossed by watching the manœuvres or suggestions of the operator, as for the time to render the subject dead or indifferent to all other sensible impressions or trains of thought. "In this stage of the sleep," he remarks, "the power of suggestion on the patient is excessive, whatever idea is suggested to his mind, whether by the natural import of the words spoken, or modified by the tone of voice in which they are uttered, is instantly seized upon by the subject, and interpreted in a manner to surprise many, and lead them to believe it has been accomplished by a sort of intuition or inspiration. In this way you may vary or modify the ideas suggested in the most remarkable manner, and the patient sees, and feels, and speaks of all as real, without the slightest desire to impose upon others."

It is easy to see, that however satisfactory and rational this mode of explanation of some of the most remarkable phenomena witnessed at mesmeric sittings may be, the theory of some occult influence, odyle, volition, or by whatever name it may be called, fostered by that innate love of the marvellous so predominant in most minds, presents so great attractions that it has ever been received with more popular favour than the more philosophical account of the matter given by Mr Braid.

He remarks, "That there is nothing occult or specific in the pass with the hand is manifest from this, that a similar agitation of the air by the blast from a pair of bellows will produce precisely similar results as the like current of air from the wafting of the human hand, as I have proved to the satisfaction of hundreds of intelligent individuals.

"A pass, therefore, as a visible or sensible impression, aids the patient in concentrating his mental attention to a given organ or part, and thus influences its function, through giving a special direction to a power residing within the patient's own frame; but it no more imparts a virtue of an occult nature from the operator to the patient, than the lens produces the light and heat which it makes visible and perceptible to the senses, through concentrating the luminous and calorific rays of the sun, and drawing them to a

focus. Both the pass and the lens aid in concentrating and manifesting the respective influences, but neither the operator nor the lens is the source or origin of the power or influence so manifested."

In the experience of Mr Braid no phenomena have manifested themselves during either the hypnotic or mesmeric sleep which have not been in accordance with generally admitted physiological and psychological principles. Though the senses and mental powers may be torpified or quickened to an extraordinary degree, he has never seen anything to warrant a belief that individuals could thereby become gifted with the power of reading through opaque bodies, and other wonderful feats, called by the mesmerists the higher phenomena.

The theory of Mr Braid, as has been seen, is entirely subjective in its principles, and it is one to which the great majority of physiologists and psychologists in this country have given in their adhesion, and to which, indeed, many who had not come forward as authors were previously inclined. The opposite theory, however, the objective, is one which has received no mean support, and its pretensions at least deserve some attention. Besides Elliotson, whose experiments have already been mentioned, there are Gregory, Reichenbach, Colquhoun, and Esdaile, to whose labours we would fail in our duty if we did not call the attention of our readers. These authors are all, more or less, wedded to the doctrine, that the phenomena of mesmerism are attributable to the agency of some power or influence which passes from the operator to the person operated on; that there exists in nature an imponderable power or influence, through which all the magnetic phenomena are excited. This influence Reichenbach designates *odyle.* Though its author is German, the work of Reichenbach, through the translation of Gregory, has become British; and his views may be more conveniently discussed in connection with the British than the German development of mesmeric doctrines, more especially as, according to the translator, the abstract of these views, published by him in 1846, was more favourably received in this country than the original work was on the continent. It may appear, *prima facie*, difficult to connect the odyle theory with that of mesmerism, but this is clearly brought out by Dr Gregory. The mesmeric state, according to him, is merely somnambulism artificially produced; but Reichenbach's discoveries show that a force or influence, analogous to heat, electricity, and magnetism, but distinct from all, exists in the human body, and that a large number of persons are, more or less, sensitive to this influence. Mesmer and others produced powerful effects by using magnets, and other means; and this is now cleared up, by the discovery that the new force residing in the human body does also reside, not only in magnets, but in all other bodies. The conclusion naturally is, according to the translator, that these forces are identical; that there is a fluid (or imponderable power or influence) which is not ordinary magnetism, and which acts strongly on the system. This fluid is odyle. It ought to be premised, that Reichenbach's experiments, on which he founds his system, were performed chiefly upon females, many of whom were afflicted with nervous diseases of various kinds. Though pretending to have followed the inductive method, and claiming for his discoveries a high scientific value, it must be confessed that there is apparent, throughout the whole investigation, a fatal want of those precautions which are absolutely necessary to make his conclusions worthy of credit. The diseased imaginings of nervous females; sensations, whose truthfulness we cannot test; and statements which are manifestly the result of ideas which have been suggested, are not the kind of foundation on which can be built systems which claim for themselves the accuracy of physical research.

If these imposing investigations of Reichenbach, which were brought forward with all the external appearance of scientific inquiry, are divested of these adventitious circumstances, there will be found a residuum, the value of which as a contribution to physical, physiological, or psychological science, is not commensurate with the trouble required for its elimination. If we apply to them the cross-questionings by which Haygarth and others detected the fallacy of the phenomena produced by Perkins' tractors, we shall find that the crystals and magnets of Reichenbach produce effects, the value of which are nearly on a par with those produced by the tractors of Perkins. Mr Braid has had the sagacity to adopt this method in testing the truth of Reichenbach's experiments. He was invited to spend an evening at a lady's house, who was extremely susceptible to ordinary mesmeric processes, and who was so sensitive to the influence of magnets that she was quite uncomfortable if a magnet was near her in any room; and in the dark she could point out any part of the room where a magnet of very moderate power was placed, from her *seeing* the light it produced streaming all around it. "I had the pleasure," says Mr Braid, "of sitting very near the lady, and of enjoying a long and interesting conversation with her and her husband (who was a most respectable and intelligent gentleman), and no manifestation whatever took place during the whole time, until after I had explained my views regarding the power of an *act of fixed attention*, directed to any part, in modifying the natural condition of the part so regarded. She was requested to direct her fixed attention to her hand, and watch the result, without anything being done either by her husband or any one else. She did so, and very quickly fell asleep; and the arm to to which she had directed her attention became rigidly cataleptic. Some time after being aroused, and when the shades of deep twilight had set in, the most interesting experiment was proposed, which was this,—that she should walk round the room and find a magnet which had been hidden behind some pictures when she was out of the room, in order to prove to me her power of *seeing* its light, and thus detecting it. She walked cautiously round the room (wide awake, for she did not require to be asleep to manifest this quality), her husband repeatedly urging her to seek about and persevere until she should find it. I feel satisfied that *he* had no intention of aiding her; but from his long silence when she approached the place where the magnet was hid, *I* should myself have caught the suggestion that I was *near to it*, or, in nursery phraseology, that I was then getting *very hot.* After she had passed it a little she sat down on a chair, but said she could not *see* it to-night, and then came up to where we were, shortly after which we sat down to supper. The lady showed no symptom of being uncomfortable from the proximity of a magnet, until requested to look out and fix her attention upon her hand; and after being aroused all seemed right again, until she was told that the *dreaded magnet was hidden somewhere in the room;* and she was requested to go round in the dark and endeavour to find it. The husband thought her sitting down in the chair proved that she *felt* the influence of the magnet, although she could not *see the light* from it; but what seemed conclusive evidence to *my* mind, that it was the *mere idea*, and *not* any *physical* influence in the magnet which affected the lady was this,—that all the time I had been sitting so close to her, conversing with her and her husband, I had had a fourteen pound lifting magnet, with the armature unattached, in my side pocket next to the lady; and that was a magnet of more than double the power of her husband's, and yet no visible effect was produced by my powerful but unsuspected magnet."

Let "Mdlle. Maria Atzmansdorfer, daughter of a military medical man; Mdlle. Angelica Sturmann, daughter of an hotel-keeper; Friedrich Wiedlich, an invalided sol-

dier; Mdlle. Nowotny, daughter of a subaltern official; Anka Hotmanek, a country girl, working on my property of Schloss Reisenberg; Johann Kleiber, carpenter in my service;" and all such magnetically susceptible persons, submit to the same experimental test as that to which Mr Braid's female friend was subjected, and the result will not be widely different from that which was witnessed in that well observed case.

We cannot enter in detail upon the various experiments of Baron Reichenbach; but when we find that they terminate with a positive statement of the results, founded on the assertions of the persons experimented on, without any crucial or negative experiments by which it may be proved that their sensations are produced by causes altogether different from those to which they ascribe them, and that the causes to which they are ascribed are such as do not in many cases produce them; although it may be that the causes assigned are true causes; yet if the tests applied are not subjected to rigid scrutiny, and the numerous sources of fallacy to which physico-physiological experiments are so peculiarly liable are not sufficiently attended to, we can have little or no faith in the validity of the conclusions arrived at.

The first patient experimented on by Baron Reichenbach was Mdlle. Nowotny, who was preternaturally sensitive to light and to the action of magnets. Reflecting that the aurora borealis appears to be nothing else than an electric phenomenon, caused by the magnetism of the earth, it occurred to him to try whether such an acute vision as that of Mdlle. Nowotny might not possibly, in absolute darkness, be able to perceive some luminous appearance in connection with the magnet; and if such should be the case, it seemed likely to supply the key to the explanation of the northern lights. She was first experimented on by her father, and she of course did see a luminous appearance so long as the magnet was open. If other instruments had been tried without the knowledge of the patient, and changed from time to time, and if it had been found that she could discriminate between the true and false magnet by light given out by the former, and the absence of light in the latter, the result would have been more satisfactory. Six other females, affected with nervous diseases, were experimented on with nearly similar results. The experiments were made in 1844, and they were followed by others in 1845–6–7. It soon became apparent, even to the Baron himself, that it was of the greatest importance that perfectly healthy persons should be able to see the odylic light. It is only, however, for the benefit of the sceptical that the evidence of additional witnesses is adduced; and he invites all those who are satisfied with the proofs already adduced, and with the accuracy of his mode of investigation, to pass over, if they please, the pages in which it is recorded. Beginning with the healthy sensitives, he proceeds progressively to the delicate, the sickly, and the highly sensitive. This latter class we need not further notice, as the record of the sensations of persons who are confessedly disordered in their nervous systems will never be accepted by scientific men as admissible evidence in favour of any class of physical phenomena or facts. To the first class—the healthy sensitives, which looks very like a contradiction in terms—as it is admitted that the vast majority of healthy persons do not perceive any of the appearances seen by the highly sensitive, we may pay some attention; but when we find that the first of the so-called healthy sensitives, who is called a young and healthy physician, was subject to sleep-walking, we may entertain some doubts as to what constitutes the healthy condition in the opinion of the Baron. The multiplication of such witnesses *ad infinitum*, whose morbid impressions are made the foundation on which a scientific fabric is attempted to de built, would only result in the manufacture of a rope of sand; one witness scientifically tested is worth a thousand such. It happened to the Baron in the same manner as to Mesmer and others, that when his speculations and pretended discoveries had received a certain amount of notoriety, inquisitive physicians obtruded themselves upon him. "I well know," he remarks, "that notwithstanding all this, people enough will be left, to whom all that I have done will not appear enough; for there are such things as *irrational* doubts; there is an absurd *incredulity*; and, lastly, there is also an *evil-minded* scepticism. These I am unable, and do not wish to refute." In a foot-note, p. 275, he informs us, that a small association of Vienna physicians has lately given us a deplorable instance of these unamiable qualities. "These gentlemen," he says, "after an examination lasting for half a year, came to the edifying result, that Mdlle. Reichel, Kreuzer, and Nather, were merely impostors and liars! I sincerely pity these gentlemen (there are altogether not less than twenty-three of these doctors and professors of medicine); after twenty-two sittings these deluded men lost themselves in a monstrous labyrinth of confusion, and arrived at the most absurd and perverted conclusions." In another foot-note, p. 370, the Baron repudiates the experiments of the doctors, on the standard objection which has been uniformly employed by mesmerists, where crucial experiments are made by medical men to test the accuracy of their results,—that their presence so disturbed the system of the sensitive, by the powerful odylic influence emanating from their own persons, that she was unable to succeed in the experiments. "Under such circumstances," exclaims the Baron, "how could a dozen of doctors and professors expect or insist, that an ignorant girl, driven in the midst of them, should find her way among the confused influences acting on her from all sides, and give clear and scientifically available answers to questions which they themselves did not understand how to put rightly."

Did space permit it would be easy to point out that the Baron himself is guilty of blunders even more egregious than those with which he charges the Vienna physicians. With a mere show of adopting the inductive method in his investigations, he violates its principles in every page, and systematically neglects the precautions which it inculcates. His plan throughout is essentially hypothetical, and his experiments are devised to prove foregone conclusions. He imagines a system of the universe, of which the hypothetical odyle is the sun and centre; and, unappalled by manifest contradictions which rise at every step, he boldly advances to its demonstration by experiments, whose flimsy and fanciful elements are too puerile and absurd to merit our serious consideration.

In the *British and Foreign Medico-Chirurgical Review* for October 1851, there is to be found an elaborate review of Reichenbach's work, which those who wish fuller information on this subject would do well to consult. The following is the estimate which the reviewer gives of the Baron's character as an original scientific investigator, with which every one who studies the subject will heartily concur:—"We find Von Reichenbach highly hypothetical; very credulous—credulous as to the extent of his own powers; credulous in receiving subjective for objective phenomena; negligent in the highest degree of those precautions which ought to have been adopted in making the experiments, so that they should have scientific accuracy; and incompetent from his manifest ignorance of the construction and working of his principal instruments of research—the human brain, and the senses of touch and vision—to make the experiments at all."

The late amiable Dr William Gregory, whose originality, learning, and candour in chemical investigation would have led us to expect a different judgment from him, has, in his translation of Reichenbach's work, accepted, without

question, all the theories, doctrines, and experiments of the Baron; and in his *Letters on Animal Magnetism*, afterwards published by Dr Gregory in 1851, we find that there is nothing too extravagant or outrageously absurd in the pretensions of the most obvious impostors which he is not prepared to support and defend.

In 1846 the work published by Dr Esdaile, entitled, *Mesmerism in India, and its Practical Application in Surgery and Medicine*, attracted the attention of medical men to mesmerism, more particularly in its connection with the state of induced anæsthesia. The facts there stated, as to the truth of which we can entertain no reasonable doubt, are worthy of careful attention and study. But while we admit the facts, it is not necessary that we should accept the author's theory of the nature of the mesmeric influence, or the conclusions which he draws from them. Dr Esdaile adopts the objective hypothesis, that some occult and powerful influence passes from the person of the operator to that of the person operated on; he maintains that this agent which, in passing out of the person of the former, causes lassitude and loss of nervous energy, is transmitted to that of the latter, and produces healthful and beneficial effects. Nay more, that it can be incorporated with other than living substances, and through them conveyed to living beings, as by means of water, &c. It will be seen, therefore, that Dr Esdaile discards the rational and physiological hypothesis promulgated by Mr Braid, by which all the credible phenomena of mesmerism may be explained upon purely subjective principles. It will be found, however, that the facts and cases reported by Dr Esdaile may be satisfactorily explained without calling to our aid any new and mysterious agent, as there is nothing in the experience of Dr Esdaile materially new, or widely differing from the experience of the older advocates of the mesmeric doctrine.

Without entering into the particulars of his cases, it may be stated that he performed seventy-three painless operations, of an importance varying from the extraction of a tooth, to the removal of a large tumour from a sensitive part of the body, weighing 80 lb. He also gives a return of eighteen medical cases, in which various cures were effected by mesmeric means. In relating his cases, Dr Esdaile is in the habit of stating the names of the persons who were present at his operations, in order that their acquiescence may more surely induce us to believe in the truth of the phenomena. His plan of mesmerising is somewhat tedious, laborious, and disgusting, inasmuch as, in addition to the other means employed, the use of the operator's saliva is called into requisition, to enable him the more easily to attain the desired end. It may be remarked, however, that the witnesses add very little to the credibility of the phenomena described, inasmuch as it never appears that they made any attempt to look very narrowly into, or scientifically to test the reality of the phenomena.

In addition to the production of a state of anæsthesia, and the other phenomena of mesmerism, by the laborious and exhausting method indicated, Dr Esdaile holds the view, that the mesmeric influence is capable of being absorbed by water, and of passing through stone walls. He adopts the theory, that something is transmitted from the system of the operator to the person of the patient operated on.

"From all I have seen," he says, "I cannot but believe that there is an influence of some kind which passes from one person into another, when one of two persons is mesmerised in the way I have described; that, in fact, there is a virtual transfusion of some vital agent from the one body into the other. The wonderful subtlety, as well as the effects of this power, lead us to suspect that it is a nervous product; and may it not be the nervous energy passing off by the organs of sense, and even for a short time *going beyond the surface of the body*, the lungs meanwhile, and periphery of the body, retaining their vital properties, and remaining under the direction of the will? Every time we move a finger, it is by transmitting *something* under the control of the will to the end of the fingers, and why should it not go farther? Supposing this to be possible, and that this nervous emanation can be directed by one person upon another, then I would venture to conjecture that, being a nervous product, it is accepted by the nerves of sense, on coming into contact with them in a continuous well sustained stream, and is transmitted by them to the brain, thereby adding to, rather than subtracting from the nervous secretions of the brain, which it is their duty to carry off as soon as formed. If the sensorial secretions are not conveyed away by the nerves of sense and volition, and the exercise of the perceptive and intellectual organs, the brain becomes torpid and oppressed. In like manner the transmission of foreign nervous matter might overwhelm the brain, or a mere stoppage of its own fluids might steep it in a sleepy drench, and the functions of the sensorium would not be restored until the usual outlet for its energies were re-established."

Dr Esdaile is solicitous, with respect to his various experiments, to inform us that numerous witnesses, such as Mr Russell the judge, Mr Money the collector, and Budden Chunder Chowdaree the sub-assistant surgeon, attest the truth of the phenomena in each case. For some months he confined his public experiments to purely professional subjects, but he was at length requested, from a high quarter, to gratify some of the inhabitants of Government House with an especial mesmeric exhibition. It was, therefore, generally made known that all the curious might be gratified, for the *first and last time*, on the 29th July. The exhibition took place in due course, and Dr Esdaile professes to have been heartily ashamed of it, as he ought to be, though it affords the culminating point in the evidence in favour of his peculiar views. According to the "Mesmeric Visitor," whose letter was published in *The Englishman* of 30th July 1845, a somewhat ludicrous but entertaining exhibition took place, in which patients were mesmerised through walls, and at long distances from the operator. The effects of the "sleeping water," or the "veritable *eau* merveilleuse," were tried on eight patients, of whom four were rendered cataleptic, and several converted into somnambulists.

It would almost appear that Dr Esdaile had a suspicion that his readers might not have sufficient faith in the veracity of his own testimony as to the phenomena which he witnessed, and he is thus constantly surrounding himself with respectable witnesses of his proceedings, whose declarations he publishes in his work. Now, the real difficulty is not in the testimony, for with that we are not disposed to find much fault: it lies rather in the theory or mode of accounting for the phenomena. The phenomena, indeed, are palpable, have been repeated a thousand times, and have been produced by a great variety of means or modes of operation. The grand controversy has been, and ever will be, What is the causal relation that underlies the external phenomena? The baquets, magnets, crystals, passes, inunctions of saliva, &c., are the apparent antecedents of the remarkable phenomena which follow. The question comes to be, does any virtue or causative power reside in these inanimate objects; or are they but the instruments by which a more subtle influence is transmitted from the person who wields them? or, again, are they but the occasion through which the phenomena are developed by a purely subjective process in the persons operated on? These questions receive very various answers from different individuals, and from the same individuals at different periods of their career. Thus, Mesmer at first attributed the phenomena to the power of mineral magnets. This view he afterwards abandoned, and ascribed them to a power residing in his own person. At a later period it was the baquets or tubs in which the mysterious power resided.

In the quotation given above there is developed the theory of Dr Esdaile, which, it cannot be denied, is at least a very remarkable one. It is not likely, however, to receive the sanction of physiologists until some very considerable changes have been made in that branch of science,

Somnambulism.

He advances his hypothesis by cautious steps. First, *he cannot but believe* that there is an influence of some kind that passes from one person into another; that, in fact, there is a natural transfusion of some vital agent from the one body into the other. If he had seen the same phenomena produced in circumstances in which such a transfusion was impossible, as had been so often shown by Mr Braid and others, he would have been compelled to admit that, in some cases, and probably in all, it was not necessary. Second, *he suspects*, from the wonderful subtlety, as well as the effects of this power, that it is a nervous product; and, third, *asks if it may not be* the nervous energy passing off by the organs of sense, and even for a short time going beyond the surface of the body. He afterwards speaks of the sensorial secretions being conveyed away by the nerves of sense and volition, and of the fluids of the brain steeping that organ in a sleepy drench. In the author's experiments this fluid or secretion is found, after leaving the brain, to be absorbed by water, to pass through walls, and to be conveyed through the air long distances. It is by attention that this secretion is impelled or driven forward till it strikes down its victim. Dr Esdaile's theory is one so utterly fanciful, and founded on opinions so completely destitute of any element of truth or rational probability, that it scarcely merits the attention which we have given to it. His views of the nature and functions of the brain and nervous system are such as may amuse and gratify the taste of the unenlightened multitude, but they are such as cannot be entertained for a moment by any one at all well acquainted with cerebral physiology. Such being Dr Esdaile's theory of mesmerism, the following are the general conclusions at which he has arrived from the *facts* detailed in his work:—

"That mesmerism is a natural power of the human body, and that it affects directly the nervous and muscular systems.

"That in the mesmeric trance the most severe and protracted surgical operations can be performed without the patient's being sensible of pain.

"That spasms and nervous pains often disappear before the mesmeric trance.

"That it gives us a complete command of the muscular system, and is therefore of great service in restoring contracted limbs.

"That the chronic administration of mesmerism often acts as a useful stimulant in functional debility of the nerves.

"That as sleep and the absence of all pain is the best condition of the system for subduing inflammation, the mesmeric trance will probably be found to be a powerful remedy in local inflammation.

"That the imagination has nothing to do with the *first* physical impression made on the system by mesmerism as practised by me.

"That it is not necessary for the eyes to be open; I always shut them as a source of distraction; and blind men are as readily mesmerised as others.

"That water can be charged with the mesmeric fluid, and has a powerful effect on the system when it has been previously affected.

"That the mesmeric influence can be transmitted through the air to a considerable distance, and even pass through dense materials."

Though "clairvoyance," or the transference of the senses, had not fallen under his observation, Dr Esdaile speaks of it in the appendix of his book as a thing of probable occurrence. Like Dr Gregory, he has little hesitation in accepting it without any critical examination of the phenomena and of the evidence on which it rests. He speaks of it as "one of the wonders of nature," and "a great rarity in art." After briefly alluding to some of the more remarkable cases of natural mesmeric clairvoyance collected by Mr Colquhoun, he concludes that the evidence in favour of the transference of the senses is of the most conclusive kind.

The attention of the British public was directed to the subject of mesmerism pretty frequently during the twelve years that elapsed from 1839 to 1851. Except for a short period at the end of last century, this was the only time when the phenomena of mesmerism, somnambulism, hypnotism, &c., obtained any considerable attention in these islands. When the nature of the subject is considered, it is not surprising to find that many assumed to themselves the privilege of expounding the doctrines and exhibiting the practices of this mysterious science who were ill qualified for the task. Itinerant lecturers appeared in all the cities and villages of the empire, who propounded their absurd theories, and operated upon nervous females, or upon boys and girls selected from their admiring audiences.

A class of persons thus sprung up who professed to be able to exhibit in their own persons all the wonderful phenomena of clairvoyance, pre-vision, &c. This class of persons was usually employed by lecturers, who produced them at mesmeric meetings, in order to show the higher phenomena of the art, which are altogether beyond the power of mere novices. It is only in rare and favoured cases that the higher clairvoyant faculties are developed. Out of a hundred persons who may be able to exhibit the more ordinary phenomena of somnambulism, there may not be one who possesses the qualities necessary in a prophetic and clairvoyant somnambulist. They are not to be looked for, says Dr Esdaile, as a matter of course in persons under the influence of mesmerism.

In Germany great notoriety was obtained by some very remarkable persons of this kind, whose clairvoyant powers were of the highest orders. There were also some in this country who attained to some celebrity; and if the extraordinary nature of their pretensions had not attracted the attention, and been submitted to the scrutiny of able and distinguished men of science—if we knew nothing more of them and their performances than what was written and spoken of them by their friends and admirers, we would be compelled either to accept as true what they pretended to be able to perform, or denounce them as impostors, from the inherent incredibility of their pretensions. It happens, however, fortunately, that we are not left in this predicament.

In the *Illustrations of Modern Mesmerism, from Personal Observation*, published by Dr (the late Sir John) Forbes in 1845, we have in small compass a complete exposure of the pretended clairvoyant powers of some of the most notorious persons of this class. In the preface, he states that he only professes, by a simple narrative of facts, to illustrate the actual pretensions and performances of the mesmerists of the present day, and to show on what sandy foundations the popular belief in their marvels rests. He expresses the modest hope that what is contained in this little book may teach a useful lesson to those numerous unscientific persons who are accustomed to attend mesmeric exhibitions, public or private, from motives of rational curiosity, or with the commendable object of investigating what seem important truths. He believes that such persons must now feel convinced that no reliance whatever is to be placed on the results presented at such exhibitions as evidencing the truth and powers of mesmerism.

He found that it was impossible for the ordinary visitor at these exhibitions to discriminate the true from the false, and that the coarsest juggling might pass with the trusting spectator, seated at a distance from the scene of action, for mysterious and awful truths. Mesmerism or clairvoyance may be true or false, and he professes to be ready to believe them on obtaining sufficient proof of their reality. If, however, we find the most eminent, and apparently the most trustworthy of the clairvoyants, not only uniformly unsuccessful when the necessary precautions are taken to test their powers, but actually detected, and confessing with shame that they have been guilty of the grossest imposture and deceit—where are we to look for the means of establishing the truths of this mysterious science? If we were to believe a fiftieth part of the pretensions put forth in the works and lectures of professional mesmerists,

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it would be the easiest matter in the world to carry off the prizes offered to any one who could read writing contained in an envelope so secured that it could not be read in the ordinary way. If it is an easy matter to see what is going on in the arctic regions, it cannot surely be difficult to see what is contained in a deal-box.

Sir John Forbes's first series of illustrations refers to Alexis, one of the most noted clairvoyants of the day. We cannot enter upon the details of the experiments, but must restrict ourselves to the statement of the following conclusions, which must be admitted to be just by any one who peruses the statements of what took place at the first exhibition:—

1. That the whole proceeding bore the complexion of trickery, or at all events that it wanted entirely the precision requisite in scientific inquiries.

2. That the total amount of positive failures and positive blunders greatly exceeds that of performances having even a colour or slight degree of success.

3. That the failures occurred in cases where the circumstances were such as to exclude collusion and the exercise of ordinary vision.

4. That all the instances of success occurred when circumstances allowed of collusion or ordinary vision.

5. That in all the cases of success, such collusion or vision was either proved or rendered extremely probable.

6. That there was not one single unequivocal example of what is called *clairvoyance*.

7. That, consequently, this exhibition not only affords not one tittle of evidence in favour of the existence of this faculty in the man Alexis, but presents extremely strong grounds for believing that the pretended power in him is feigned, and that he is consequently an impostor.

Even such cases as this do not make Sir John Forbes an utter disbeliever in mesmerism. The positive proofs of trickery and collusion on the part of its professors, he admits, afford no sound reason for declaring it to be false. If it appears, however, that in no case whatever, where clairvoyance is subjected to scientific scrutiny, it is able to establish its pretensions, we shall be justified in coming to the conclusion, that it is nothing more than a gigantic swindle, and that its professors are nothing more than arrant impostors.

At the second exhibition Alexis was not more successful than at the first. The whole performance was a series of blunders and unsuccessful guesses.

"Almost all the published records of mesmeric wonders," remarks Sir John Forbes, "and all those I ever heard narrated are utterly valueless, from being defective in exact and minute details. If the proceedings of Alexis, and a few more of the so-called CLEAR-SEERS were followed up for a certain time in the close manner adopted on these two occasions, we should speedily come to positive conclusions respecting the truth or falsehood of these most wonderful wonders."

The second series of illustrations referred,—

1. To Adolphe, brother of Alexis. When his eyes were carelessly bandaged, he could play *écarté* wonderfully well for a man who did not see, and rather badly for a man who did. When the bandage was more carefully applied by Dr Sharpey, and cotton placed by the side of the nose, he could see nothing; as to boxes and sealed envelopes he could make nothing of them. The failure, therefore, in this case was as signal as it was in that of Alexis.

2. To Mr Vernon's lady somnambulist, who, besides being able to read words enclosed in opaque boxes, had great power in diagnosing diseases. Two boxes and a spectacle-case, each containing words, were presented to her, and she selected the spectacle-case; but she totally failed, notwithstanding much guessing and "pinching," to approximate even to the right words. It was her habit, when she failed, to announce a day when she would be able to read with certainty. Having failed on this occasion, she announced the 21st June. On this day she was again put to the trial, and was again completely unsuccessful. Her diagnostic powers were then put to the test; a patient was submitted to her who was in good health, except in so far as he had varicose veins of the legs. Even though her attention was directed to the surface of the body for the seat of this disease, she failed to discover it, and announced a variety of diseases, such as weakness of stomach, palpitation, &c.; and on being asked what would cure the diseases, she, as in duty bound, declared that mesmerism would do him good.

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3. To Fräulein von Gönnern, who announced her arrival in London in the spring of 1845, and her intention to examine and prescribe (mesmerically) for patients either at her own or the patients' houses—the fee for the former being three guineas, and for the latter six. Sir John Forbes was invited by her brother to witness her powers. He himself became the patient, and she declared that he laboured under two diseases, which the doctor declares he is thankful to say existed altogether in his fair physician's imagination. Her anatomy was not more accurate, being an embodying of the vulgar notions of the animal structure. A lady who consulted her was informed that she was pregnant, and that the placenta was placed in an abnormal position, but that in consideration of another fee she would *change* the mal-position of the placenta, and avert the impending danger.

The following are the general conclusions deduced from the foregoing experiments:—

1. That some of the exhibitions bear the open and unmistakable impression of imposture.

2. That in all cases, wherever there resulted any positive success, the fact can be accounted for on ordinary principles, without the aid of mesmerism.

3. That all the instances of success occurred when there was at least a possibility of succeeding by the ordinary exercise of the senses in their normal state.

4. That when care was taken to render the ordinary operation of the senses impossible, failure invariably resulted.

5. That the TRIALS failed utterly in proving the possession of CLAIRVOYANCE by any of the parties submitted to examination.

6. That no proof was afforded that these parties were really in any special abnormal condition, such as is known by the name of somnambulism.

7. That, on the contrary, the evidence adduced renders it extremely probable that the apparent abnormal condition was feigned, and that these persons were consequently IMPOSTORS.

The third series contains the remarkable case of George Goble, a lawyer's clerk, who had succeeded in making his employer believe in his clairvoyant powers, and who was lauded in mesmeric periodicals as one who possessed great candour in confessing his inability to solve any difficulty that occurred to him, who did not guess at an answer if he did not really perceive the object, and who had never failed in a single instance. Invited by his master to test this boy's powers, Sir John Forbes undertook the task.

In the first experiment on the first day, a paper, on which was written the word "country," was folded in brown paper, sealed and put in a card-case, which was not secured in any way. George Goble tumbled the case about, pressed it against his forehead, put it *under* a pillow, placing both hands under the pillow at the same time, and after wasting much time in these manœuvres, in a sudden fit of fury he opened the card-case, announced the correct word, and tore the paper. From what occurred in subsequent experiments, it appeared that George Goble had, during his manipulations under the pillow, broken the seals and read the words in the ordinary way; and the sudden fury was simulated in order that his deceit might not be exposed.

In the second experiment the same card-case was employed, and the word "fold" was written on a piece of paper, which was folded into a flattened parallelogram, and placed in the case. After repeating the same manœuvres, he announced that the word was "Fould." When the box was opened, the shape of the paper was entirely changed; it was now perfectly round, rolled on itself like a common paper-match. There can be no doubt that George Goble opened the case, read the word in the usual way, though not quite correctly, rolled up the paper, and returned it in that condition, little suspecting the trap that was laid for him.

In the third experiment, the additional precaution was taken to bind the card-case with twine and seal it, and the result was that George Goble admitted that he could not

see into the box. His excuse was, that the *colour* of the paper was changed.

In the fourth experiment the required colour was adopted, and the same precautions taken, with a similar result. On the second day Sir John Forbes was assisted by Dr Sharpey and Professor Graham. They took small boxes of wood *sealed* merely. In the first experiment George Goble failed to discover the word; he guessed it to be "*har*" or "*hart*." The seal was found perfect, and the word was "insane."

In the next experiment he announced the correct word as "royal," and made a desperate effort to open the box, but was prevented, and the seal was found broken, and the result was declared to be *null*.

In the third experiment, the boxes were tied with tape and sealed. After some manœuvre he wrote the letters "cas" twice over; and then, after a little longer silence, he suddenly opened his eyes and was declared to be awake. The box contained the figures "1787."

Invited a third time to test the powers of George Goble, the ingenuity of Dr Sharpey completely exposed his roguery. Dr Sharpey prepared a card-case in the following way:—He took a card which exactly filled the case, and pasted on one side the word to be read; on the end of the opposite side he affixed a small ledge exactly filling up the space between the card and the opposite side of the case. The card being placed in the case, he piled upon the ledge a series of long and narrow slips of cork, which filled up the unoccupied space; by this arrangement the withdrawal of the card would unavoidably scatter the slips of cork, which could not be replaced.

In the first experiment a box was employed with the lid screwed down, and the screw concealed by wax. The word contained was "Exhibition," but being unable to open the box, he, nevertheless, affirmed positively that he saw the letters O U S. This was not merely a *guess*, but an egregious *failure*.

In the second experiment Dr Sharpey's ingeniously planned card-case was luckily selected by George Goble; but in order to make assurance doubly sure, he himself proposed that it should be tied. Nothing was said about *sealing*. He tied it himself, and the plan of the knot was carefully noted. Poor George Goble little dreaming of the trap that was laid for him, proceeded with great confidence to go through the usual manipulation. At one stage of the proceeding the box was seen without the *ligature*. Afterwards he buried his face in the pillow, and was observed repeatedly putting his fingers to his mouth as if placing something in it. At the same time fragments were seen falling on the floor, which turned out to be *cork*. There was a ***hiatus valde deflendus*** in the sofa, through which they had fallen. George Goble made a last effort to deceive by exposing the card-case *still tied by the tape*; but his roguery was detected, and slips of cork were forced out of his hands and mouth. His magnetism now deserted him, and he awoke up in the most natural manner imaginable. He threw himself on his knees on the ground, and in an agony of shame and terror confessed his roguery, and implored foregiveness, asserting that this was his *first offence*. On examining the card-case the tape was found crumpled, the plan of the knot was changed, the pieces of cork were displaced, and many of them were found wanting. "It was fated," says Sir John Forbes, "that George Goble's fame as a great seer was here to terminate; he had fought his last fight; he had seen his last sight among honest men; and though I shall not be at all surprised to find him again on the boards with his old itinerant masters (for he is really a clever though a somewhat clumsy rogue), it is improbable—and doubtless he felt this—that he can ever be again countenanced by any respectable mesmerist, however credulous."

Notwithstanding this signal failure and detection of George Goble, his too credulous master again invited Sir John Forbes to investigate his powers of clairvoyance. It appeared that after his tormentors left him on the last occasion, he made believe that he was not awake at all, and was afterwards demesmerised by his master in the due form. "He awoke," says his master, "in an agony of tears, quite unconscious of what had passed, and remains so at this moment!"

In order to give him a last chance to retrieve his laurels, Sir John Forbes left in the possession of George Goble's employer a small sealed box, containing a word printed in large type, on the understanding that he would renew his investigations whenever the box was returned unopened, with the inclosed word written on the outside.

George Goble was prevailed on by his master, though with difficulty, to try his skill again, and in about *three minutes* he said that the word was "Impelments." "I feel great confidence," writes his master, "from his manner of doing it, that he has read it rightly: he named it readily, first the whole word, then letter by letter." Is it necessary to say that George Goble was again wrong? The word was "OBJECTIONS."

The fourth series of illustrations refers to Miss Martineau's I. This person, an humble domestic, was, according to Miss M., an accomplished clairvoyant. I.'s cousin was an English mariner, who suffered shipwreck near Hull; and in a mesmeric meeting, I. is described by Miss M. as having given a true, full, and particular account of the circumstances of the wreck, without having any means of acquiring a knowledge of them in the usual way.

From the inquiries instituted by Sir John Forbes, it is proved demonstratively that I. was fully acquainted with all the particulars before the meeting took place; and that her mesmeric revelations, which look so wonderful as related by Miss M. in the *Athenæum*, are but the rehearsal of pieces of intelligence with which I. had become fully acquainted in the kitchen, before she ascended to announce them mesmerically in the *séance* held in the parlour.

We would not have referred at so great a length to these experiments had it not been that they present the best model with which we are acquainted of the means of exposing the charlatanry and deceit which are so often employed, to obtain notice, by those who adopt the views of transcendental somnambulism. The proceedings of Sir John Forbes, in which he was so ably assisted by Dr Sharpey and Professor Graham, stand out in bold contrast with those of the members of the second French Commission of 1825, who, if they had exhibited even a portion of the sound sense and firmness of Sir John Forbes and his coadjutors, would have given out a more certain sound than they were able to do in the Report which they presented to the Academy.

It has fallen chiefly to medical men to investigate the pretensions of the various systems of animal magnetism and somnambulism; and, as has been seen in the foregoing pages, their decisions have, for the most part, been adverse, and to such an extent as fatally to damage the claims of the higher phenomena to credit and acceptance among scientific men; and the consequence has been, that the believers in clairvoyance, and the cultivators of mesmerism generally, are uniformly discourteous, and persistently hostile to the medical profession. Narrow-mindedness, bigotry, prejudice, ignorance, unreasonableness, and many other such qualities, are ascribed to its members, though it were easy to show that, on all occasions, when medical men have been forced to deal with the subject, they have so often exhibited such a spirit of forbearance, of leniency, and of tenderness towards the disciples of Mesmer, Puysegur, Reichenbach, &c., while investigating their doctrines and practices, as to expose themselves to the animadversion of the less tolerant members of their own profession. It is to be regretted that such men as Drs Esdaile and Gregory should so far forget themselves as to join in the cry against

the profession of which they are members, for no other reason than this, that it cannot see with their eyes, and hear with their ears; when, according to their views, it might as well have no such organs at all, as they find that men can see farther, and hear clearer, without either eyes or ears, than those who possess these usually considered necessary and useful organs.

We must now briefly allude to the bearing which mesmerism has upon phrenology, a subject which has given rise to much controversy, or the so-called phenomena of *Phreno-mesmerism.* In 1842 some astounding announcements were made by Dr Buchanan, of Louisville, U.S., and Mr John B. W. S. Gardner, of Roche Court, Hants, two phrenologists acting independently of, and, it is said, unknown to each other, and whose observations are reported to have led to the same result. According to these gentlemen, it is possible to excite or suspend the action of any cerebral organ (phrenological) by means of animal magnetism directed to the part of the head where the organ is situated; and numerous cases are given in illustration of the alleged fact. "Dr Buchanan is characterised by the American papers as a gentleman of learning and experience; and we understand that Mr Gardner also, though not a medical man, is able, honourable, and well informed. The averments of the latter are corroborated by Dr W. C. Engledue, of Portsmouth; and Dr Elliotson has brought the subject under the notice of the London Phrenological Society." Such is the announcement of the origin of phreno-mesmerism, or mesmero-phrenology, which appeared in the *Phrenological Journal*, No. 70, p. 188. Dr Engledue, in his introductory address to the Phrenological Association of London, claims the discovery of the magnetic excitation of cerebration for his friends, Messrs Mansford and Gardner. The *modus operandi*, or method of exhibiting the phenomena, is, after placing the patient under the influence of mesmerism, to *apply the finger* to one or other of the phrenological organs, when the organ touched is liberated from the mesmeric trance, and at once called into lively action. This happy discovery opened up a wide field of interesting research and amusement for the cultivators of the now amalgamated sciences. It was expected that phrenology would be a great gainer by her union with mesmerism. Besides affording powerful evidence in favour of recognised organs, several new organs had already been discovered. Dr Engledue waxes eloquent over the future of this astounding discovery, and adduces it as a support of his view, "that cerebration is the function of the brain; one of the manifestations of animal life, resulting from a certain peculiar combination of matter; that it is not peculiar to man, but is exhibited, in a greater or less degree, by all the gradations of animal life." "Save me from my friends," became the cry of more sober-minded phrenologists, when the subject of the union of mesmerism and phrenology came to be discussed. Mr Churchill took the view, that phrenology had enough to do to maintain its own character with a prejudiced public, and ought to say to mesmerism, as one lady of rank said to another, whose reputation was more than doubtful, "Madam, I cannot afford to be seen in your company. My own character is barely sufficient for my own wants; it is not enough for us both." The addition of Dr Engledue's "Cerebration" to their company was not likely to contribute anything to sustain the slender reputation which confessedly attached to both.

Mr Atkinson read a paper before the same society on "Mesmero-phrenology;" the facts of which doctrine, according to him, consist chiefly in the power of throwing persons of a peculiar constitution, with regard to nervous susceptibility, into a state of somnambulism, and in such condition, of exciting or paralysing the different cerebral organs at will. Mr Atkinson then proceeds to give the following description of this new doctrine:—

"There are several ways in which this may be effected, depending much on the peculiarities of the individual case; for the effects of mesmerism, of course, like all other effects, though traceable to general laws, are yet modified according to the conditions of the particular instance. One case will only resemble sleep, another case will appear a completely altered state of existence; in one case you may have attraction to the mesmeriser, which in another instance may be wanting; one patient may exhibit clairvoyance, and not ultra-vision; the next ultra-vision, and not clairvoyance; and so on with regard to all the other phenomena. But, nevertheless, there is a general uniformity running through the whole; the cases may be classified, and many of the most essential conditions observed. But it is not necessary to explain further on this head; it is sufficient if I describe the general bearing on the subject, and my individual conviction of the fact, not so much with the idea of convincing, as of inducing others to follow out the inquiry for themselves. In ordinary cases there are several methods of exciting the organs, all of which I have practised with success. You may *touch* or *pass* upon the organs, and observe the natural language which may be exhibited, together with the explanations which may accompany this; or you may engage the patients in conversation, by which means you may lead the mind at will; they will follow with their hand pressing on the excited part, and they will press the more firmly according to the degree of excitement in the organ; covering one or several, and taking the other hand, if they are not able to reach to a distant part excited in combination. This they will often do of themselves; or, if even induced to do so, may continue the habit. A third method is, to touch an organ, and ask for an explanation of the power which is manifested there, or you may picture any particular sense, and request to be shown where such is felt to be located, or require the analysis of any sensation, and by what combination it is produced, or if it be a simple power. In some cases you may demesmerise organs, and thus bring them into action; or you may paralyze any particular power which may be acting. Music is another means which may be used; and many other methods of inquiry will, doubtless, suggest themselves to those engaged in these experiments. If the organs are much excited, they will no longer manifest their functions with any distinctness and energy; the patient will complain of headache, and a strained sensation in those parts, and a desire to rest. You may excite the organs only on one side of the brain; and when they are becoming confused, you may continue the same feelings on the other side with renewed energy, just as you raise one arm, and then raise the other. You may leave the patient in a talking dream, and observe how thought suggests thought, and feeling connects with feeling; how the organs become fatigued, and others become excited for relief, just as we change from one constrained position to another, perhaps the opposite, for relief. You may watch the effect of any single organ, and how it is modified when acting in combination."—(*Phrenolog. Mag.*, No. 70, p. 326.)

Both in this country and in America, where this new system of mesmerism and phrenology combined seems to have had a simultaneous origin, experiments and lectures, demonstrating the most remarkable phenomena, soon caused phreno-mesmerism to attract a considerable share of attention. By one party of phrenologists the union of the two systems was hailed with delight, as likely to shed a new flood of light upon their favourite system, while by another it was repudiated as a source of weakness. The advanced opinions of such men as Dr Engledue and Mr Atkinson were regarded with alarm by more cautious and prudent phrenologists, some of whom, considering phrenology to be not inconsistent with Christianity, separated themselves from the parent association, and formed themselves into a "Christian phrenological association."

Mr George Combe suggested a source of fallacy, which applies both to the magnetical experiments of Reichenbach and those of the phreno-mesmerists. If, as is pretended, a magnetiser, by a mere act of the will, can command the thoughts and feelings of the magnetised, without actually touching or approaching his person, may not the manifestations proceed from these acts of volition, and not from physical excitement through touch of each particular organ? If so, the proof of the situation of the organs, supposed to be afforded by phreno-mesmeric experiments, fails. Dr Elliotson's answer to this objection is, that though the will of the operator may be influential, yet this is only one source of power; he had never been able to produce any

effect by mere willing; that in all cases the organs had been excited by the fingers even when his mind was occupied with other matters. It is difficult to understand how, even when otherwise occupied, he could direct his finger to an organ without a very decided act of volition. It is worthy of remark how readily the ground is shifted when any real difficulty or palpable inconsistency is stated. What at one time is insisted upon as an essential and necessary part of the system, is at another, when its presence is inconvenient, quietly set aside and ignored. Principles are advanced and laws laid down, which are being constantly trampled upon, or forced upon our attention, according as the exigency of the case demands.

In connection with phreno-mesmerism a periodical, called the *Phreno-Magnet*, started into a brief existence. "Phreno-magnetic societies" were formed, and all the usual methods of agitation and promotion followed when any new delusion has taken possession of the popular mind.

Mr Colquhoun, whose labours to advance the cause of animal magnetism in this country were second to none, regarded the union of phrenology and mesmerism with alarm, and in a pamphlet entitled *The Fallacy of Phreno-Magnetism Detected and Exposed*, denounced it as "a bastard science—the hybrid offspring of a most unnatural union of phrenology with animal magnetism." Mr Colquhoun advocates the principle, that in certain states of the magnetic sleep the patient is placed completely under the arbitrary control of the magnetiser, and is entirely directed by his *will*, that the minds of the two are in such close *rapport*, that in the latter, for the time, it may be said the former lives, moves, and has being; so that if this be so, the whole paraphernalia of organs necessarily falls to pieces. Mr Colquhoun's argument is but an expansion of the source of fallacy suggested by Mr Combe.

In 1843 *The Zoist, a Journal of Cerebral Physiology and Mesmerism, and their applications to Human Welfare*, was started under the auspices of Drs Engledue, Elliotson, and others. This journal existed for several years, and contains numerous articles on animal magnetism, and records of cases of mesmerism, and advocated the doctrine of materialism and necessity. Through its pages, and those of the *Phrenological Journal*, there may be found notices of what was being done in reference to phreno-mesmerism. The new doctrine does not appear to have taken very deep root, and the public exhibition of its phenomena seems to have had no greater or more useful result than to afford a new source of amusement.

It was in the year 1851 that the "mesmeric mania," as it has been called, reached its climax in this country. The temporary excitement, however, soon subsided, and from that time to the present the whole subject seems to have been consigned to oblivion and neglect, both in this and other countries. Electro-biology was the new name invented by Dr Darling at the time referred to, and imported into this country from America; and under this designation the same phenomena, and a mode of producing them almost identical with that which Mr Braid had discovered many years before, were brought into notice into this country. A disc of metal placed in the left hand, and intently gazed upon for a quarter of an hour in complete silence, sufficed to put boys and girls, as well as adults of a weak constitution, into that peculiar state in which voluntary motion is suspended, the organs of sense and sensation are disturbed, and the brain and intellectual faculties are temporarily placed under subjection to the will of the operator. Mr Lewis, another American mesmerist, was contented to follow the older methods, and was able, by means of the system of passes and gazing, to produce even more striking phenomena than those which were ascribed to electro-biology. When reduced to the electro-biological state, the patient cannot move if at rest, or cease moving if in motion, except by command of the person operating. The senses and sensations are equally under his command. What is cold is felt to be hot, and what is bitter is felt to be sweet, if he pronounces them to be so. Both in private parties and public meetings these phenomena were exhibited and lectured upon, throughout the greater part of this country.

The *Letters to a Candid Inquirer on Animal Magnetism*, by Dr Gregory, give an elaborate description and analysis of the phenomena of animal magnetism, which he considers to be identical with mesmerism, electro-biology, electro-psychology, and hypnotism. We need scarcely say that Dr Gregory regards all the objections raised against his favourite science as illogical and absurd in the extreme; that he admits, almost without question, all the lower as well as the higher phenomena; that clairvoyance, pre-vision, retro-vision, intro-vision, and transference of the senses, present to him no insurmountable difficulties. He is an enthusiastic advocate of, and a firm believer in animal magnetism, under whatever name it is presented to him. Being more of a chemist than a physician, he was less qualified than many other members of his profession to form sound opinions, and a correct judgment, respecting doctrines and practices, the just appreciation of which required no small amount of physiological and psychological knowledge. Of the three most eminent supporters of animal magnetism in this country, it ought to be remarked that one, Mr Colquhoun, was a lawyer; another, Dr Elliotson, was a physician; and a third, Dr Gregory, a chemist.

Our limits do not permit us to discuss at length the numerous interesting and important bearings of the questions relating to animal magnetism and somnambulism. We must content ourselves with stating briefly the following general conclusions:—

I. That it has not been proved that there is any magnetic influence, or nervous fluid, which passes from the operator to the person operated on, and produces in him the various phenomena of magnetic somnambulism.

II. That it has been proved that all the phenomena recorded, which have received sufficient scientific scrutiny to convince men of their truth and reality, can be accounted for on ordinary principles, without the aid of mesmerism.

III. That the lower phenomena—such as sleep, diminished or exalted sensibility, loss of voluntary motion, muscular rigidity, and the like, can be produced by persons acting on themselves by means of fixed staring at objects, which are incapable of giving out any nervous or magnetic influence.

IV. That the evidence which can be obtained of the reality of the existence of magnetic somnambulism, in any case, is inconclusive; that it is possible that the person supposed to be in such a state may really be awake, and simply feigning sleep; and that in many cases there is the most conclusive evidence that the persons pretending to be so affected are impostors, while in other cases, in which no intention to deceive may have existed, the patients have acted under a peculiar state of mind, to which only the weak and nervous are liable.

V. That though numerous cases of surgical operations are recorded in which the patients are reported not to have felt pain, it is probable that some at least may have really experienced painful sensations without giving any outward expression of their sensations; that we have no evidence or means of knowing, except from their own testimony, that they did not really feel pain, but that it is very probable that in some cases, from a peculiar state of the mind acting upon the nervous system, the patients were really rendered unconscious of pain.

VI. That it does not appear from experiment that immunity from pain in operations can be induced, in any but exceptional cases, in Europeans; though it appears, from

the experience of Dr Esdaile, that it can be produced with comparative facility in the natives of India.

VII. That the higher phenomena of clairvoyance, prevision, intro-vision, and retro-vision, do not rest on adequate and satisfactory evidence. That it has never been proved in a single instance, when the necessary precautions have been taken, that a person could read or see objects through opaque substances; and that the alleged instances of the possession of such a power, when put to the test, have proved uniformly unsuccessful, and have amounted to nothing more than attempts at vague guessing. That it has been proved in some cases that the persons pretending to know events which happened at a distance, were fully acquainted with the events through ordinary channels of information. That the description of events pretended to have been discovered by means of clairvoyance has not been in accordance with the truth, unless it has been possible for the patient to employ the usual means of discovering them; and that in most instances there are observed the most manifest attempts, on the part of their friends, to assist clairvoyants by suggestions and leading questions. That the attempts to describe what is going on in the interior of their own bodies, to diagnose diseases in themselves or others, and to prescribe remedies for the cure of the diseases which they pretend to discover, have been complete failures, and mere repetitions of such notions of anatomy, of disease, and of treatment, as they may have acquired by casual reading, conversation, or more careful study.

VIII. That there is no recorded instance, worthy of credit, of transference of the senses—that is, of persons being able to read, taste, smell, or hear, by the fingers, stomach, or any other part of the body, other than the organs by which these functions are naturally performed—and that pretended instances of the possession of such powers have been proved to be cases of fraud and wilful imposition.

IX. That phreno-mesmerism does not prove the truth of phrenology, or throw any light upon the doctrine that the faculties of the mind have a local seat in special parts of the brain, which can be tied up and let loose—mesmerised or de-mesmerised—at pleasure; and that the experiments designed to prove the excitement of the so-called phrenological organs by magnetic operations, have all resulted in manifest failures or impositions when properly tested.

X. That the phenomena described by different authors, under the various designations of animal magnetism, magnetic somnambulism, hypnotism, odyle, and electro-biology, are identical in their nature, and can be explained, in so far as they possess any truth or scientific value, upon recognised physiological principles; that the whole subject has been systematically obscured by its cultivators with a cloud of mystery, which has given rise to difficulties, and placed impediments in the way of rational and scientific investigation. That the real phenomena which not unfrequently occur in the weak and nervous subjects of magnetic operations, are in themselves very remarkable; but that they are not different from phenomena which occur spontaneously; and that they are to be explained by the reciprocal influence exerted by the mind and the nervous system upon each other, and by the unnatural influence thus induced of the nervous upon the muscular systems.

3. *Somnambulism in Germany and other Countries.*—We have already seen that Mesmer attempted to propagate his doctrines in Germany, but not meeting with sufficient encouragement he emigrated to France. He left France in the end of 1784, and retired to Frauenfeldt in Switzerland, where he was visited by Dr Wolfart of Berlin. This gentleman had been engaged in magnetical practice since the year 1808. To him Mesmer left his manuscripts at his death, and a system of Mesmerism was drawn up by Wolfart from these documents and published in 1814.

It was the discovery of magnetic somnambulism, however, by the Marquis de Puysegur in 1784, and the remarkable phenomena developed in that state, which chiefly aroused the attention of the Germans to the subject of animal magnetism. The person who seems principally to have awakened in his countrymen an interest in this revolution which was working in animal magnetism in France, was the celebrated physiognomist Lavater, who resided at Zurich. He opened a correspondence with M. de Puysegur in the latter half of 1785. In November of that year one of his letters was published in Berlin, giving an account of the somnambulency of his wife, and of the surprising phenomena which had resulted from it. (Vide *Berlin Monatschrift*, and *Eschenmeyers Archiv*, for Lavater's correspondence; also Sprengel's *Notes to the Stockholm Sendschreiben*, p. 116.)

In 1788 animal magnetism made great progress in Germany. Separate treatises and letters were published by Hoffman, Wienholt, Rahn, and others on this subject. Bickers of Bremen seems to have been one of those who took up the subject with most zeal. Two letters of his on the subject of Lavater's magnetism were published and republished in several journals in the course of 1787. Wienholt gives an account of the introduction of animal magnetism into Bremen, in the "Vorbericht" to his *Heilkraft*, p. 3. In the same year, C. L. Hoffmann published at Frankfort (on the Main) *The Magnetist*, to which two appendices appeared in the course of the year, besides a reply by Pichler, entitled *The True Magnetist;* and as a mode of testing the reality of the alleged powers, he offered a prize of 100 ducats to the person who could distinguish magnetised from ordinary water (*Kluge*). Eberhard Gmelin of Tübingen was one of the early patrons of animal magnetism on its return to Germany. In 1787 he addressed a letter on the subject to Mr Privy Councillor Hoffman of Mayence; and in 1789 he published new investigations on that subject. (*Salzb. Med. Chir. Zeit.*, 1790, i., 358.) In 1791 he commenced the publication of his materials for *Anthropology*, of which a second volume was published in 1793. (*Salzb. Med. Chir. Zeit.*, 1791, iii., 387.) The views of this author on the analogy of the act of magnetising with that of generation are equally indecent and absurd, and do not merit any farther mention here. Journals were instituted for the collection and diffusion of magnetic knowledge. In 1787–8, Bockmann's *Archives of Magnetism and Somnambulism* was published at Carlsruhe, and extended to eight parts. The *Magnet. Magazin für Nieder-Deutchsland* was published at Bremen, and consisted chiefly of the writings of the opponents of magnetism. At this period, as was afterwards done by Deleuze in France, and Colquhoun in this country, investigations were made by German writers to ascertain how far the new phenomena and doctrines corresponded with phenomena previously noticed, or doctrines previously entertained. In 1788 appeared Kinderling's *Comparison of the Somnambulism of our Times*, with the *Incubation, or the Temple-sleep and Prophecy Dreams of Ancient Times;* and, in the same year, Uster's *Specimen Bibliothecæ Criticæ Magnetismi sic dicti Animalis.* Nor were opponents to the new views wanting in Germany. Councillor Meiners of Göttingen published a work against animal magnetism in 1788. In the same year Josephi published at Brunswick a work on the same subject, as a contribution to the history of human errors; and a similar work appeared at Königsberg, from the pen of Professor Metzger. In 1789 J. A. Murray published at Göttingen an oration in Latin, *De Laude Magnetismi sic dicti Animalis Ambiguâ*, which is mentioned with approbation in the *Salzburg Med. Chir. Zeit.*, 1790, i., 212. As the Hotel Dieu in Paris, and the North London Hospital were opened for magnetical practices, so also we find that, in 1790, the wards of the Charité Hospital of Berlin

were thrown open for a similar purpose by Selle, who was not satisfied with the results (Sprengel's *Zustände*). In the same year appeared Rahn's (of Zurich) *Physical Treatises on the Causes of Sympathy, Magnetism, and Somnambulism*, by which the editor of the *Salzburg Med. Chir. Zeitung* confesses that he was greatly strengthened in his unbelief in animal magnetism. At Vienna, in 1794, Dr Soherr attracted attention by his magnetic and electric cures; but as soon as an order of the court appeared regulating his proceedings, his successful treatment was no longer heard of. At Leipzig, in the same year, a wonderful cure was pretended to have been performed by the Count de Thun (Sprengel, *Zustände*, p. 217).

Dr Pezold of Dresden experimented on animal magnetism, and an account of twenty-two of his experiments was published in the second volume of Reil's *Archiv* for 1797. Some of his patients had convulsions. One or two answered questions put to them by other persons than the magnetiser. Perception in the epigastrium occurred at the same time with hearing in the ears. The subjects of his experiments were chiefly servant-maids, and they were chiefly operated on to excite the wonder and gratify the curiosity of people of wealth, rank, and fashion. These experiments of Pezold, as well as a previous work by the same author, were noticed very unfavourably in the *Salzburg Med. Chirurg. Zeit.*, 1798, iii., 81.

Numerous articles appeared in Reil's *Archiv* on the subject of animal magnetism. In the sixth volume, 1805, two essays were published—the one by Fred. Hufeland, and the other by Fischer. Hufeland's patient was a hysterical female, and long accustomed to the attentions of medical men. She was apparently a great admirer of Hufeland. Fischer's patient was an epileptic, twenty years of age, who knew when he was about to have an attack by the dislike he felt for everything metallic. He had a great liking for sulphur, and was, like Hufeland's patient, a manifest deceiver. Reil's ninth volume contains a paper by Nasse. His patient had been affected with an ulcer on the breast for two years. After fourteen days of animal magnetism, applied in *grand currents*, she fell into the state of somnambulism. From this time she passed from three to five hours daily, for six weeks, in the somnambulic state, produced by magnetic manipulations. She could not rest at any time content without the presence of her magnetiser. They sat opposite to one another. She sat with her feet on a small footstool, and, as often as his fingers were pointed to her, she saw light streaming out from them towards her. Had she lived at a later period in the history of animal magnetism, she would have proved an able assistant at the odylic experiments of Baron Reichenbach. Her case might be claimed as an additional testimony to the truth of the Baron's discoveries, if it had not been shown that these luminous phenomena are merely subjective sensations, readily produced in nervous and hysterical females. This patient was also clairvoyant, and could see with the eyelids closed. Other cases are related in Reil, but those already given are sufficient to indicate their value. In the twelfth volume will be found Nasse's somewhat useless experiments on the influence of animal magnetism on the growth of plants.

From the time of the French Revolution till near the end of the war, there was, as we have seen, an interruption in the general practice of animal magnetism in France; but its employment in the cure of diseases was adopted by a considerable number of German physicians, and various little essays and reports of cases were published in the different journals from 1787 to 1811, when a more elaborate treatise on animal magnetism was published by Professor Kluge, a work which embraced and combined all the theoretical views which had been adopted and the practical observations that had been made previous to its appearance. Lectures on the subject were delivered two years previously by Professor Spindler in Wurzburg. Kluge's work, *Versuch einer Darstellung des Animalischen Magnetismus als Heilmittel*, is divided into two portions—a theoretical and a practical. In the former, he gives a history of the discovery of animal magnetism, and a review of the magnetic phenomena, as they are witnessed both in the magnetiser and in the magnetised. After noticing the various magnetic operations, both general and particular, he proceeds to give a determination of the magnetic degrees, which he divides into six. He next offers an explanation of the magnetic phenomena, and the mode of operation of the nerves, for the purpose of elucidating the phenomena. In the latter, he describes the qualities of the magnetiser, under the two heads, physical and psychical. He then gives an account of the various magnetic operations, and describes the cases in which their employment is indicated.

According to Kluge, we may, in the first place, conformably with Hufeland's sketch, distinguish the following leading or principal grades in animal magnetism, viz., the purely physico-magnetical state, without participation of the mental, and the magnetic state with psychical affection, of which again there may be two forms, either simple exalted sensibility, or combined with exaltation of the inner sense. These three principal grades are again subdivided each into two particular grades, thus producing a sixfold series.

In the *first* degree, the common entrances by which the mind (*psyche*) stands in connection with the external world are still uninjured. The sensibility remains unclosed, and keeps the persons constant in the sphere of the usual, whence this state may be called the degree or grade of waking.

If the person reaches a higher degree, then the sensibility is in part closed; but the greater part of the senses give him still a knowledge of surrounding objects, and only the sense of distance (the eye) withdraws itself from the government of the will, and passes into the state of a momentary objectlessness. This *second* degree of simple disturbed sensibility is named by some magnetists half-sleep, or imperfect crisis. If the whole sensibility retreats, then the individual passes over from the connection with the outer world, and goes to inner darkness. This relation, characterising the *third* degree, comes very near the state of stupor, and is designated by the name of magnetic sleep. Passed from life, and sunk into himself, man stands here on the limits of two very different worlds, at the dark gate of the passage into a higher and better existence. It is remarkable that memory is carried over from actual life, through this degree of darkness, to the higher degrees, and on the return through this degree, this new link remains behind, and is not brought over into the waking state. If, accordingly, in those higher states, memory resembles an unbroken chain, all the links of it which fall within these states are lost for real life. If the individual wakes, not from that sleep, but within himself, consciousness returns to him as from a confused dream, and he again feels distinctly himself and his state. He is sleeping, but waking in sleep, and now in so far master of sleep, that though he cannot indeed extinguish it, yet he is not confined by it, but can go out from himself and carry himself out. Already cut off by the preceding degree from life in external things, and brought out into the magnetic sphere, he now lives within it—lives, therefore, only in it—and in dependence on the things associated with it. This dependence has reference chiefly to the magnetiser, through whom he, to a certain degree, feels, thinks, and acts, and who is to him like a new organ, by means of which he is replaced in a very peculiar connection with external objects. So far from the loss of his freedom being painful to him, and his dependence on his magnetiser oppressive, this relation is to him exceedingly agreeable. When in his vicinity, he feels himself as in a region in which he delights to live and breathe; and when at a distance from him, as if cast into a wilderness, forsaken and tormented with feelings of home-sickness.

The *fourth* degree is mentioned in the writings of the magnetists, frequently under the names of *perfect crisis*, and also of *simple somnambulism*. To the patients themselves are given the names of *somnambule*, *somnilogue*, and *crisologue*. From the preceding degrees, it differs by the peculiar relation of the connection with the external world, and from the subsequent degrees, by the circumstance that in it the consciousness is of its natural character; but in them it is exalted. As the patient in the transition from the

second to the third degree returns into himself, so also in passing from the fourth to the *fifth* degree, he again returns back into himself, not, however, to the same dark confusion, but to internal self-intuition. By his common sensibility, raised to a degree of strength it did not previously possess, and by his exalted consciousness, he acquires a clear and luminous knowledge of his own interior condition of body and mind, marks the morbid phenomena occurring as necessary consequences in the most precise manner, and determines the most efficacious means for their removal. This, his inwardness, he maintains also in the case of other persons placed in magnetic relation with him. The connection with the magnetiser is closer than before, and consequently the dependence upon him is greater, but at the same time the pleasure of magnetic existence is increased. From the *fifth* degree, which is also named the degree of self-intuition, all the succeeding magnetic states are comprehended under the denomination *clairvoyance*, and to the patients involved in them is given the name of *clairvoyants*.

In the *sixth* degree, the patient again passes out from himself and into a higher union with the whole of nature. The clearness that exists in self-intuition, expands over the near and the distant in space and in time: and hence this state is called the degree of general *lucidity*, or *ecstasy*. The patient is withdrawn from everything little or earthly, and elevated to greater and nobler feelings. The highest tranquillity, innocence, and purity, which proceed from his whole constitution, give him the appearance of an angel. The connection with the magnetiser is so close, that the patient knows his thoughts most intimately, and hearkens to his mere volition. The feeling of this state must border on spirituality.

There is still a higher degree, which Kluge does not enumerate, because, on the one hand, its properties are lost to us; and, on the other hand, it does not belong to the phenomena of rationally conducted magnetic treatment. It is the degree of *transport* or *rapture*, in which the person enters into himself for the third time, so far that the intellectual part seems to be completely withdrawn, and life to be entirely transported from the sphere of the animal into that of the vegetable kingdom. Destitute of sensation and consciousness, the person remains for a shorter or longer period in a state of such apparently spiritual non-existence, that on awakening, and even during his magnetic sleep, he has no recollection of it, and may, in case of the frequent return of such a state, pass very readily into that of a permanent confusion of mind.

Kluge was the principal surgeon to the Prussian medico-chirurgical Pepinière, and a man of considerable standing in his profession. He, like Gmelin, Reil, and other German magnetists, attempted to explain the phenomena of mesmerism and somnambulism on the theory of a nervous atmosphere. In the third part of his work he discusses the mode of operation of the nerves, the relation of the ganglionic to the cerebral system, the influence of volition and the passions upon the operation of the nervous atmosphere, and attempts to elucidate in this way the magnetic phenomena. When we compare this theory with that of Mesmer, and the earlier cultivators of animal magnetism, we shall find that it saps the foundation on which Mesmer constructed his system, and converts the universal fluid which fills space, and has existed through all time, into the merest ephemeral emanation. A nervous atmosphere depending for its existence upon the presence of perishable organisms, is but a fleeting cloud when compared with the mighty all-pervading physico-dynamic power, which, in the hands of Mesmer, accounted for all the magnetic phenomena. We have already seen, in our account of Dr Esdaile's experiment, that he had adopted this theory of a nervous atmosphere or emanation, and there can be no doubt that he derived it from a German source, as, in the appendix to his *Mesmerism in India*, he gives abundant evidence of his acquaintance with the proceedings and opinions of the German magnetists. We may remark that the work of Kluge, strange as it may appear to English readers from the extracts we have given from it, contains less extravagant opinions than some of the other German writers on this subject; and though some of the cases reported by him in support of his views are sufficiently absurd and ridiculous, the whole style and tone of his work is more rational than that of the generality of the German magnetical writers.

In 1812 regulations were published relative to the practice of magnetism in the Prussian states. (Hufeland's *Journal*, xxxv., 125.) In 1813 the Baron Von Strombeck published at Brunswick an account of an animal magnetism produced by nature alone, and of a cure effected by it. To this a reply was published at Cassel in French (*par un ami de la Vérité*), which was answered by Strombeck, whose reply was translated into French and published at Paris in 1814 (Stieglitz, p. 463). In 1814 Dr Stieglitz, physician to the King of Hanover, published a work on animal magnetism, in which he treated of its phenomena and theory, of the magnetic sleep, of the knowledge of their own diseases possessed by somnambulists, of the cure of diseases by animal magnetism, and many of the more important questions belonging to this subject. It is curious to remark how many of the court physicians of Germany at this period were disciples of Mesmer, or at least believers in and defenders of some one or other of the many protean forms of the doctrines which are usually associated with his name. Besides Stieglitz of Hanover, we have Hufeland, physician to the King of Prussia; Brandis, physician to the King of Denmark; and Klein, physician to the King of Wurtemberg. An abstract of Stieglitz's work, published at Berlin by Hufeland in 1816, called forth a reply from Wolfart in the same year, which led to the publication in the following year of explanations by Hufeland.

While the German magnetists were thus engaged in developing new theories, and were wandering far away from the orthodox doctrines of the founder of animal magnetism, Dr Wolfart of Berlin, who had become engaged in magnetical practice in 1808, betook himself to Frauenfeldt in October 1812, and visited Mesmer, who confided to him his manuscripts, out of which he drew up a system which he published at Berlin in 1814, under the title of *Mesmerism, or System of the Operations, Theory, and Application of Animal Magnetism, as the general Curative for the Preservation of Mankind*. This work was revised by Mesmer, and received his warmest approbation. Mesmer died in 1815, and left his harmonican as a legacy to Wolfart, who published in the same year *Commentaries on the Aphorisms of Mesmer*. In Berlin, Wolfart enjoyed opportunities for the observation of the phenomena and effects of animal magnetism which no individual is likely ever again to possess. The Prussian government gave him an hospital for the reception and treatment of all kinds of diseases by means of that remedy. Besides being director of a magnetic clinique, he was a professor of the Faculty of Medicine in the University of Berlin, Knight of the Iron Cross, and of the order of St Anne. In 1818 he commenced a journal entitled, *Jahrbücher für den Lebens Magnetismus, oder neues Asclepieion, Allgemeines Zeitblatt für die Gesammte Heilkunde, nach den Grundsätzen des Mesmerismus*, which was continued till 1823, and consisted of 5 vols. The title *Asclepieion* was derived from a journal of that name published in 1811. The *Annals* contain numerous reports of cases and papers by different writers. At the commencement of the fifth volume he has recorded the general results of his practice in a statistical report of hospital and private practice. He mentions that he had seen about fifty somnambules; but it was chiefly the curative effects to which his attention seems to have been turned. Weisse states that, after graduating at Dorpat in 1815, he came to Berlin, where he attended the private clinique of Wolfart.

"I studied mesmerism," he says, "heard Wolfart lecture on general therapeutics according to mesmerian principles, and was for almost half-a-year nearly daily present at his magnetic manipulations, and likewise very often at the treatment by the *baquet*. By what I saw, my belief in

the healing power of magnetism grew into conviction. I saw many diseases give way under the magnetic treatment only. I had not here had opportunity to see clear-seeing somnambules, for Wolfart, not insane, like so many others, steered clear on this point, and even when he had subjects, did not present them publicly like marvellous beings, but in a quiet manner so employed this salutary state as not to give to the somnambule himself a temptation to vanity, and to the deceptions springing from that source."

The number of patients treated daily in the magnetic clinique of M. Wolfart amounted to more than 200, most of whom had themselves magnetised in the morning by particular manipulations, and the number so operated on was much more considerable than the number who were treated at the baquet. It is worthy of note, that besides mesmerism, he employed other remedies, such as purgatives, emetics, &c. Physicians were sent from Stockholm, from St Petersburg, and from Vienna to study under Wolfart.

At this period animal magnetism appears to have reached its culminating point in Germany. It was adopted as a true and authentic doctrine by many of the most eminent physicians and men of science; and it appears to have obtained a greater hold on the scientific mind of Germany than it ever had in any of the other countries of Europe. Besides Wolfart's *Jahrbücher*, another periodical, the *Archives of Animal Magnetism*, was conducted from 1817 to 1821 by Kieser, Nasse, and Nees Von Esenbeck. This journal represented the German school of somnambulism, and is full of the most remarkable cases of clairvoyance, transposition of the senses, introvision, prophecy, and the development of supernatural powers of knowledge. Our space will not permit of the quotation of any of these cases, which are equal in extravagance and incredibility to any that have ever been published.

Before concluding this brief sketch, we must still notice another phase of animal magnetism in Germany—viz., the system of Tellurism—propounded by Dr Kieser of Jena, and published at Leipsig in 1823. This work is entitled *System des Tellurismus, oder thierischen Magnetismus.* The tellurism of Kieser, though it resolves itself substantially into somnambulism, is as great a departure from the doctrine of Mesmer as that of Kluge was. The universal fluid of Mesmer, and the nervous atmosphere of Kluge, become in the hands of Kieser a telluric spirit. Though this essence might be supposed, from the appellation which has been given to it by its discoverer, to belong peculiarly or exclusively to the earth or tellus, we find that it is not so restricted, but is a property of other bodies of the solar system. By night the moon is said to magnetise the dwellers on the earth, while the sun demagnetises them in the morning. This new system was carefully elaborated by its author; and by its ingenuity, and the harmonious development of its parts, it secured the favour and countenance of some eminent men, though in reality it was nothing more than the old doctrine of somnambulism dressed up in a new name. The fact that this work of Kieser's passed through several editions unchanged sufficiently indicates the powerful hold which it took of the public mind.

From the time of its publication till the appearance of the *Researches of Reichenbach*, no attempt at an introduction of a new system or theory of animal magnetism seems to have been made. The work of Reichenbach, however, was not received with favour by his countrymen; and but for its translation into English by the late professor of chemistry in the University of Edinburgh, would probably have been little heard of. In consequence of this circumstance, we have already noticed the work of Reichenbach in connection with the history of somnambulism in Great Britain. Besides the works already referred to which have a claim upon our attention, from the pretensions which they set forth of treating the subject of somnambulism in a scientific manner, there are other productions of the German press which, from their extravagance and absurdity, are scarcely worth even a passing notice. We allude to such works as—*The Prophetess of Prevorst; Revelations on the Inner Life of Man, and on a World of Spirits extending into our Sphere*, by Justinus Kerner, published at Stuttgart in 1832; and *Finger-marks of God in divine Revelations for the celestial and terrestrial Salvation of a Somnambule*, published at Leipsic and Weimar in 1838. We might with equal advantage undertake to explain the incoherent ravings of lunatics, upon any department of science, religion, or morals, which might form the subject-matter of their delusions, as attempt to analyse or discuss such lucubrations as these.

The history of somnambulism in Germany is, as we have seen, associated with the names of many eminent men, to a greater extent perhaps than in any other country. The magnetic doctrine also penetrated into Russia through German channels. Lichtenstædt published *Researches on Animal Magnetism* at St Petersburg in 1816; and Professor Reiss, chemist in Moscow, made experiments in 1817. It also spread into Denmark, Sweden, and Holland; but in none of these countries were any new investigations made worthy of special notice. In Italy, an elaborate work on the theory and practice of animal magnetism, by Verati, was published, in 4 vols., at Florence in 1846.

From the United States of America we have derived, at the hands of Dr Darling, that modification of the doctrine which he has styled Electro-Biology; and to some extent we are indebted to that country for the hybrid science of mesmero-phrenology. The Spirit-Rapping mania which recently invaded the United States speedily eclipsed all the lesser forms of delusion; but, following the fate which sooner or later overtakes all such preposterous schemes, its glory has already waned, and the spiritualism, as it is now called, of the present day is neither more nor less than our old friend Clairvoyance under a new name.

A perusal of the foregoing brief review of the progress of the theory and practice of animal magnetism and somnambulism in different countries, will have convinced the reader that it must be a very difficult task to attempt the physiological and psychological analysis of all the varied phenomena which have been observed, or which have been supposed to occur in these states; and some perhaps may be of the opinion that such an analysis, if possible, might be attended with little profit. The space allotted to this article forbids our entering into such a discussion of the subject, and we have thought it best therefore, in the foregoing narration of the different phases which this protean subject has assumed, at different times and among various nations, to introduce very briefly such criticism and reflections as might of themselves conduct the reader to the justest view of its truth or falsehood. We would more especially refer to the general conclusions stated in pp. 441 and 442, as presenting a fair view of the result of an impartial estimate of some of the more remarkable of the magnetic phenomena. But at the same time we feel that the whole subject cannot be finally dismissed without some statement of the general impression which we conceive is left upon the mind of the physiologist by a candid examination of the whole evidence which has been adduced in favour of the existence of the animal magnetic or somnambulic state. That impression appears to be briefly as follows:—That the peculiar condition of nervous excitement into which many so-called susceptible individuals are thrown by the very various practices of the magnetisers, is not, in all instances, as is often supposed by the opponents of the system, unreal, or voluntarily assumed for the purposes of deception, but, on the contrary, may be a real and an involuntary state of their nervous system; and it is equally certain that it is due to the influence of the patient's own

mind upon his body. The notion that the magnetic state, in so far as it is real, can be directly induced by the will of the operator, and the opinion that it may be due to any unseen influence, or to the agency of any physical or vital force, known or unknown, passing between the body of the operator and his patient, are entirely devoid of all credit. The extent to which the mind is known to be capable of influencing the condition of the body, is not by any means greater than that which is manifested by any of the physiological states of magnetic somnambulism which can be admitted to be real or established. That some deception has existed among the practisers of magnetism, and still more among those who have professed themselves susceptible somnambulists, there can be no doubt; but this does not warrant the rejection of the whole of the evidence in favour of the reality of some of the phenomena exhibited. Indeed, it seems certain that the deceptions practised would never have been attempted but upon the basis of some credible and real phenomena. Those phenomena, which we are inclined to admit as real, though they may appear very extraordinary to the uninstructed, are in truth not more remarkable than, nor different from, those known to physiologists and pathologists as liable to occur in certain states of the organism, in the production of which the supposed magnetic agency can have had no share. It seems almost unnecessary to add, that among the possible or real phenomena of the magnetic or somnambulic state, we do not include any of the exhibitions of clairvoyance, or transference of the powers of the senses from their natural seats to other organs. In respect to these we do not hesitate to affirm, that upon due examination and trial they have all proved to be miserable failures, and that after an unbiassed consideration of the result of such examinations, nothing but the most perverse or weak credulity could lead any one to place reliance in the statements of the supernatural powers alleged to be acquired in the states to which the names of clairvoyance, lucidity, pre-vision, self-intuition, and the like, have been given. In conclusion, we would remark that the whole subject is fraught with the deepest interest, not only in a physiological point of view, from the striking illustrations which the so-called magnetic phenomena afford of the relations between the natural and unnatural conditions of the nervous system; but still more in its psychological aspects, from the vivid picture which the subject presents of the extent to which many persons, and frequently even those of superior mental power and acquirement, if of a theoretical turn of mind, allow themselves to be misled by the careless observation of phenomena, and by loose reasoning upon their causes; and from the many examples which it furnishes of the peculiar and forcible influence which the principles of imitation, vanity, and love of notoriety exercise on the human mind; leading many persons who would not otherwise be deceivers to make themselves the willing and yielding subjects of magnetic experiments, in the performance of the various feats of which they experience the greatest pleasure, and in which they come to acquire so much dexterity that they end by making dupes of operators, who fondly imagine that in leading on their patients to the performance of the most incredible jugglery, they are advancing the cause of scientific truth by philosophical researches. (A. T—N.)

SOMNAUTH, or Somnath Pattan, a town of India, in the Guicowar's dominions, on the S.W. coast of the peninsula of Guzerat, 28 miles N.W. of Cape Diu. It is surrounded by a thick and strong wall, which is further strengthened by a ditch on all sides, except where it is washed by the sea. The situation of the town is very fine, commanding a wide prospect over the Arabian Sea. It contains numerous mosques, but is chiefly remarkable for a celebrated temple, which stands on a hill to the north-west. This building is not very large, its internal dimensions being 96 feet by 68; but it is now in a very dilapidated condition. It once attracted immense crowds of worshippers at certain seasons, and was attended by a vast number of Brahmins, and other dependants. The town has a good harbour and a considerable trade. Pop. 5000.

SOMNER, William, an eminent English antiquary, was born at Canterbury in 1598 or 1606. His first treatise was the *Antiquities of Canterbury*, which he dedicated to Archbishop Laud. He then applied himself to the study of the Saxon language; and having made himself master of it, he perceived that the old glossary prefixed to Sir Roger Twisden's edition of the laws of King Henry I., printed in 1644, was faulty in many places, he therefore added to that edition notes and observations valuable for their learning, with a very useful glossary. His *Treatise of Gavelkind* was finished about 1648, though not published till 1660. Somner was zealously attached to King Charles I.; and in 1648 he published a poem on his sufferings and death. His skill in the Saxon tongue led him to inquire into most of the European languages, ancient and modern. He assisted Dugdale and Dodsworth in compiling the *Monasticon Anglicanum*. His Saxon Dictionary was printed at Oxford in 1659. He died in 1669.

SONATA (*Ital.*), a piece of music, consisting of various movements for a single instrument, with or without accompaniment. The name has sometimes been given to certain vocal compositions, in which all the voices are equally essential. Some of the most remarkable modern sonatas are for the pianoforte, such as those of Haydn, Mozart, Beethoven, Clementi, Dussek, &c. Formerly sonatas were classed as *sonate di camera* and *sonate di chiesa*—i. e., *chamber-sonatas* and *church-sonatas*—on account of their difference of style, and the place of performance.

SONDERSHAUSEN, a town of Germany, capital of Schwarzburg-Sondershausen, on the Wipper, 34 miles N.N.W. of Weimar. On a hill near the town stands the palace, which is the residence of the prince, and contains a museum of antiquities. Trinity church is a large and splendid building; and the town has also a theatre, gymnasium, and other schools; an hospital, jail, &c. Pop. 5117.

SONDRIO, a town of Lombardy, capital of a province of the same name, on the Adda, 57 miles N.N.E of Milan. It contains numerous churches, a theatre, hospital, gymnasium, and other schools, courts of law, &c. The Malero, a mountain-stream, which here joins the Adda, has several times destroyed the town by its inundations; but it is now confined by strong stone erections in a deep and wide bed. Pop. 4731.

SONE, or Soane, a river of India, rises in the territory of Nagpore, on the lofty table-land of Ulmmunkuntuk, 4 or 5 miles E. of the source of the Nerbudda. It flows at first north-west; and after leaving Nagpore, separates the British district of Saugor and Nerbudda from the Rajah of Rewa's dominions. Further down, it turns and flows alternately north-east and east, through the territories of Rewa; traverses the British district of Mirzapoor; and finally separates that of Shahabad from those of Behar and Patna. It falls into the Ganges 10 miles above Dinapore, after a course of 465 miles. Its tributaries almost all join it from the right or south-west side; the chief of them are the Rehund, Kunker, and Koel. Below the confluence of the last of these the river is broad and deep, and is navigable during the rainy season for boats of 10 or 12 tons, though the passage is tedious and dangerous.

SONG, in *Music*, in a general sense, applies to melody, whether vocal or instrumental. It is usually applied to an air adapted to the words of a short poem. Sometimes, with an adjunct, it means a particular form of melody, as *plain song* (Fr. *plain chant;* Ital. *canto piano*, or *canto fermo*). Among songs, the most characteristic and interesting are the national ones of various countries. To the influence of national song may be traced those remarkable changes and improvements in the style of melody, with regard to freedom and expression, that are so perceptible in the music of professed composers within the last two centuries.

SONNINI DE MANONCOURT, Charles Nicolas Sigisbert, a French naturalist, was born of a good family, at Lunéville, on the 1st of February 1751. After having completed his education at the Jesuit University of Pont-à-Mousson, he became acquainted with Buffon and Nollet, who encouraged his taste for natural history. He obtained a commission in the marine engineer service, and was sent to Cayenne, where he distinguished himself so much by his energy and perseverance that he was made lieutenant on his return to France. He again visited Cayenne in 1775; but finding his health give way, he was induced to pass a winter as the assistant of Buffon. He subsequently joined the African expedition of Baron de Tott in 1777, and visited Egypt, Asia Minor, and Greece, before his return to France in 1780. He busied himself in agricultural affairs, and was appointed one of the administrators of the department of Meurthe. He contributed the volumes of fishes and cetacea to Buffon's *Natural History*, wrote part of the volumes on reptiles, edited a dictionary of natural history, and published several volumes of *Voyages* in Egypt and in Greece. Sonnini set out for Moldavia in 1810, but died on his return to Paris, from the effects of a fever which he had caught during his travels in the East. He deserves much credit for his labours as a naturalist; while in the department of archæology and topography his researches were not distinguished by any degree of originality. A complete list of the works of Sonnini will be found in the *Biographie Universelle*.

SONORA. See Mexico.

SONSONATE, a town of Central America, San Salvador, at the mouth of a river of the same name, in the Pacific Ocean, 50 miles W.S.W. of San Salvador. It contains several fine churches and convents, and manufactories of spirits and other articles, and has an active trade in indigo and tobacco. Pop. 6500.

SONUH, a town of British India, in the district of Goorgaon, 39 miles S.W. of Delhi. It stands in a long valley, which stretches from S.W. to N.E., and is enclosed by hills from 300 to 400 feet high. It contains a bazaar, and on a height there is a fortress used as a place of refuge against freebooters; but the most remarkable building is that built over a sulphureous spring, which is much resorted to by the inhabitants. It consists of an antique dome, surrounded by the apartments of the Brahmins, who take charge of the edifice. The water is used with good effect for many diseases. Pop. 8513.

SOOLOO ISLANDS, a group in the East Indian Archipelago, lying between Borneo on the S.W., and the Philippines on the N.E.; and separating the Sea of Sooloo on the N.W. from that of Celebes on the S.E. It consists of nearly 150 islands, but most of them are of very small size. There are three principal groups clustering round the three largest of the islands, which are Basilan in the N.E., Sooloo in the centre, and Tawee-Tawee in the S.W. The first of these lies south of Samboangan in Mindanao, from which it is separated by a narrow strait. It is 42 miles long by 6 broad; and while the coasts are low, it rises to a considerable elevation in the centre. The soil is fertile; and the island exports rice, birds'-nests, pearls, mother-of-pearl, and tortoise-shell. Its population is 20,000. The only other important island in this group is Pilas, lying to the west of Basilan. The dimensions of Sooloo are 40 miles by 10, and its area is 212 square miles. It has two hilly regions, with a tract of low country between; and the soil is for the most part fertile and well wooded. Teak and sandal wood, cocoa and other nuts, bananas, yams, &c., are produced in this island; and many of the inhabitants are employed in pearl-fishing, and obtaining the edible birds'-nests. The population of this island is variously estimated from 60,000 to 200,000. In it is a small town, called Sooloo or Soog, where the sultan of the whole group resides. The island of Tawee-Tawee is about 40 miles long by 12 broad; and like the others it has some considerable hills. Its productions are similar to those of the other islands of the group. The sultan of Sooloo and his subordinate chiefs were formerly notorious for their piracy, and kept up a large fleet for that purpose; but their power has been entirely broken by the Spaniards in 1851. The seas, however, are still much infested with pirates, which prevents the full development of the commerce of these islands.

SOPHIA (Bulg. *Triaditza*, Anc. *Sardica*), a town of European Turkey, Bulgaria, in a wide plain on the Bogana, at the northern base of the Balkan Mountains, 310 miles W.N.W. of Constantinople. It is a large place, and looks well from a distance, with its castle and numerous mosques, but the houses are in general mean and ill built; and the streets narrow, crooked, and dirty. Besides the mosques and churches, Sophia contains large and well supplied bazaars, khans, and warm baths. The churches belong both to the Greek and Roman Catholics; and the latter have also here two convents. As this town stands on the great high road from Constantinople to Belgrade, it is a place of considerable commerce, which is chiefly in the hands of Greeks and Armenians. Cloth, leather, and tobacco, which are manufactured here, are the chief articles of trade. Sophia was formerly the residence of a pasha, and still gives a title to a Greek archbishop and a Roman Catholic bishop. It was founded by the Emperor Justinian, on the site of the ancient Sardica, and still contains some remains of the church erected by that monarch. Sardica was celebrated for an ecclesiastical council held here in 347, which occasioned some controversy in connection with the papal authority. Pop. 46,000.

SOPHISM. See Fallacy and Logic.

SOPHIST (Σοφιστής), the name which inqurers after the σοφία originally assumed to themselves in Greece, previous to the time of Pythagoras, who is said to have originated the more modest title of *philosopher*. In time the term sophist came to imply those who, like Protagoras, Prodicus, and Critias, &c., believed that the σοφία was not only unattainable, but that no relative degree of it was possible for the human faculties. This scepticism as to science naturally gave rise to eloquence and other branches of art, which the sophists taught often with much èclat in the various towns of Greece. Protagoras' maxim that "man is the measure of the universe," indicates how thorough-going was the scepticism of the sophists. Plato, who allows no opportunity to escape him of holding up these men to scorn, is censured by Lewes in his *History of Philosophy*, and by Grote in his *History of Greece*, for his unfair representations of this class.

SOPHOCLES, perhaps the greatest tragedian of ancient times, was the son of Sophilus, and was born at Colonus, an Attic village, which lay rather more than a mile to the north-west of Athens. The only respectable ancient biography which now remains of the great tragedian assigns his birth to Olymp. 71. 2., B.C. 495. The Parian marble makes it occur two years earlier; but this date is rejected by the majority of biographers, on account of its not harmonising well with the other recognised dates of the poet's life. Supposing, then, that Sophocles was born in 495 B.C.,

he was five years old at the battle of Marathon, fifteen when Euripides first saw the light, and when the battle of Salamis was fought; and ere he had completed his eleventh year, all Greece rang with the fame of Æschylus, the father of the Greek drama. Æschylus, who was the cotemporary of Simonides and Pindar, was born in 525 B.C., or thirty years before Sophocles. Some have made the father of the tragedian a common carpenter, a common smith, and a common sword-maker; while others, equally uninformed, have made him a master sword-maker, a master smith, or a master carpenter. Without attempting to determine the precise trade or profession of Sophilus, it is obvious that he must have held a very good position among the inhabitants of Colonus, for he gave his son an education very little, if at all inferior to what was commonly received by the sons of the most distinguished citizens of Athens. In music and gymnastics, the two leading branches of a Greek education, Sophocles gained much distinction, and received the prize of a crown of garland. So great an adept was he in music, and so much was his youthful beauty esteemed, that he was selected by the Athenians, in his sixteenth year, to lead the chorus and dance naked, with lyre in hand, round the trophy of the victory of Salamis.

Sophocles, doubtless, had his attention early directed to the triumphs of Æschylus in the drama; but it does not appear that he ever received any more special instruction from that dramatist than the study of his tragedies might be supposed to bestow. In the year 468 B.C., when Sophocles had reached his twenty-seventh year, he came forward at the solemnities of the great Dionysia to oppose the veteran Æschylus in a trial of dramatic skill. Cimon, who had just returned from a successful expedition against the pirates of Scyros, and who had brought back to Athens the bones of Theseus, happened to enter the theatre at the time, along with his nine colleagues, to pay the accustomed offering to the god Dionysus, when Aphepsion, the archon, whose duty it was to elect judges for the dramatic contests, thought that he could not better exercise the trust which had devolved on him, than by administering to these warriors the oath appointed for the dramatic judges. Cimon and his colleagues accordingly took their place on the judges' bench; and after the recital was heard, Sophocles received the first prize, and Æschylus the second. The veteran dramatist, who had never known rivalry for a generation, is said to have been so mortified at this defeat that he left Athens, and retired to Sicily. The drama which Sophocles exhibited on this occasion is supposed to have been the *Triptolemus*. (See Welcker, *Die Griechischen Tragödien.*) For the next eight-and-twenty years Sophocles must have held the supremacy of the Athenian stage, until a formidable rival arose in Euripides, who gained the first prize for the first time in 441 B.C. Sophocles gained in all twenty times the first prize, several times the second, but never the third. Nothing is known regarding this period of his life. He brought out the *Antigone*, the first of his extant dramas, in 440 B.C. The shrewd reflections on public matters expressed in this play induced the Athenians to number him among the ten *Strategi*, of whom Pericles was the chief. The war which the *Strategi* had then to conduct was that against the aristocratical faction of Samos, which lasted for more than a year, during 440 B.C. and 439 B.C. It was on this occasion that Sophocles became acquainted with Herodotus, who was then residing at Samos; and he is said to have written a lyrical poem for the father of historians. The dramatist seems to have preserved his cheerfulness of temper, and his wonted tranquillity of mind, amid the din and bustle of war. He quietly contemplated human affairs, if he did not take an active share in conducting them. As Pericles said of him, he understood the making of poetry, but not the commanding of an army. This is one of the numerous testimonies which may be brought forward in evidence of the position, that a man, whose genius runs freely in the channel of reflection, can never be a man of action in any high and emphatic sense. To speak of what men are originally capable can never be brought to the test of proof; and while human nature remains as it is, no amount of preconcerted theory can reverse the palpable evidence of fact. It was the case of Sophocles, as it had been before of Æschylus, that poetry was the business of his life, and to it he devoted his entire strength.

Regarding the second period of Sophocles' greatest poetical activity, from his fifty-sixth year till his death, or from 439 B.C. to 406 B.C. or 405 B.C., very little personal is known. He is said to have written 130 dramas; but Aristophanes, the grammarian, pronounced 17 of them spurious, which leaves 113 genuine tragedies and satirical dramas. More than two-thirds of his works belong to the latter part of his life. The chronological order of his extant dramas, so far as it can be ascertained, is as follows:—*Antigone*, *Electra*, *Trachinian Women*, *King Œdipus*, *Ajax*, *Philoctetes*, and *Œdipus at Colonus*. The last play was brought out by the grandson of the dramatist in 401 B.C., some years after the author's death. Those who may care to see a careful analysis of these plays can refer to Müller's *History of the Literature of Ancient Greece*, and to A. W. Schlegel's *Lectures on Dramatic Literature*. Sophocles likewise wrote an elegy, several pæans, and other minor poems, and a prose work on the chorus. There is a beautiful story, bearing strong marks of authenticity, which usually accompanies all biographies of Sophocles. His family consisted of two sons, Sophon, the offspring of Nicostrate, a free Athenian woman, and Ariston, the son of Theoris of Sicyon. Ariston had a son named Sophocles, to whom allusion has just been made, and to whom his grandfather showed the greatest affection. Sophon, who, by the laws of Athens, was his father's rightful heir, dreading an alienation of the paternal property in behalf of young Sophocles, summoned the old dramatist before the *phratria*, and urged a plea of mental incapacity, induced by old age. Sophocles at once answered, "If I am Sophocles, I am not beside myself; and if I am beside myself, I am not Sophocles." He then read from the magnificent *parodos* to his unpublished play, *Œdipus at Colonus*, beginning, Εὐίππου, ξένε, τᾶσδε χώρας; and when he had finished, the judges dismissed the case, and rebuked the ungrateful prosecutor. The poet was allowed to pass the remainder of his days in peace. He died either towards the end of 406 B.C., or the beginning of 405 B.C., at the extreme age of ninety. The reports of his death vary. Some would have us believe that he was choked by a grape-stone, some that he died of an affection of the throat, occasioned by a public recitation of his *Antigone;* while others, with equal improbability, would make him die of joy at the announcement of a victory obtained by one of his dramas. He was buried in the tomb of his ancestors, near Deceleia.

The mind of Sophocles was as full and as symmetrical in its development as his bodily form was handsome and his expression beautiful. His passions, in the early stage of his career, appear to have been wild and turbulent, and it was only when he brought the weight of experience to balance them that he was able to keep in check that tendency to sensual pleasure in which his enemies accuse him of having indulged. The solidity which a man gains by years, if not seasonably checked, is apt to crystallize, and the idle scandal-mongers of Athens, who could no longer gloat over the youthful follies of the successful dramatist, sought to tarnish the lustre of his genius by whispering the avarice of the poet into the ears of his fellow-citizens. The comic poets of his day ranked Sophocles with Simonides, both, as they said, prostituting the divine gift which

the gods had given them for a piece of base gold. If anything more than the expression of the petty envy of inferiors, this statement is not likely seriously to damage the brightness of the fame of Sophocles in the eyes of a modern reader. If the charge is true, all that a man now-a-days is likely to remark regarding it is, that it proved the good sense of the poet in not squandering his earnings or giving free rein to the habits of the spendthrift. A spirit of evenness and tranquil contentment, of piety and of cheerfulness, seem to have attended him to the grave. The fine spontaneity of genius which he signally illustrated in his dramas was notably visible in his life. A noble simplicity and tenderness waited on all he did, and the intensely human character of his writings was wholly borrowed from his own heart. If Æschylus could bear the torch higher than Sophocles, Sophocles bore it with a much steadier hand than Æschylus. The latter rose at times to a superhuman height in his ambition to seize upon his lofty ideal; the former was always content to dwell among the homes of men, directing their gaze upon their own hearts, and wistfully turning them towards heaven. He had better possession of his faculties than Æschylus, and they never carried him away beyond the bounds of the intelligible. Sophocles was the high-priest of humanity. He chose, as he phrased it, "to put away the pomp of Æschylus along with his childish things;" and he exhibited that mild grandeur and matchless refinement in which he excels all the dramatists of Greece. He made tragic poetry a true mirror of the passions of the soul of man, and exhibited as has seldom been done the true moral significance of human action. He gave men their own hearts to read, and compelled them to peruse the volume. He said that "he himself represented men as they ought to be, but Euripides exhibited them as they are." Æschylus, by the height of his genius, always creates heroes; Sophocles, by the very moderation of his powers, exhibits idealized men; Euripides, by the intense spirit of scepticism which presides over all he did, dwarfed man beneath his natural dignity, and appears occasionally to laugh in secret at the creatures which his own hands had made. The characters of Sophocles are always strong and great, but they are always men and women drawn with such singular power, that one can always recognise some feature in his own character as the scroll of the appetites, affections, and passions is unrolled before him. In his earlier attempts his hand occasionally gave marks of indecision and wavering; his style was sometimes artificial and even obscure; but once he got all the powers of his mind entirely at his command, the whole world seemed to be laid bare before his eye, and everything gave way before natural simplicity and directness.

Sophocles introduced important changes into the arrangements of the Athenian stage. With the exception of the *Antigone*, all the dramas of this poet turn upon one great action. With Æschylus again the three plays of a triology resemble so many acts of one drama. The chorus, which in Æschylus expressed the feelings supposed to be called forth in an intelligent audience, with Sophocles played a much more subordinate part, representing, as it appeared to do, what was passing in the minds of the actors rather than in those of the spectators of the drama. Hitherto in the history of the stage the actors had always been limited to two, but Sophocles introduced a "triagonistes," a third actor, which materially relieved the monotony of the scene and the stiffness of the dialogue. His other improvements were confined to stage-painting and other artificial parts of the mechanism of the stage.

After the masterly work of Lessing on Sophocles, unfortunately left as a fragment, the reader may refer to the treatises of Schultz and Schöll, besides the history of K. O. Müller and the *Lectures* of A. W. Schlegel.

The *editio princeps* of Sophocles was printed by Aldus, at Venice, in 1502. The best of the subsequent editions are those of Stephens, 1568; Brunck, 2 vols., 1786; Musgrave, 2 vols., 1800; Erfurdt, 7 vols., 1802–25; Bothe, 2 vols., 1806; Elmsley, 8 vols., 1826; G. Hermann, 7 vols., 1850–51. All subsequent to Brunck have based their text upon his edition. A useful issue for students is that of Wunder, 1831–41; also one based on Dindorf's text, London, 2 vols, 1854. The editions, translations, &c., &c., of single plays of Sophocles are almost countless. There are besides many versions of the whole of Sophocles' tragedies both into English and other continental languages. The English prose translations are those by Adams, 2 vols., 1729; by Franklin, 2 vols., 1758–59; by Potter, 1788; by Dale, 1824; and a revision of the Oxford translation by Buckley, 1849.

SOPHRON, said to be the inventor of the Mime, which was one of the numerous varieties of the Dorian comedy, was the son of Agathocles, and was born at Syracuse, and flourished during the middle of the fifth century. Not only incidents, but characters were represented in the Mimes of Sophron, and they were composed in an irregular halting rhythm, consisting of a medium between poetry and prose. They were written in the old Doric dialect, and were doubtless intended for public exhibition. Sophron was closely imitated by Theocritus. Plato esteemed highly the productions of Sophron, and is said to have introduced them to the notice of the Athenians. (Quintil., i. 10, 17). The fragments of Sophron which have survived him have been collected by Blomfield in the *Classical Journal*, No. 8, and more fully in the *Museum Criticum*, vol. ii.

SORA, a town of Naples, in the province of Terra di Lavoro, 15 miles E.N.E. of Frosinone. It occupies a flat piece of ground, partly surrounded by the Liris, where that river issues from a narrow glen; and immediately behind the town rises a rocky hill crowned with old Cyclopean walls and Gothic towers. The streets are broad, well paved, and lined with large and substantial houses. There are here a fine cathedral, several churches and convents, a school, hospital, and alms-houses. Woollen cloth and paper are manufactured. Sora was originally a Volscian city, and probably the furthest north of their possessions. It was seized by the Romans in 345 B.C., and subsequently made a colony; but in 315 the inhabitants rose against the Romans, and joined their enemies the Samnites. It was not finally secured as a Roman colony till the end of the second Samnite war in 303. After this period its history is of no importance; but it is frequently mentioned as a quiet country town. A few Roman remains have been preserved. Sora was the birth-place of Cardinal Baronius, the eminent Roman Catholic historian. Pop. 8000.

SORATA. See ANDES.

SORAU, a town of the Prussian monarchy, in the province of Brandenburg, government and 50 miles S.S.E. of Frankfürt-on-the-Oder. It is surrounded by walls flanked with towers, and is also defended by two castles. Here there are numerous churches, a gymnasium, several hospitals, and a lunatic asylum. Woollen and linen cloth are manufactured here, as well as hosiery, leather, tobacco, &c. Pop. 7891.

SORBAS, a town of Spain, Andalusia, in the province and 28 miles E.N.E. of Almeria. It stands on a hill, and is generally ill built. It contains a square in which stand the principal buildings of the town. These are the church, court-house, prison, and the palace of the Duke of Valoig and Alva. Pottery is manufactured here of a much esteemed kind; linen cloth and serge are also woven. Pop. 5200.

SORBONNE. See UNIVERSITIES.

SORIA, a province of Spain, in Old Castile, bounded on the N. by that of Logroño, E. by that of Saragossa,

S. by that of Guadalajara, S.W. by that of Segovia, and N.W. by that of Burgos. Area, 5468 square miles. It is a bleak and lofty region, being bounded on three sides, the N., E., and S. by mountains. The Sierra Madera in the north, and the Sierra de Moncays in the east, separate the valley of the Douro from that of the Ebro, while on the south it is divided from that of the Tagus by a continuation of the Sierra Guadarrama. The whole of the province belongs to the region watered by the Douro and its affluents. This river rises in the northern mountains, and after traversing the province in a circuitous course, first to the south and then to the west, it leaves it, and enters that of Burgos. The other rivers are mostly affluents of the Douro, such as the Tuerto, San Pedro, &c.; but a few of the tributaries of the Ebro have their sources within the limits of the province. The soil is not remarkable for fertility; on the contrary, a large proportion of the area is occupied with barren mountains, which are covered with snow for a great part of the year. There are, however, in some places extensive forests of pine, oak, and beech; while in others there are large tracts of pasture land, on which numbers of cattle, sheep, and swine are reared. Grain and vegetables are raised, but neither of very good quality, nor in sufficient quantities to supply the wants of the population. The climate is cold and dry; and the scenery grand, but not very pleasing in its character. Most of the people are employed in farming and rearing cattle; but the cutting and sawing of timber, and preparation of charcoal, also occupy a considerable number. There is a great want of roads in this part of the country; and the commerce is consequently very limited. Fine wool was formerly an important production of the province; but of late years it has considerably fallen off. The only important article of trade at present is timber, which is sent to Madrid and Aragon. Pop. (1857) 178,645.

SORIA, the capital of the above province, on a hill on the right bank of the Douro, 113 miles N.E. of Madrid. It is an ancient town, and still surrounded by walls which were built in the thirteenth century. This dull, though well-built town, contains several squares, in one of which stand the court-house and prisons, and in another the spacious palace of the Dukes of Gomara. There are also numerous churches, monasteries, and nunneries; a theatre, college, and several hospitals. The population is chiefly agricultural; but there are also flour-mills, tanneries, potteries, &c.; and some trade in timber, wool, and fruit is carried on. Near Soria is supposed to be the site of the ancient Numantia, of which no traces remain. Pop. 5400.

SOROCABA, a town of Brazil, in the province, and 50 miles W.S.W. of San Paulo, in a mountainous but fertile district on the River Sorocaba. It contains various manufactories, and in the vicinity there are quarries of flint, and an imperial foundry at Ypanema. Pop. 12,000.

SORRENTO, a town of the kingdom of the Two Sicilies, in the province and 17 miles S.S.E. of Naples, in a beautiful and rich tract, called the Piano di Sorrento, on the south shore of the Bay of Naples, and nearly opposite the capital. It is surrounded on three sides by a wild and gloomy ravine, 300 feet deep; while on the fourth it rises from precipices skirting the sea. It is an archiepiscopal see; and contains a cathedral and numerous other churches, as well as convents, hospitals, a college, &c. Silk is manufactured here; and a considerable trade is carried on with the capital. The ancient Surrentum, which occupied the site of this town, was founded, according to tradition, by a Greek colony; but little is known of its early history; and it never rose to great historical importance. It was chiefly known in ancient times for its highly esteemed wine, which was grown in the hills encircling the Piano di Sorrento; that at present raised here is very indifferent. The only existing remains of the ancient town are numerous fragments; but none of them are of much interest. Sorrento is distinguished as the birth-place of Tasso. Pop. 8000.

SOSNITZA, a town of European Russia, capital of a circle in the government and 59 miles E. of Tchernigov, at the confluence of the Ubeda and the Desna. It contains a cathedral and several other churches, a school and an hospital. Some trade is carried on in corn and cattle. Pop. 5276.

SOTTEVILLE-LES-ROUEN, a town of France, in the department of Seine Inférieure, 4 miles S. of Rouen, of which it is sometimes considered a suburb. It contains spinning-mills, and manufactories of soap, glue, and chemical substances. Pop. 4960.

SOUDAN. See NIGRITIA.

SOULIÉ, MELCHIOR FRÉDÉRIC, a fertile writer of French romances, was the son of a teacher of philosophy, and was born at Foix, on the 23d of December 1800. In his youth his residence was unsettled. He accordingly received a sort of peripatetic education at Nantes, Poitiers, Paris, and Rennes. He entered on the study of the law, but gave himself up to literature. His first work was a volume of fugitive pieces, bearing the title of *Amours Françaises.* Having come to Paris, he now became foreman to an upholsterer, and wrought hard during his leisure hours at poetry and the drama. His *Romeo and Juliette,* after much tossing about from theatre to theatre, at last was got acted in 1828, and met with considerable success. Soulié continued to labour for the theatres and for periodicals till 1833, when his *Clotilde* having gained great success, he was engaged on various newspapers as a feuilltonist. He produced upwards of thirty fictions in this capacity, of which his *Mémoires du Diable* in 1842 was by far the most popular. The great demand for this novel unquestionably gave rise to Sue's *Mystères de Paris.* Soulié bought an estate at Bièvre, where he died September 22, 1847.

SOULT, NICOLAS JEAN-DE-DIEU, *Maréchal, Duc de Dalmatie*, was born, like nearly all Napoleon's generals, of humble parents, on the 29th of March 1769, the same year in which Wellington first saw the light. He was sent duly to school in his native place St Amand du Tarn, but the future marshal displayed no love for books. He betrayed a liking for military enterprise, and he was allowed to enlist as a private soldier in 1785. He rose successively to be corporal in 1787; sergeant in 1791; adjutant-major in 1792; captain in 1793; chef-de-bataillon, and chef and general of brigade in 1794. During this rapid rise into notoriety, he displayed great firmness, self-possession, and tact in the management of men, whether individually or in masses. He gave a signal instance of his bravery at the retreat of the French army at Herborn. He was hemmed in by a body of Austrians nearly ten times his number; yet, after sustaining seven distinct charges, he drew off his troops without the loss of a single soldier. During the Revolution Soult was as diligent among the civilians as he was vigorous among his soldiers. He frequented the clubs, flattered the men in power, and was loud in his denunciations of the old regime. He was made general of division in 1799, and fought successively under Jourdain, Massena, and Napoleon. He became lieutenant-general of the army in Italy in 1800, of the army of the south in 1801, and he was created a marshal of France in 1804. When a general of division on the heights of Boulogne, his labours were prodigious. From early dawn till late at night he was never off his horse, riding through the ranks, and investigating into every detail of military discipline with so much rigour and minuteness that the men and officers requested the interference of the First Consul. Soult answered Napoleon, "Sire, such as cannot withstand the fatigue which I support myself, ought to remain in the depôts. Such as do stand it will be fit for the conquest of England and of the world." At the battle of Austerlitz Napoleon thanked

him publicly on the battle-field for his skill. "Marshal," said the conqueror, "you are the ablest tactician in the army." Soult was created Duc de Dalmatie in 1807, and received the chief command under Napoleon. He was despatched immediately to Spain, where he was destined to receive such a series of checks from the "nation of shop-keepers," as was likely to make him speak more cautiously of conquests of England and of the world ever after. For this portion of Soult's career the reader is referred to the articles BRITAIN, FRANCE, and SPAIN.

On the retirement of Napoleon to Elba, Soult at once attached himself to the restored monarch, and as minister of war, charged the army "to rally round their legitimate and well-beloved sovereign, and resist the adventurer, who wanted to seize again that usurped power of which he had made so pernicious a use." The warlike Duc, however, saw "the adventurer" on the 25th of March 1815, and accepted a generalship at his hands for the coming campaign. Waterloo was fought and lost, and Maréchal Soult was banished from France. He was permitted to return, however, in 1819; his baton was restored to him; he was received with favour by Charles X., who made him a peer of France in 1827. He rose to be prime minister under Louis Philippe, and was present as ambassador-extraordinary at the coronation of Queen Victoria. Louis Philippe permitted him to retire with the ancient dignity of maréchal-general of France in 1847. Soult survived till November 26, 1851, when he died at Soult-Berg, near his native town of St Amand-du-Tarn. After his death the splendid gallery of pictures which he had plundered during his residence in Spain were sold by auction, and realized a very large sum. The first part of the *Mémoires* of Soult were published in 3 volumes by his son in 1854.

SOUND. See ACOUSTICS.

SOUND, THE, a narrow strait, forming one of the communications between the Cattegat and the Baltic, and separating the Danish island of Zealand from the coast of Sweden. In the most extensive application of the term, the Sound is 66 miles long, from the Kullen in the N. to Falsterbo Point in the S., both on the Swedish coast; and its greatest breadth, opposite Copenhagen, is 17 miles; but the name is more properly restricted to the narrow portion between Elsinore and Helsingborg, where it is only 3 miles across. The Sound dues, formerly payable to the Danish crown by all vessels passing the strait, were abolished, 14th March 1857, by a treaty between Denmark and Great Britain, Austria, Belgium, France, Hanover, Mecklenburg-Schwerin, Oldenburg, the Netherlands, Prussia, Russia, Sweden, and Norway, and the Hanseatic cities of Bremen, Lubeck, and Hamburg. The contracting powers agreed to pay to Denmark a pecuniary compensation; and Denmark, on the other hand, consented to abolish the dues, and to continue the preservation of the lighthouses and superintendence of the pilotage of the Sound. The total amount of compensation granted to Denmark by this treaty was L.3,386,258, of which L.1,125,206 is from Great Britain. A separate treaty was concluded shortly after, between Denmark and the United States of America, for a similar purpose. The compensation in this case was fixed at L.79,759. The navigation of the Sound is somewhat dangerous, as there are shoals and quicksands on each side of the channel.

SOUNDING. See SEAMANSHIP.

SOUR, or TSOUR. See TYRE.

SOUTH, ROBERT, a distinguished clergyman of the Church of England, was born at Hackney, in Middlesex, in 1633. He seems from his boyhood to have been attached to the reigning monarchy, for, in the school of Westminster, where Dr Busby was master, he prayed for his majesty, Charles I., by name, on the day of his execution. In 1651, he entered Christ Church, Oxford, at the same time with the distinguished John Locke. He took his bachelor's degree in 1655, and wrote, on that occasion, a copy of Latin verses, congratulating Oliver Cromwell on his late peace with the Dutch. The apology usually offered for this indiscretion on South's part is, that it was then usual to impose such a task upon baccalaureates. He took his degree of M.A. in 1657, not without some opposition from the dean of Christ Church, Dr John Owen. South was appointed university orator in 1660; domestic chaplain to Chancellor Clarendon shortly afterwards; prebendary of Westminster in 1663; and canon of Christ's Church, Oxford, in 1670. His "Scribe Instructed" is as good a specimen of his sermons as one could wish for. Although written while the author was a comparatively young man, it displays all the sharp clear sense of his maturer years. It is full of insight, vivacity, perspicuity, copiousness and force. In the latter qualities, he has very few equals among English writers. But the sin of his sermons was the sharp, keen, cutting wit and sarcasm with which they abounded. If his hearers refrained from occasional bursts of laughter, it said much for their gravity, and is more than a reader of the nineteenth century would be capable of. He is perpetually down upon the poor dissenters, mocking them, holding up their defects to the jeers of his audience, and their merits not unfrequently to their bitterest scorn. But a short specimen from the sermon already alluded to will put this in a clear light. The teachers of those days, he says, "first of all seize upon some text, from whence they *draw* something (which they call doctrine), and well may it be said to be *drawn* from the words, forasmuch as it seldom naturally *flows* or *results* from them. In the next place, being thus provided, they *branch* it into several heads, perhaps twenty, or thirty, or upwards. Whereupon, for the prosecution of these, they repair to some trusty Concordance, which never *fails* them, and by the help of that, they range six or seven Scriptures under each head: which Scriptures they prosecute one by one; first amplifying and enlarging upon one for some considerable time, till they have spoiled it; and then, that being done, they pass to another, which, *in its turn*, suffers accordingly. And these impertinent and unpremeditated enlargements they look upon as the *motions, effects, and breathings of the Spirit*, and therefore much beyond those *carnal ordinances of sense and reason*, supported by industry and study; and this they call a *saving way of preaching*, as it must be confessed to be a way to save much labour, and nothing else that I know of."

South accompanied Lawrence Hyde, son of Clarendon, on his embassy to John Sobieski, the King of Poland, as his chaplain. The long letter which South wrote home, descriptive of Poland, is both curious and interesting. Sobieski, he says, in addition to his own language, was acquainted with French, Italian, German, and Turkish, and could speak Latin with great fluency. South on his return to England was made rector of Islip, and continued to preach up divine right and no quarter to Protestant dissenters or to Roman Catholics; yet curious to say he would accept of no preferment either from Charles II. or James; and it is said some of the highest dignities of the church were laid at his feet. He is reported to have had the best of the discussion which was carried on with Dr Sherlock, with more wit than wisdom, and with more sarcasm than solemnity. The latter had written a book entitled, *A Vindication of the Holy and Ever-blessed Trinity;* and South attacked him for having promulgated tritheism. The war of words ran so high that the king had to interpose. South died on the 8th of July 1716, and was buried in Westminster Abbey. There is a very intemperate and injudicious biography of South prefixed to Curll's edition of his works, published in 1717. The *Sermons* of Dr South will be found in the 7-vol. edition of Oxford, 1823, or in any of the recent issues of them.

South-ampton.

Situation. SOUTHAMPTON is situated on the south coast of Hampshire (Lat. 50. 55; Long. 1. 32), at the junction of the small river Itchen with a straight arm of the sea, which runs inland from the Solent. This inland sea, called the Southampton Water, extends for four miles above the town to the village of Red Bridge, and for seven miles below it to the promontory of Calshot Castle, a small fort nearly opposite Cowes in the Isle of Wight, which commands the entrance. The width of this arm varies from one and a half to two miles, and being skirted on the north bank by the wooded heights about Netley Abbey, it forms a beautiful sea-approach to Southampton. Being, from its position, completely land-locked, it is exempt from the swell of the open sea, from whichever direction the wind may blow; and possessing at the sametime a straight channel, with considerable depth of water and good holding-ground, it is not surprising that the Southampton Water should be regarded as one of the safest and most commodious harbours on our coasts.

Characteristics. To this fortunate peculiarity is due the present thriving condition of the town, its population having increased by nearly *one-half* since the year 1840, when it was selected as the port of departure for the mail steam-packets to India and the West Indies. To the same cause must be also ascribed the very marked alteration which has taken place in the character of the town, which, before the opening of the famous docks in 1842, was a fashionable watering-place, much resorted to by the county families in the neighbourhood, as well as by visitors from London. Steam has now brought about a complete revolution in this respect. Modern Southampton, though still cheerful and attractive, has assumed the graver habits of a mercantile community; her well-stored shops being tenanted by a shrewd bustling class of tradespeople, who depend, to a great extent, upon the custom of the large steam-shipping companies, and on the whimsical wants of the crowd of Indian passengers who sojourn here for a few days on their way to and from the east.

Such at least is the character of the business portion of the town below the "Bar-gate;" but Southampton yet owns an aristocratic section, occupying the high ground to the north, where the town begins gradually to merge into the beautiful country beyond. This quarter is mostly tenanted by the families of retired military and naval officers, and others not connected with the trade of the port, but who are attracted to this pleasant town by its own intrinsic merits.

Suburbs. Still further removed from business, and beyond the limits of the *borough rates*, which add materially to the expense of a town residence, are the suburbs of Portswood, Highfield, Bassett, Shirley, Millbrook, which are built over with villas of moderate pretensions, and are rapidly absorbing the finely wooded parks and grounds of the numerous country-seats in the immediate neighbourhood. The open country beyond is undulating and woody, with occasional downs and common-land, presenting a variety of beautiful rides, walks, and drives.

Crossing the Itchen, from Southampton, by the steam floating-bridge, we gain the suburbs of Bitterne, West End, Woolston, and Netley, surrounded by an equally pleasant country.

The approach to Southampton by the London road is through a very fine avenue of old lime-trees, about a mile in length; and beyond this distance the road enters the broad expanse of Southampton Common, planted with picturesque groups of the Scotch fir, many of them of great age and size. The holly and laurel here flourish luxuriantly, in a wild state, in company with furze, brambles, and broom.

General features. The general appearance of Southampton is that of a clean, well built, well ordered town, with little architectural display, it is true, but with a certain picturesque irregularity of style and outline in the streets and houses, which has a lively and pleasing effect. It can boast of at least one handsome, wide, bustling thoroughfare, the High Street, leading from the quays on the south of the town to the commencement of the "Avenue" on the north. This street is about a mile in length, and is chiefly occupied by shops of a superior description, whose well-stored windows present a tempting display. It is divided in the middle of its length by the Bar-gate, a relic of the ancient city-walls, like the Temple-bar in London, and the street is called Above or Below-bar, according to its position with reference to this gate. Southampton is not remarkable for the beauty of its churches or public buildings, which scarcely accord with the wealth and importance of the modern city; but it excels in those more essential works of public utility—sewerage, gas-lighting, and water-supply, each of which is tolerably perfect in its kind. Within the last few years a "park" has been enclosed and planted for the recreation of the citizens, and a corner of the beautiful Southampton Common has been appropriated as a cemetery. The town is supplied with excellent water from the river Itchen, at about 4 miles from its mouth. The water is pumped up by steam power, at the rate of 1000 gallons per minute, into two large reservoirs on the Common, which have an elevation of 180 feet above the sea, being about 80 feet higher than the upper part of the town. About 1,500,000 gallons of pure water are thus supplied per day of 24 hours, which is equal to 20 gallons per day for each person.

The educational establishments of the town are numerous and respectable, but of only local celebrity. Mention should be made, however, of the munificent bequest of the late Mr H. R. Hartley, once a resident of Southampton, who has recently left a sum of L.105,000 to the mayor and corporation upon trust, "to employ the yearly proceeds thereof in such manner as may best promote the study and advancement of the sciences of natural history, astronomy, antiquities, and classical and oriental literature in the town of Southampton—such as by forming a public library, botanic garden, observatory, and collections of objects in connection with the above sciences." This will, unfortunately, was disputed by the relations, and became the subject of an expensive suit in the Court of Chancery, which terminated in 1858; when, after settling the terms of compromise with some of the claimants, and paying the lawyers to the amount of about L.35,000, the sum finally secured by the corporation did not exceed L.40,000. The testator left, in addition, his books, manuscripts, and antiquities, and three houses and furniture, for the same object. It is proposed to spend about L.10,000 in the new building, to be called the Hartley Institute, which will comprise two lecture-theatres, a laboratory, museum, library, reading-room, picture gallery, model-room, class-rooms, and observatory, the remainder of the money being spent in furnishing and endowing the same. The Hartley Institute.

This town has been selected by government for the headquarters of the staff of royal engineers engaged in making the Ordnance surveys of Great Britain and Ireland. A spacious building for their accommodation was erected in 1857, where the maps are drawn, reduced, and engraved to three different scales, being afterwards printed and coloured on the premises, and prepared for distribution to all parts of the country. Colonel Henry James, R.E. and F.R.S., is the superintendent of the ordnance map office, about 300 persons being employed under him. The process of reducing the maps to the required scales is effected with great expedition and accuracy by the aid of photography. An institution of this kind is of great benefit, as tending to raise the standard of education and intelligence amongst the middle classes. The Ordnance Map Office.

The South Hants Infirmary (with which the names of Doctors Joseph and William Bullar are so gratefully and South Hants Infirmary.

South-ampton. honourably associated) is located at Southampton, and is one of the best managed and most extensively useful institutions of its kind. It makes up sixty beds, and during the past year it has relieved 521 in-patients and 1788 out-patients.

The principal feature of modern Southampton are undoubtedly the docks, which were opened in 1842. They consist of an open or tidal basin, and an inner or close basin. The tidal dock has an area of 16 acres of water, with a depth of 18 feet at low water, and about 31 feet at high water. Its entrance from the Itchen estuary is 150 feet wide, and will admit the largest steam-ships at high water. The quays round the dock measure 3000 feet, and are formed of very substantial granite masonry. Three large graving-docks enter from the tidal basin, one of which is the largest dry-dock in the world, measuring 425 feet long on the floor, and 80 feet wide between the gate cills. Even the royal navy require to use this dock occasionally. In the inner basin, which enters from the tidal basin, the water is always retained at the level of high-water by means of a pair of dock-gates closing the passage between the two basins. The inner basin has an area of 10 acres, and a depth of 25 feet. The docks were designed by Mr Francis Giles, and completed by Mr Alfred Giles, C.E. The Southampton docks have *four* tides every 24 hours, a peculiarity not found in any other of our seaports. This is caused by the Isle of Wight being situated across the entrance to the Southampton Water. A portion of the great tidal wave, in its progress up the Channel, becomes separated from the main body, and, flowing up the Needles passage into the Solent, reaches Southampton, and causes the *first* tide about the same time that the main body arrives at Dunnose Point. This tide, beginning to ebb, is stopped and driven back again by the main stream from Spithead, and this causes the *second* tide, about 2 hours later, and 6 inches higher, than the first tide. Low water is about 3½ hours after the second tide-flood. These "double tides" are very valuable to the port, as they allow an additional two hours for docking and undocking ships. The mean rise of water is 18 feet at spring-tides, and 8 feet at neap tides. The tides here are highest about 48 hours after the full and new moon. In the Hamble estuary, which falls into Southampton Water about 5 miles below the town, the flood-tide remains stationary for two hours. At low water extensive mud-banks are left bare on each side of Southampton Water, but the anchorage in the offing is good, with nearly 4 fathoms of water at spring-ebb; and the *clear-way* within the buoys is deep, and about half a mile broad.

The Docks.

Peculiarity of the tides.

Statistics of shipping.

The number of ships which entered the docks during the year ending 31st March 1859 was as follows:—Entered inwards, 1017 ships, 323,361 tonnage; outwards, 918 ships, 323,965 tonnage. The value of exports is upwards of six millions; duties received, L.127,072.

Manufactures.

The manufacture for which this town is most noted is that of carriages, of which above 500 are annually built here, and exported to all parts of the world. This branch of industry is chiefly indebted for its local celebrity to Mr Andrews, the late patriotic mayor of Southampton, and a very successful coach-builder. The requirements of the numerous steam-ships frequenting the port have naturally led to the establishment of engineering works (of which there are several) for the manufacture and repair of machinery and iron-vessels. These works employ a great number of skilled mechanics, of whom a large proportion are Scotch; and as the majority of the engineers afloat were bred on the Clyde, it will be perceived that Scotchmen muster very strongly in Southampton.

Climate.

Southampton has a mild climate, and a rain-fall somewhat above the average, although the number of rainy days is not so great as in most parts of England. There is a marked difference between the air of the lower portion of the town and that of the higher; the former being moist and relaxing, and occasionally redolent of exhalations rising from the mud-banks exposed at low-water. The upper part of the town, and more especially the suburbs of Portswood, Highfield, and Bassett, enjoy a much drier and purer atmosphere, partly due to the gravelly nature of the soil, which admits of quick surface-drainage.

Southcott.

Population

The population of Southampton, according to the census of 1851, was 35,305, exclusive of the suburbs, which, as we have seen, are very numerous. As the town has been rapidly increasing since that time, the population of the *borough* is now calculated (in 1860) to amount to 45,000; and if we include the surrounding neighbourhood, it is probable that a population of 50,000 souls is not in excess of the reality.

History and antiquities.

Though not of Roman origin, Southampton is still a place of great antiquity, and probably may date its rise from the decay of the Roman station *Clausentum*, at Bitterne, on the opposite side of the river Itchen, about 1½ miles N.E. of the town. Its name was probably derived from *Anton*, the ancient name of the river Test, whose estuary forms the upper part of Southampton Water, the latter being supposed to represent the *Antona* mentioned by Tacitus. In *Doomsday Book* the town is spelt *Hantun*, the prefix *South* probably arising from its relative position to *Northam*, a hamlet within the borough, on the banks of the Itchen, opposite the Roman *Clausentum*, and believed to be the oldest part of Southampton. The earliest mention of the town occurs in the *Saxon Chronicle*, from which it appears that it was attacked by the Danes in 873, who landed here from 33 vessels; but after committing many atrocities, they were repulsed and driven back to their ships. All the more interesting remains of antiquity (with the exceptions of the Bar-gate and St Michael's Church) stretch along the shore of Southampton Water, where a strong castle, the remains of which are still extant, protected the town from the land side. That wise and pious Danish monarch Canute, when he became king of England, had a palace at Southampton, and here it was that he reproved the impious flattery of his courtiers. The ancient town, comprising about one-sixth part only of the present town and suburbs, was surrounded by an embattled wall of 1¼ miles in circumference, having several gates and posterns. The greater part of these fortifications have long since been cleared away, but many interesting portions still remain. The Bar-gate, which crosses the High Street, was the principal entrance into the town from the north. It is a large and handsome tower-gateway, which appears to have been repeatedly strengthened and altered, in many different styles of architecture, since its first erection by the Normans. On the projecting buttresses are two paintings, executed more than 180 years ago, and representing the Saxon knight Sir Bevois, and his gigantic squire Ascupart, who figure conspicuously in the legendary history of Southampton. (R. M—Y.)

SOUTHCOTT, Joanna, an English fanatic, was born in Devonshire about 1750. She was employed originally as a domestic servant; but having been an adherent of the Methodists, she, at about the age of 40, set up for a prophetess. She wrote, dictated, and rhymed prophecies, and announced herself as the woman spoken of in the 12th chapter of the Revelation. She published her unintelligible jargon to the world, and, strange to say, her followers soon swelled out to the number of 100,000. When beyond the age of 60, she announced that she was to be delivered of a "Second Shiloh" on the 19th October 1814. Her fanatical dupes, in great numbers, stood watching round her door, day and night, till the 19th passed away; but "Shiloh" failed to appear, and it was announced to the multitude that the prophetess had fallen into a trance. She died of dropsy on the 27th December 1814. Her followers have now (1860) dwindled down to an almost nominal existence. She declared a

short while before her death, that "if she was deceived, she was at all events misled by some spirit, either good or evil." Curious to say, her most substantial supporter was William Sharp, the eminent engraver. (See SHARP.)

SOUTHERN, THOMAS, an English dramatist, was born at Oxmantown, in the county of Dublin, in 1660, and received his education in Trinity College. He came young to London to study law; but instead of that, devoted himself to poetry and the writing of plays. His *Persian Prince* was introduced in 1682, when the Tory interest was triumphant in England; and the character of the Loyal Brother being intended to compliment James Duke of York, he rewarded the author when he came to the throne with a commission in the army. On the Revolution taking place, he retired to his studies, and wrote several plays, from which he is supposed to have derived a very handsome subsistence, being the first who raised the advantage of play-writing to a second and third night. The most finished of all his plays are the *Fatal Marriage* and *Oroonoko,* which is founded on a true story related in one of Mrs Behn's novels. Southern died in 1746, in the 86th year of his age; the latter part of which he spent in peaceful serenity, having, by his commission as a soldier, and the profits of his dramatic works, acquired a handsome fortune, and being an exact economist, he improved what fortune he gained to the best advantage. His plays were printed in 3 vols. 12mo. in 1774.

SOUTHEY, ROBERT, a poet-laureate of England, and a singularly industrious man of letters, was the son of a linen-draper at Bristol, where he was born on the 12th of August 1774. His ancestors were yeomen of Somersetshire; and as they bore arms of a religious character, he indulged in the fancy that, in distant crusading times, a Southey may have broken a spear with the infidel on the plains of Palestine. During his childhood, books were a very rare commodity. The small paternal cupboard that contained the family crystal likewise found a place for all the books the linen-draper possessed. His aunt, however, a foolishly eccentric lady, who had a passion for theatricals, and with whom he spent the most of his youth, duly introduced him to the giants of the drama. A neighbouring library of some hundreds of volumes was likewise laid under contribution during his holidays; and on this rare feast he revelled almost unconscious of the passing weeks. The recital of *Chevy Chase* brought water into his eyes at three years of age, and he continued to live in a kind of waking dream with the characters which the wand of Shakspeare, of Beaumont and Fletcher, of Tasso, of Ariosto, of Spenser, of Camoens, of Homer, of Sidney, and of Chatterton had summoned into palpable existence from the charmed spirit-world. Southey's school-life was, according to conventional notions, the most unsatisfactory that could well be conceived. He was constantly changing his instructors, who as regularly proved the most incorrigible tyrants a child-poet could meet with. He passed through the hands of a whole half-dozen of masters who were nearly all cruel and hard-hearted. Perhaps the temperament of the youth had been too fine, or his sensibilities too delicate for the tear and wear of a public school. To set down whole six schoolmasters in nearly unbroken succession as harsh and inexorable, is more than a patient biographer can stomach. It must have been a sad age for the Bristol boys, if all was literally true that Southey wrote down in his autobiography regarding their instructors. He had the misfortune to meet an awful dame at the age of six; next he was ground by a cruel Baptist minister named Foot; afterwards he suffered much from a remarkable man named Fowler at Corston; later he fell into the hands of Williams, a sarcastic Welshman; and after passing through the clerical superintendence of Lewis, he entered Westminster School in 1788. Here his fate was not more lucky than before. The irregularity of his school-life, the custom of the schools which he had attended, and the partial incompetence perhaps of his teachers, all combined to render him anything but a dab at Latin verse-making. This was a sufficient drawback to prevent his shining at Westminster. Add to all this, that his satirically jocular paper in the *Flagellant,* a school-journal, on corporal punishment, brought down upon his head the stupid wrath of Dr Vincent, the superior of the school, and led to his dismissal in 1792. The ill fame of his poor paper in the *Flagellant* preceded him to Oxford; and on his presenting himself at Christ Church, the virtuous dean, Cyril Jackson, refused to admit him. On the whole, on whose side soever the fault lay, Southey until now had a poor enough time of it. But the light that "ne'er was seen on land or sea" haunted his dreams; the thirst for fame almost maddened him; and he burned to be of age, that he might by the might of his pen carve his way to renown. His education had been paid for at Westminster by his maternal uncle, Rev. Herbert Hill, and he now entered Balliol College, Oxford, with the ostensible design of entering the church. The French revolution was now casting its fiery glare on all lands, reddened by the fierceness of political rancour and by the bitter animosity of religious zeal. Freedom, both in action and in thought, was the watchword of the revolutionists; liberty of the most impossible kind, was the cry echoed back to them by the European people. That young Southey, with his eager passions, should be caught in the fervour of this frenzied whirlpool is nothing very strange. The writings of Rousseau were then in every one's mouth; and why should not the more arduous youth of Oxford exercise their logic on his propositions, as well as on those of the academic Stagyrite? Southey exercised his right of freethinking on all manner of subjects, political, social, religious. Meanwhile he wrote verses by the thousand, and read books by the heap. The church, the state, all offices of society were shut against him, from the wrong-headed violence of his opinions. It was in these circumstances that he formed the grand design, with Coleridge, Lovell, and some others, of establishing a "Pantisocracy" on the banks of the Susquehannah in North America. Laws, selfishness, discord would be unknown words in their patriarchal home beyond the Atlantic. Primeval innocence was to harmonize with all the graceful refinements of European society: the male members of this select community were to till the ground which their joint contributions had purchased, while their wives were to engage their fair hands in the necessary domestic duties. The truth was, that the three dreamers had married three sisters, named Fricker, in the town of Bristol. Cottle, a Bristol publisher, who had just bought Southey's *Joan of Arc,* written in 1793, for fifty guineas, was let into their secret. The honest bookseller inquired, in trepidation, when they would sail. A laconic epistle from Coleridge dispelled his fears. "My dear sir," wrote the pantisocratist, "can you conveniently lend me five pounds?" Cottle dispatched the money with tears of joy. To such abrupt close came this sublime scheme for the regeneration of humanity, by no means a new phenomenon in the history of the race.

Southey had now quitted Oxford, partly from his religious views, and partly from the withdrawal of his uncle's support. After casting about him for a time, he came pretty soon to the conclusion, that he would be compelled "perforce to enter the muster-roll of authors." He did not repine at his lot, rather secretly rejoiced in it. Mr Hill chancing to be in England at this time induced Southey to accompany him to Lisbon, where he held a chaplaincy. One of the designs of the clerical uncle was accomplished by this journey, for Southey renounced his revolutionary tendencies; but the other, which was to persuade him to enter the church, proved entirely fruitless. After six months' absence he returned to England in May

1796. He had got up material for his *Letters from Spain and Portugal*, and he commenced writing for the *Monthly Magazine.* Meanwhile he wrote epics, tragedies, histories, romances: nothing was deemed too aspiring for his towering ambition. To secure a competence he resolved to study law, and accordingly entered himself at Gray's Inn, on the 7th Feb. 1797. Whether or not he ever had any serious intention of devoting himself to that dry and somewhat severe mistress, he at all events soon deserted her in the most unfeigned disgust. Wynn, his school-fellow at Westminster, nobly offered him an annuity of L.160, which he frankly agreed to accept. Southey's reputation was meanwhile increasing with the publishers; he was busily engaged in hammering his *Madoc* into shape, and had already another epic, *Thalaba*, on the anvil.

With all this toil, Southey had as yet made but a slight impression on the public. His views of religion and politics were gradually mellowing; but the novel guise which his poems assumed, his rejection of rhyme in their construction, and his frequent assaults upon all that England had hitherto admired in the poetical art, could be got down only with a considerable effort, even by those who most admired the splendour of his imagination and the beauty of his diction. To say truth, too, there was wanting in his verse the evidence of that "diviner mind" of which Coleridge, Shelley, and Keats had given such illustrious examples. His poetry was certainly often opulent and even gorgeous, but it wanted that nameless something which at once lends a charm to all that a man writes, and lifts him up on the ever-increasing admiration of the world to the very presence of fame. The greatest fertility cannot give it, the most artistic taste in the management of details cannot give it, refined sensibility cannot give it, nothing but the sublime gift of genuine vision, at once creative and natural, simple and human, can make a man a genuine poet, whom men will admire while the world lasts. Southey seems neither to have known this nor to have felt it. He always speaks with the strongest self-confidence, and not unfrequently expresses a much higher opinion of his own claims to immortality, than the great majority of his readers will be inclined to subscribe. "It is not every one," he says, "that can shoot with the bow of Ulysses, and the gentlemen who think they can bend the bow, because I make the string twang, will find themselves somewhat disappointed." His historical powers he likewise rated much too highly. He had not sufficient intensity of consciousness in looking at a fact to see through it, before he handed it up to the imagination to mould and fashion according to her will. As a necessary consequence of this, he was deficient in reflective power. It was entirely beyond his ability to present either a living vital account of a great national movement, or to gather up its discordant elements into a subtle and lofty harmony. His prose was as much below the vigorous though florid pictures of Gibbon, as his poetry was beneath the *Paradise Lost*, to which he unblushingly compared it. He worked with prodigious labour, and towards the end of the year 1799 his health sank under the incessant energy of his brain. Portugal was again tried in 1800, and with the best effects. Taking up his abode at Cintra, he commenced busily to collect materials for a *History of Portugal.* He returned to England with some reluctance in the summer of the following year. Coleridge, who then occupied Greta Hall, near Keswick, wrote to Southey a glowing description of the place, which so attracted his fancy, that he ultimately settled in that charming spot. Before doing so, he paid a visit to his old friend Wynn in North Wales, where he found a letter awaiting him, offering him the situation of secretary to the chancellor of the exchequer for Ireland, with a salary of L.350 a year. The chancellor would have Southey teach his son, to fill up his spare time, but the author of *Thalaba* indignantly refused, and threw up "a foolish office and a good salary," after he had held it for six months. Henceforward he clung close to the pen to the end of his life. Between writing and projecting works and review articles, his time was wholly taken up. He edited an edition of Chatterton's works, in 3 vols., for the poet's sister, who was in great poverty, and had the gratification of handing over to her the sum of L.300, the proceeds of his industry. This was only one of a thousand of his generous acts performed to the needy and the distressed. He aided the lamented Kirke White, James Dusautoy and Herbert Knowles, and was of much service to Ebenezer Elliot in his early attempts to woo the Muse.

Gradually Southey became stationary at Keswick, by the sheer weight of his vast and ever-accumulating library. Unlike the Delos of ancient fable, and the floating island of modern fact in the adjoining Lake of Derwentwater, here he was rooted firm and fast to his moorings, by a cable which time and its chances could not sever. With the exception of occasional excursions to London or the continent, generally with a party of friends, he now settled down with great good-will to his books and to his pen. Writing to a friend about this time he said—"My actions are as regular as St Dunstan's quarter-boys. Three pages of history after breakfast (equivalent to five in small quarto-printing); then to transcribe and copy for the press, or to make my selections and biographies, or what else suits my humour, till dinner-time; from dinner to tea I read, write letters, see the newspapers, and very often indulge in a siesta. After tea I go to poetry, and correct, and re-write, and copy till I am tired, and then turn to anything else till supper. And this is my life, which if it be not a very merry one, is yet as happy as heart could wish." And so he continued almost until the grave received him, toiling, and cheerful until the end. In conjunction with his friend Elmsley, he visited Scotland, and Sir Walter Scott in 1805. The great novelist received him very warmly, as was his wont, and subsequently wrote to him, in 1807, to secure his talents for the *Edinburgh Review*, to which he himself occasionally contributed. But Southey, who in his youth was the most radical reformer in England, had now crystallized into one of the most rigid conservatives, did not relish the free manner in which the Edinburgh reviewers treated all manner of subjects that came within their reach; and he was particularly galled by the very liberal criticism which Jeffrey had made on his *Madoc* and *Thalaba.* He therefore begged to be excused from entrusting the treasures of his mind to such rash pilotage. A more congenial field for his occasional employment presented itself shortly afterwards in the *Quarterly Review.* The editor, Gifford, frequently made rough work of his fine periods and moonshiny opinions, but this slashing mutilation was entirely owing (so Southey was pleased to think) to the ignorance or ill-will of the unscrupulous mentor. The Grenville ministry in 1807 gave him a pension of L.200, but it was so reduced with taxes that it amounted only, when it came to the poet's hands, to L.144. In 1808 he engaged to write the history of Spanish affairs for the *Annual Register*, published by Bannatyne in Edinburgh, and next year he was asked to take up the historical department generally, with an allowance of L.400 a-year. But the affairs of Bannatyne did not admit of its continuation; and after a two years' engagement, the publication became defunct. Southey contributed no less than 126 articles to this periodical during his life. The laureateship having fallen vacant by the death of Pye in 1813, at the instigation of Sir Walter Scott, it was offered to Southey. He became embroiled, at the close of the war, in the general agitation of which English society was then the theatre. He used all his endeavours to check the riotous proceedings of the enraged mobs, and a portion of society taunted him with the epithet of "renegade."

and actually published his *Wat Tyler*, an inflammatory production of his hot youth. The gust blew over, and peace came; and as a solatium to Southey, he had conferred upon him the honorary degree of LL.D. by the University of Oxford in 1820. This was mainly gained for him by his *Book of the Church.* His *Roderick, the last of the Goths,* was received with favour on the continent. It was partly translated into Dutch by Mrs Bilderdijk, whom Southey visited in the summer of 1825. During his absence he had, through the influence of Lord Radnor, been elected parliamentary representative of Downton, but the property qualification did not permit of his accepting it. In 1829, by the marriage of Miss Coleridge, she and her mother left Southey's roof, where they had found shelter for six-and-twenty years. In 1834, the poet received L.300 a year from government, on the recommendation of Sir Robert Peel. That eminent statesman had previously failed in his endeavour to have Southey made a baronet, by reason of the smallness of his income. His books only gained a very tardy sale, and he was at times careless of his resources, in increasing his already vast library. He lost the companion of his life on the 16th November 1837. She had for some years previous to her death been labouring under mental derangement. This was probably attributable to the mental anxiety to which she had been exposed. The grave had not well closed over her, when mental prostration overcame the poet himself. His memory failed, his recognition of time and place gave way, and the strongest symptoms of mental alienation manifested themselves. He travelled in Normandy and Brittany, he married Caroline Bowles the poetess, he wandered about in the most helpless condition, and gradually becoming weaker and weaker, he died on the 21st March 1843. Southey rests, with his beloved Edith Fricker, in the quiet little churchyard of Crosthwaite, adjoining the town of Keswick.

Since Southey's death there have been published by Warter in 1856, 4 volumes of his common-place books, &c., and 4 volumes of his letters. His life has been written by his son, the Rev. Charles Cuthbert Southey, in 6 vols., 1849–50. The following is supposed to be a tolerably complete list of Dr Southey's works, condensed from the *English Cyclopædia :—*

Poems, in conjunction with his friend Lovell, 1 vol. 8vo, in 1794. *Joan of Arc, an Epic Poem,* 4to, 1795. *Minor poems,* 2 vols. 8vo, 1797. *Letters written during a short residence in Spain and Portugal,* 1 vol. 8vo, 1799 and 1800. *The Annual Anthology,* 2 vols. 8vo; *Thalaba the Destroyer, a Metrical Romance,* 2 vols. 12mo, 1801. *Amadis de Gaul,* a prose translation from the Spanish version, by Garcia Ordoñez de Montalvo, 4 vols. 12mo, 1803. The works of Thomas Chatterton (in conjunction with Amos Cottle), 3 vols. 8vo, 1803; *Metrical Tales and other Poems,* 8vo, 1805. *Madoc, a Poem,* in two parts, 4to. *Specimens of the Later English Poets, with Preliminary Notices,* 3 vols. 8vo, 1807. *Palmerin of England,* translated from the Portuguese, 4 vols. 8vo; *Letters from England,* by Don Manuél Velasquez Espriella (pseudonymous), 3 vols. 12mo; *Remains of Henry Kirke White, with an Account of his Life,* 2 vols. 8vo; *The Chronicle of the Cid, Rodrigo Diaz de Bivar,* from the Spanish, 4to, 1808. *The Curse of Kehama, a Poem,* 4to; *The History of Brazil,* vol. i., 4to, 1810. *Omniana,* 2 vols. 8vo, 1812. *Life of Nelson,* 2 vols. 8vo, 1813. *Carmen Triumphale for the commencement of the year* 1814, *and Carmina Aulica,* 1 vol. 4to; *Roderick, the last of the Goths,* 4to, 1814. *Minor Poems,* 3 vols., 1815. *The Lay of the Laureate; Carmen Nuptiale,* 12mo; *A Poet's Pilgrimage to Waterloo,* 8vo; *Specimens of later British Poets,* 1816. *Wat Tyler, a Dramatic Poem* (written in a vein of ultra-Jacobinism, in 1794, and now surreptitiously published), 12mo; *A Letter to William Smith, Esq., M.P.* (on the subject of the preceding publication), 8vo; *Morte d'Arthur (a reprint of Sir Thomas Malory's prose romance), with Introduction and Notes,* 2 vols. 8vo; *History of Brazil,* vol. ii., 4to, 1817; and vol. iii., 4to, 1819. *Life of John Wesley,* 2 vols. 8vo, 1820. *A Vision of Judgment, a Poem,* 4to; *The Expedition of Orsua and the Crimes of Aguirre,* 12mo, 1821. *Remains of Henry Kirke White,* vol. iii., 8vo, 1822. *History of the Peninsular War,* vol. i., 4to (an expansion of what had been originally published in the *Edinburgh Annual Register,* 1810, &c.) *The Book of the Church,* 2 vols. 8vo, 1824. *A Tale of Paraguay* (a Poem), 12mo, 1825. *Vindiciæ Ecclesiæ Anglicanæ,* &c., 8vo, 1826. *History of the Peninsular War,* vol. ii., 4to, 1827. *Sir Thomas More, or Colloquies on the Progress and Prospects of Society,* &c., 2 vols. 8vo; *All for Love, or the Sinner Well Saved;* and *The Pilgrim to Compostella, or A Legend of a Cock and a Hen,* 12mo, 1829. *Life of John Bunyan,* prefixed to an edition of the *Pilgrim's Progress,* 1830. *Attempts in Verse by John Jones; with Introductory Essay on the Lives and Works of our Uneducated Poets,* 8vo; *Selections from the Poems of Robert Southey, Esq., LL.D.,* 12mo; *Select Works of British Poets, from Chaucer to Jonson, edited with Biographical Notices,* 1 vol. royal 8vo, 1831. *Essays Moral and Political,* 2 vols. 8vo; *Selections from Southey,* prose, 12mo; *History of the Peninsular War,* vol. iii., 4to, 1832. *Naval History of England,* vol i. 12mo (in Lardner's *Cabinet Cyclopædia*), completed in 5 vols., 1840. *Dr Watt's Poems, with a Life of the Author* (in Cattermole's *Sacred Classics*), 12mo, 1834. *The Doctor* (anonymous), vols. i. and ii., 8vo, 1834; vol. iii., 8vo, 1835; vols. iv. and v., 8vo, 1837. *The Works of William Cowper, with a Life of the Author,* vol. i., 12mo, completed in 15 vols. in 1837 and 1838. *The Poetical Works of Robert Southey,* collected by himself, 10 vols. 12mo, 1837; to which may be added the eight volumes of *Letters,* &c., published by Warter since his death. (J. D—S.)

SOUTHPORT, a village of England, in Lancashire, at the mouth of the Ribble, 20 miles N. of Liverpool. It is a favourite watering-place, and has some broad streets and handsome houses, two chapels, a theatre, news-room, library, and school. Pop. 4765.

SOUTHWARK, a parliamentary borough in the city of London, on the south bank of the Thames, in the county of Surrey. It returns two members to the House of Commons. See LONDON.

SOUTHWARK, a suburb of Philadelphia, which see.

SOUTHWELL, a market-town of England, in the county and 14 miles N.E. of Nottingham. It is a straggling town, but generally well built, and has four main streets. The church of St Mary, an ancient edifice, partly Norman, and partly early English, was restored in 1804. It is cruciform, and large and imposing in its appearance. A low massive tower rises from the centre, and two lofty ones of seven storeys from the west end. The tombs and effigies of several archbishops of York and other prelates are in this church; and in the vicinity are the ruins of an old palace of the archbishops of York, which was a favourite residence of Cardinal Wolsey, and was at one time occupied by Charles I. Southwell has also a district church and several other places of worship, a number of schools, theatre, assembly rooms, jail, poor-house, &c. Brick, tiles, and cotton stockings are manufactured in the vicinity; and there is also a large silk-mill. Population of the parish, 3516.

SOUTHWOLD, a seaport-town of England, county of Suffolk, near the mouth of the Blyth, 11 miles south of Lowestoff. It consists chiefly of a long line of houses, some of which are good, but the majority of an inferior description. The parish church is old and handsome, containing much elegant carving. There is a harbour formed by two piers at the mouth of the Blyth, and there are two batteries for the defence of the town. Fishing forms the main occupation of the inhabitants; but they also depend very much on those who visit it for the sake of sea-bathing. In Southwold or Sole Bay a naval engagement took place between the British and the combined French and Dutch fleets, May 1672, in which the Earl of Sandwich was blown up in his ship. Pop. of parish, 2109.

SOVEREIGN, the name applied to the person or persons who preside over every society which is not habitually in a state of nature or of anarchy. The marks of sovereign power are, that the ruled profess a habit of obedience to the ruler, while the ruler professes no such habit.

SOZOMENUS, HERMIAS, an ecclesiastical historian of the fifth century, was born at Gaza or Bethelia, in Palestine. He was educated for the law, and became a pleader at Constantinople. He wrote an abridgment of *Ecclesias-*

tical History, in two books, from the ascension of our Saviour to the year 323. This compendium is lost; but a continuation of it in nine books, written at greater length, down to the year 439, is still extant. He seems to have copied Socrates, who wrote a history of the same period. The style of Sozomenus is perhaps more elegant; but in other respects he falls far short of that writer, displaying throughout his whole book an amazing credulity and a superstitious attachment to monks and the monastic life. His work, with those of Eusebius and Socrates, was published by R. Stephanus in 1544, by H. Valesius at Paris in 1668, and by Reading at Cambridge in 1720. All these editions are in folio. Several others have likewise appeared. An English version of Sozomenus has been published by Walford, 1854.

SPA, or SPAA, a market-town and watering-place of Belgium, in a wild rugged country, in the province and 16 miles south of Liege. It is well built, and consists almost altogether of inns and lodging-houses. The town derives its chief importance from its medicinal water, which is more impregnated with iron than that of any other spring known. This water is not only much used on the spot, but exported in considerable quantities. Over the principal spring is built a pump-room; and in the vicinity is the Redoute, an edifice containing a coffee-house, theatre, ball-room, and gambling-rooms. The town has also several churches, a town-hall, hospital, and barracks. Some manufactures are carried on, especially of linen and cotton cloth, leather, snuff-boxes, &c. Pop. 3969.

SPACCAFORNO, or SPACCAFURNO, a town of Sicily, near the mouth of the Bufardone, on the south coast of the island, in the province and 29 miles west of Syracuse. It stands in a very fertile region, but is itself a poor town, though containing several churches and convents. There are salt-pans on the neighbouring coast, and there is some trade carried on in the town. Pop. 9000.

SPAIN.

THAT the Spanish Peninsula was peopled at a very early period seems abundantly certain, but by whom it would be vain to inquire. The earliest inhabitants whom history makes known to us were the Iberians, a race probably of Asiatic origin. At some period lost in the depths of antiquity, the Celts, amid their wide-spread migrations, penetrated into the peninsula; and although they seem at first to have contended with the Iberians for the sovereignty of the soil, the two races at length amalgamated, and assumed the common name of Celtiberians. They were split into numerous tribes or clans, each of which occupied its own particular territory.

The fertility and mineral wealth of the country led the Rhodians and Phœnicians to establish colonies here at a very early period; but the Carthaginians were the first to obtain a firm footing in it. Under the pretext of commerce, they established themselves on the coast of Cadiz, whence they pushed their conquests into the interior as well as along the coast, till they at length made themselves masters of the whole of Bætica or Andalusia. The Spaniards were roused to resistance, but it was too late. Hamilcar, the father of Hannibal, succeeded in overrunning a considerable part of the country, and bringing it, at least nominally, under subjection to Carthage, 238 B.C. He extended his conquests towards Murcia, Valencia, and Catalonia, in the latter of which provinces he founded the city of Barcelona. This conqueror having perished in a battle fought with some of the native tribes, was succeeded by his son-in-law Asdrubal, who built the port of New Carthage, now called Carthagena. The rapid strides which the Carthaginians had made towards the total subjugation of the Peninsula aroused the fears of the Greek colonies situated on the coast of Catalonia and Valencia, and alarmed those tribes in the interior who still stoutly maintained their independence. Too weak to make head against Carthage themselves, they applied to the Romans for assistance. This great nation had long regarded with a jealous eye the growing prosperity of its rival Carthage, and eagerly embraced the cause of the discontented states. In the character of ally and protector, Rome sent a deputation to Carthage, and obtained from its senate two important concessions; that the Carthaginians should not extend their conquests beyond the Ebro; and that they should not disturb the Saguntines and the other Greek colonies. These conditions, however, did not correspond with the gigantic designs of Asdrubal, whose purpose was to subdue the whole of Spain before Rome could send succours to the confederates; but when marching against Saguntum, one of the most flourishing cities of the Peninsula, and an ally of Rome, he was assassinated by a slave; and the chief command passed into the hands of Hannibal, then in his twenty-fifth year, and greatly esteemed for his valour and his talents. After having conquered the kingdom of Toledo, this renowned general laid siege to Saguntum with his whole force, which is said to have amounted to 150,000 men. The Romans lost much time in fruitless attempts at negotiation, and failed to send prompt succour to its faithful ally. The consequence was, that after a vigorous defence, the Saguntines were so reduced by hunger and fatigue, that they retired from the walls into the centre of the city, where they amassed all their valuable effects, and everything combustible, into one vast pile. Placing their wives and children around it, they themselves issued from the gates, and plunged, sword in hand, into the midst of the Carthaginians. The slaughter was prodigious on both sides, but in the end the Saguntines were cut off almost to a man. No sooner was their fate known in the city than their wives set fire to the pile, and precipitated themselves and their children into the devouring element. Thus perished Saguntum, one of the largest and most flourishing cities of Spain; and its destruction may be regarded as the opening of the second Punic war. Of the contests carried on between the Carthaginians and the Romans, till the final subjugation of the former, and the consequent incorporation of its territories with the Roman empire, an account will be found under the articles CARTHAGE and ROMAN HISTORY. We shall here only notice such leading events as are necessary to give connection to our narrative.

Two centuries were required by Rome to effect the total subjugation of Spain, that is, from the first invasion of the country by Cneus Cornelius Scipio, in the year 218 B.C., till the last tribes, the Cantabrians and Asturians, laid down their arms to Augustus in the year 19 B.C. No other conquest had cost Rome so much. The numbers who perished in the field of battle, and the amount of treasure sacrificed, are not to be calculated. At the same time, scarcely any other acquisition was productive of so much advantage to the state from the inexhaustible riches of the country. After the destruction of the Carthaginian power in Spain, this country was regarded as a Roman province, received the name of Hispania, and was divided by the senate into Citerior and Ulterior, or Hither and Farther, the Ebro serving as a boundary between the two. Each of these was governed by a prætor annually appointed by Rome. The extortions of these functionaries very soon became so oppressive to the natives, that they at last resolved on attempting to rid themselves of their unprincipled rulers. Viria-

thus, a native of Lusitania, the most remarkable man in the ancient history of Spain, collected a considerable body of malcontents, and took the field against the Romans. Not only by stratagems and sudden surprises, but in regular pitched battles, he succeeded in foiling the most valiant officers of the Roman legions. For above eleven years he bade defiance to the formidable hosts of the invader. To subdue him by force of arms was found impossible, and the base spirit of Q. Servilius Cæpio had recourse to treachery. The offer of a magnificent recompense stimulated three of the followers of Viriathus to assassinate him, which bloody deed they accomplished whilst he lay asleep. It is some consolation to record, that the murderers were disappointed of their reward, and dismissed from the Roman camp with insults and contempt. The indomitable spirit of independence which animated the Spaniards was not, however, broken by the death of their great leader. The Numantians, in particular, still remained fiercely hostile to the Romans, and the destruction of Numantia was decreed by the senate. Scipio Æmilianus, the conqueror of Carthage, was appointed to the command of the legions destined for this service, and the city was closely invested by a powerful army. While food was left to the besieged, they defied all the efforts of the Romans to take their city. Famine however humbled them into submission, and they sued for mercy, but in vain. Driven to desperation, the wretched remains of the defenders issued from the gates, and fell with fury upon the Roman intrenchments; but they were forced back within the walls. Æmilianus had formed the cruel resolution of starving them into an unconditional surrender. Rather than yield to this, the Numantians determined, in imitation of the Saguntines, to make a sacrifice of themselves, and of all that was valuable which they possessed. This resolution they carried into effect under circumstances even more shocking than those which accompanied the destruction of Saguntum. When the victor entered the city, not a human being remained alive to grace his triumph; nothing met his eyes but smouldering ruins and a horrible solitude. This event took place in the year 133 B. C.

After the destruction of Numantia, three fourths of the Peninsula submitted to Rome; and nothing very remarkable occurs in its history till the time of the civil war between Marius and Sylla. The latter having crushed the Marian faction, proscribed those who had taken a part in it, whom he could not immediately destroy. Among these was Sertorius, who had previously served in Spain as a tribune; a man of great bodily and mental endowments, of consummate valour, and experience in the art of war, but whose ambition was equal to his nobler gifts. Having escaped to Spain, he there succeeded in gaining over to his interest several of the native tribes, raised a considerable army, and routed the Roman legions in repeated engagements. He introduced a strict order of discipline among his troops, founded public schools, constituted a senate in imitation of that of Rome, and attempted to establish in Spain a rival sovereignty to that of Italy. But, in the midst of these brilliant though ambitious undertakings, Sertorius was basely assassinated by his subaltern Perpenna, in the year 73 B. C. With the death of this great captain expired the last faint glimmer of national independence. Pompey, and afterwards Julius Cæsar, reduced most of the native tribes to subjection. After the fall of Pompey in Africa, his eldest son selected Spain as the fittest scene for opposing the dreaded dictator. For the fourth time, Cæsar hastened to the Peninsula, and, on the plains of Munda, gained a bloody but decisive victory over the younger Pompey, who was slain in attempting to effect his escape from the country. Augustus, the successor of Cæsar, effectually secured the dominion of Rome over Spain, having reduced the Asturians, Galicians, and Cantabrians, the bravest and most warlike of the native tribes. Spain now began to rest from the continual wars with which it had been devastated from the period of the Carthaginian conquest, and quietly submitted to the domination of Rome, from which it received its religion, its laws, its manners, and its language.

It has already been noticed that the country was at first divided into two provinces, Citerior and Ulterior, between which flowed the Ebro as the natural boundary. With the advance of the Romans the size of the provinces increased, but it is impossible to define their exact limits before the time of Augustus. This emperor, less desirous of effecting new conquests than of securing the old, made arrangements for improving the condition of the whole peninsula. Out of the two provinces he formed three, and gave them the names of Tarraconensis, Lusitania, and Bætica. Under the pretext of saving time and trouble to the senate, but really for the purpose of retaining power over the whole army in his own hands, he undertook the management of two of the provinces, in which, on account of the pretended insecurity of their situation, a considerable number of troops was maintained. Only Bætica came under the direct control of the senate. A proconsul, who had his seat at Hispalis, was installed governor of this province, but without any military power; whilst in the imperial provinces, a legatus Augustalis in Emerita, and a legatus proconsularis in Tarraconensis exercised complete civil and military authority. Subsequently the province conceded to the senate fell entirely under the sway of the emperor, when the governor received the name of præses or president. The districts being very extensive, it was found necessary to appoint inferior officers; under the legate of Lusitania was placed a vice-legatus militaris, and there were three placed under the consular legates of Tarraconensis. A legate and a quæstor were subject to the proconsul of Bætica. In this manner the country as a whole was divided. Let us now take a glance of the constitution and condition of the towns.

After the complete subjugation of the Peninsula, the cohorts, composed principally of the natives of the country, were transplanted to the most distant parts of the empire, while Roman legions were sent into Spain to supply their place. No arrangement could have been made that was better calculated to give a Roman impress to the character of the people, and to their manners, customs, and establishments. In the interior of the country, towns purely Roman sprung up, small tracts of country having been conferred on soldiers as a reward for their services. Thus the town of Leon is indebted for its name and origin to the seventh legion, which settled there; and in the same manner arose Emerita Augusta (Merida), Pax Julia (Beja), Cæsar Augusta (Saragossa), and many others. Originally, most of the cities managed their own affairs; but when Caracalla declared all his subjects throughout his vast empire Roman citizens, the constitutions of the cities of Spain were made uniform with those of the other cities of the empire. Rome, the capital, was the great type to which they all conformed. For purposes of general police, and for the superintendence of public works, fortresses, entertainments, and the like, ædiles were appointed in provincial towns, whose office, however, was one more of pomp and honour than emolument. The affairs of the cities were universally administered by a council or curia, the members of which, called *decuriones*, were chosen from among the richest and most respectable of the inhabitants. As advocates or defenders of the people, there were the *defensores civitatum*, who neither belonged to the body of the decurions nor to the army, but formed rather a sort of check upon these, and resisted the encroachments of power on the rights of the citizens. We pass over a number of other subordinate functionaries, whose duties are either imperfectly known, or, where known, of minor importance.

All matters not cognizable by the legal tribunals, nor af-

fecting the interest of the emperor, were discussed in the assembly of the decurions. For all important affairs, such as those affecting the welfare of the whole district, the decurions of the principal city of a province could call a general assembly, *concilium*, to which the other towns sent plenipotentiaries. Long after the comitia had ceased to exist in Rome, the province enjoyed the privilege of calling together such meetings; and they served at the same time as a means of making known their wants to the emperor.

Of all the provinces incorporated with the Roman empire, there was not one productive of so much gain, not one in which such inexhaustible sources of wealth were discovered, as the Pyrenean Peninsula. Mines, rich in the precious metals,[1] satisfied the thirst of the Romans for gold; and a soil nowhere surpassed in productiveness filled their granaries with corn. During the republic the Peninsula was laid under the obligation of supplying the capital of the empire with the twentieth part of its corn harvests. The price paid for the grain was fixed by the Roman senate itself, a convenient way of obtaining cheap provisions.

While Spain continued to be ravaged by war, the Romans did not in general bind themselves to a regular system of taxation, but only drew as much from the Peninsula as it was convenient for it to pay at the time; but when the conquest of the country was completed, a fixed rate of taxation was introduced. Consequently, after Augustus had divided Spain in the manner which we have described, the senate sent quæstors into the provinces to collect the taxes. In those provinces placed under the immediate control of the emperor, there were procurators employed; and functionaries of this class were also appointed to look after the monies received by the officers of the senate, the application of the whole being under the entire management of the emperor. These procurators were likewise extremely useful in preventing the subordinates from defrauding the emperor. By degrees their number increased, so that ultimately there came to be procurators, not only for the collective income of a province, but for separate branches of the taxes.

In Spain, as well as throughout the whole Roman empire, the taxes consisted of a capitation and a land tax; but by degrees, more from the extravagance of the emperors than from the necessities of the state, the people came to be burdened with a multitude of other imposts. The towns had their own particular estates and incomes, independent of those of the government, and which were managed by the civic authorities themselves. These served to defray the expenses of erecting public establishments, building fortresses, and instituting games. The contribution to the state taxes paid by the towns was levied by the magistrates from the inhabitants, in exact proportion to their wealth; hence the taxes, although they continued to rise, did not press with unequal and crushing weight upon individuals and classes. Never was Spain so wealthy, so populous, and so industrious, as during the first centuries of the empire. Aqueducts, bridges, amphitheatres, and other magnificent structures, even the ruins of some of which posterity surveys with wonder, still bear testimony to the flourishing condition of the country during that period.

When Constantine the Great assumed the purple, important changes were introduced into the empire. From the province of Tarraconensis he separated the governments of Carthagena and Galicia, thus making five provinces in the Peninsula, viz., Tarraconensis, Carthagena, Galicia, Lusitania, and Bætica. Theodosius the Great erected the Balearic Isles into a province, and the African district of Tingitania was also reckoned another, so that there were seven in all. The principal cities of these provinces were as follow: of Bætica, Hispalis; of Lusitania, Emerita; of Galicia, Bracara; of Tarraconensis, Cæsar Augusta; of Carthagena, New Carthage; of the Balearic Isles, Palma; and of Tingitania, Tingis. The first three were placed under consuls, and the others under presidents (*præsides*). Spain was subject to the prefecture of Gaul, and over these local governors was placed a vicar (*vicarius*), whose administration was chiefly confined to civil affairs, and the count (*comes*), whose functions were of a military nature. Sometimes, however, both the civil and military departments fell to the vicar. We have yet to mention one important event connected with the Roman conquest of Spain, namely, the introduction of Christianity into the Peninsula. This took place so early that the unanimous voice of tradition has ascribed it to St James the elder; and from the same authority we also learn that St Paul preached "Christ crucified" to the idolaters of Spain. Of course little or no reliance is to be placed on such statements; but whether the apostles or their successors propagated the gospel in these regions, certain it is that Spain can adduce her martyrs as early as the second century. There is abundant evidence to prove the antiquity of the persecutions sustained by the Christians of Spain, but our limits prevent us from entering into details.

The prosperity of the Peninsula began to decline after the death of Constantine, A. D. 337. A species of tax introduced by Diocletian, which was made to fall with paralysing weight on the middle or industrious classes, proved so pernicious in its operation, that in a short time the country presented the melancholy picture of deserted towns, fields lying waste, fruit-trees uprooted from the soil, that the possessors of the ground might lessen the value of their property, and thus escape the taxes; trade and manufactures at a stand; in short, nothing but desolation, poverty, and misery, everywhere presented themselves. It only required a strong impulse from without to overwhelm the whole country in ruins. The last day of the year 406 marks the passage of the Vandals, Alans, Suevi, and other Teutonic tribes, across the Rhine. From this river to the Pyrenees, terror and dismay announced their approach, death and destruction marked their progress. For a time this great barrier of nature and of nations restrained the roving bands, and the mountain-passes were at first well guarded. But the prolific fields and wealthy mines of Spain were too rich a prey not to be reached at all hazards. Finding an opportunity, when negligence had weakened the line of defence (409), they burst like a torrent through the Pyrenean chain, and poured the tide of destruction from its base to the Pillars of Hercules. Native historians of the Peninsula describe the ravages committed by these barbarians as dreadful and revolting almost beyond parallel. The very wild beasts quitted their lairs to prey upon the human species, too emaciated by famine and pestilence to drive them back. In a word, the country was turned into a desert; and, satiated with carnage and rapine, the barbarians sat down amidst its ruins and divided it by lot. Bætica fell to the Vandals, Lusitania to the Alans, and Galicia, with a great portion of Leon and Castile, to the Suevi. Tarraconensis alone seems still to have been retained by the Romans.

But a fourth people, more formidable than all the rest combined, came to disturb the new settlers in their possessions. These were the Goths under Ataulphus, to whom Honorius, the Roman emperor, had ceded the fertile provinces of Southern Gaul and the Peninsula. The Gothic monarch espoused Placidia, the emperor's sister, in 414, and immediately proceeded to Barcelona, where, however, he was shortly afterwards assassinated. His successor, Sigeric, a detestable monster, shared the same fate; and the election of the Goths now fell upon Wallia, a chief every way

[1] Gibbon very justly observes, "Spain, by a very singular fatality, was the Peru and Mexico of the old world. The discovery of the rich western continent by the Phœnicians, and the oppression of the simple natives, who were compelled to labour in their mines for the benefit of strangers, form an exact type of the more recent history of Spanish America." Chap. vi.

worthy of their choice. Peace being made with Rome, hostilities were vigorously commenced against the kindred barbarians (418). The result of the war was the subjugation of the Suevi, the total destruction of the Alans, and the expulsion of the Vandals from Spain (427). But the restless and powerful Suevi were scotched, not killed. During the reign of Theodoric, Wallia's successor, they became formidable alike to the Romans and the Goths, and made many important conquests in the neighbouring provinces. Theodoric might easily have subdued them had he not been summoned to encounter a far more terrible antagonist, the renowned Attila, with his half million of mounted Huns. The death of the Gothic monarch on the plains of Chalons (451), the elevation of his son Thorismund to the vacant throne, his assassination by his brothers, and the elevation of the elder of the fratricides, Theodoric, were events which closely followed each other. The reign of the last-named prince was diversified by alternate success and disaster. The Peninsula, become one great battle-field to three contending hosts, the Goths, Romans, and Suevi, was plunged in misery, and, from the Pyrenees to the sea of Africa, was overspread with innumerable swarms, which, like so many locusts, utterly destroyed the spots on which they settled. While Theodoric was preparing to conduct an army across the Pyrenees against Remismund, king of the Suevi, he was assassinated by his brother Euric, in his capital of Toulouse (466).

The reign of Euric was unusually brilliant and successful. He rendered himself absolute lord of the country, by extinguishing the dominion of Rome in it, and completely subjecting the Suevi. Euric was the first legislator of his nation, and the founder of the Gothic kingdom of Spain; for hitherto the country had rather been overrun than subdued. This prince died at Arles, the capital of his empire, A. D. 483. He was succeeded by his son Alaric, a weak sovereign, who, after submitting pusillanimously to many indignities, was overthrown in battle, and slain by Clovis, king of the Franks (506). Amalaric, the son of Alaric, being a minor, was for a time superseded by his natural brother Gensaleic, but ultimately ascended the throne (522). He was the first Gothic king who established his court in Spain. He fixed on the city of Seville. From the death of this prince (531) till Recared I. became king of the Goths (587), a few obscure royal names occur, regarding whom it would be a mere waste of space to enter into details. The chief act of this sovereign was to reclaim his subjects from the heresy of Arianism to orthodox Catholicism. He died in 601. Of eleven monarchs who followed, occupying a period of seventy years, none is in any way remarkable. In 673, Wamba, a man distinguished alike for wisdom, valour, and virtue, was raised, by the unanimous voice of the Gothic electors, to the throne, left vacant by the death of Receswind (672). The early part of his reign was spent in quelling intestine war. During the latter part of it he successfully cultivated the arts of peace, and built a fleet for the protection of the coast; a very wise precaution, for the Saracens had already begun to swarm all over the sea of Africa. Had Wamba been succeeded by monarchs of equal prudence and activity, the scourge of Saracenic domination, the greatest perhaps that ever afflicted any people, would probably have been for ever averted from Spain. In consequence of having sunk into a death-like trance, in which state he was apparelled in the garments of the grave, Wamba was compelled to relinquish the crown (680).

One of the most celebrated names in the line of Gothic princes is that of Roderick, who ascended the throne in 709. He owed his elevation to a party which rose against his predecessor Witiza, whose two sons, with their relations, Count Julian, governor of the Gothic possessions in Africa, and Oppas, an archbishop, are supposed to have aided the Saracens in their design of conquering the Peninsula. At all events, the party which they formed against Roderick weakened the Gothic monarchy, and thus gave encouragement to the Moors to make a descent on the country, which they effected in 711. Roderick marshalled a large army, amounting, it is said, to 90,000 men, and advanced against the audacious infidel. The hosts met upon the plains of Xeres, where was fought a battle, so bravely contested on either side that it seems scarcely unworthy to have decided the fate of a kingdom. For three days, from sunrise to sunset, the embattled squadrons fought with equal ardour and obstinacy, till victory at last declared for the Mahommedans. Roderick himself is believed to have perished in the conflict, as he was never heard of more. By this decisive battle the Moors made themselves masters of nearly the whole of Spain. The wretched remains of the Goths retired into the mountainous parts of Asturias, Burgos, and Biscay, where they maintained their independence, and perpetuated their monarchy. In a few years their power began to revive under the renowned Pelagio or Pelayo, a prince of the royal blood. But before noticing the exploits of this warrior, we shall take a brief view of the political, civil, and religious condition of the people subject to the Gothic monarchy.

The local divisions of Spain, as already laid down, underwent little or no change until some time after the descent of the Mahommedans. The power possessed by the Gothic kings was considerable; but its exercise was greatly controlled by the nobles, in general a fierce, turbulent, and haughty body. The jurisdiction of the monarch was not confined to affairs purely temporal. He nominated bishops, presided, if he chose, at ecclesiastical tribunals, convoked national councils, and regulated the discipline of the church. Next to the king in civil dignity were the dukes, who appear to have been governors of provinces. After them came the counts, whose jurisdiction is supposed to have been confined to particular cities. A number of other functionaries were subordinate to these; and besides the officers of the crown, each city or town had its municipal council. Of course there were regular courts of law instituted throughout the country, where justice was administered; the forms of procedure in these tribunals being much the same as those practised in the Spanish courts at the present day, but less tedious. There was a Visigoth code of laws, partly of Gothic, partly of Roman origin. If we pass from the civil to the military state of the country, we find that the Goths were a nation of soldiers, the obligation of service being imperative on all freemen. After the Gothic power was established in Spain, the constitution of the church underwent important changes. The pope was acknowledged as supreme head, and metropolitan sees were formed, which exercised an ecclesiastical jurisdiction over the suffragan bishops. The bishops possessed an irresponsible power over the rectors, displacing or removing them at pleasure. The cathedrals and parish churches were in general well endowed; lay patronage existed, and monasteries were introduced. As in other countries, the ecclesiastical councils were of a threefold description, diocesan, provincial, and national, convoked respectively by the bishop, the metropolitan, and the king. The Goths present nothing of literature worthy of particular notice. If we pass to the domestic arts, we find still less to admire; in every thing they consulted the useful in preference to the beautiful or magnificent. It is therefore to be concluded, that however devout, temperate, honest, and sincere the Goths might have been, as many historians attest, yet Spain under their dominion made little advancement in civilization and the elegant arts.

The Moors under Tarik and Musa subdued the fairest portion of Spain, including the largest and strongest cities of the kingdom, with a rapidity which shows how complete-

ly the power of the Goths was broken. Still many of them preferred independence under severe privations amidst the wild rocks of the Asturias, to abundance and plenty on the fertile plains of Murcia. At the head of those who sought a refuge in this mountain sanctuary was Pelayo, a prince of royal Gothic blood, and who is recognised by Spanish historians as having acceded to the throne in 718; Theodomir, the legitimate monarch, having ingloriously submitted to the yoke of the infidel. Numbers of his countrymen flocked to his standard, and his force became at length so formidable as to create alarm in the Saracens. A large army was despatched to the Asturias to crush the rising insurrection; but in attempting to gain the position where Pelayo and his resolute followers were strongly posted, the Moors were repulsed with a slaughter so terrible, that for some years they showed no inclination to assail their formidable neighbours. Various successes followed, and the Asturias, now left in the undisturbed possession of Pelayo and his band, became the asylum of the liberty and the religion of the Christians in Spain. It formed the nucleus of a kingdom, which was destined slowly but surely to increase in size from century to century, until the invaders were finally expelled from the Peninsula. Little more is known of Pelayo, than that he gained repeated victories over the Moors, and died in peace in 737. He was succeeded by his son Favila, whose reign was brief and his end tragical, he having been killed by a wild boar in 739. The subsequent history of Spain is rendered so confused by the numerous kingdoms established by Christians and Moors, that some chronological guide is necessary to render it intelligible. We shall therefore present a chronological list of the various sovereigns who reigned over different parts of the country, which had been erected into distinct and independent sovereignties. The dates given mark the years in which the sovereigns acceded to the throne; the intervening periods, of course, indicate the duration of their respective reigns. We shall commence with the Mahommedan succession, as during the earlier centuries the greater part of Spain was subject to the Moors.

MAHOMMEDAN RULERS OF SPAIN.—CORDOVA.

1. *Emirs.*—Tarik ben Zeyad and Musa ben Nozeir, 711. Abdelasis ben Musa, 714. Ayub ben Habib and Alhaur ben Abderahman, 715. Alsama ben Melic, 721. Abderahman ben Abdalla, 722. Ambisa ben Sohim, 724. Hodeira ben Abdalla and Yahia ben Zulema, 726. Othman ben Abi Neza, Hodeira ben Alhaus, and Alhaitam ben Obeid, 727. Mohammed ben Abdalla, 728. Abderahman ben Abdalla (second time), 729. Abdelmelic ben Cotan, 733. Ocba ben Albegag, 736. Abdelmelic ben Cotan again, 741. Baleg ben Bakir, and Thalaba ben Sulema, 742. Husam ben Dhizar, 743. Thueba el Ameli, 744. Yussuf el Fehri, 746.

2. *Kings.*—Abderahman I. ben Moawia, 755. Hixem I. Abderahman, 787. Alhakem ben Hixem, 796. Abderahman II. ben Alhakem, 821. Mohammed I. ben Abderahman, 852. Almonahir ben Mohammed, 886. Abdalla, brother of the former, 888. Abderahman III. grandson of Abdalla, 912. Alhakem, II. son of Abderahman III. 961. Hixem II. ben Alhakem II., dethroned to make way for his cousin Mohammed, but restored in 1010; in 1012 finally removed, 976. Suleyman, 1012. Ali ben Hamud, 1015. Abderahman IV. 1017. Alcassim ben Hamud, brother of Ali, 1018. Abderahman V., and Mohammed II. cousin of Hixem II., 1023. Hixem III. brother of Abderahman IV. 1026. Gewahr ben Mohammed, 1031. Mohammed ben Gewahr, 1044. Mohammed Almoateded, 1060. Mohammed Almosstadir, 1069. *Dynasty of the Almoravides.*—Yussef ben Taxfin, 1094. Ali ben Yussef, 1107. Taxfin ben Ali, 1144. *Dynasty of the Almohades.*—Abdelmumen, 1147. Yussef Abu Yacub, son of Abdelmumen, 1163. Yacub ben Yussef, 1178. Mohammed, son of Yacub, 1199. Abu Yacub, 1213. Abulmelic, and Abdelwahid son of Yacub, 1223. Almamon and Abu Ali, 1225.

KINGDOM OF GRANADA.

Mohammed I. Aben Alhamar, founder of the kingdom, 1238. Mohammed II. ben Mohammed, 1273. Mohammed III. Abu Abdalla, 1302. Nassir Abul Giux, brother of the preceding, 1309. Ismail ben Ferag, nephew of Nassir, 1313. Mohammed IV. ben Ismail, 1325. Yussef Abul Hagiag, brother of the former, 1333. Mohammed V. ben Yussef, 1354. Ismail II. brother of Mohammed, 1359. Abu Said, brother-in-law of Ismail II. 1360. Yussef II. Abu Abdalla, son of Mohammed V. 1391. Mohammed VI. son of Yussef II. 1396. Yussef, brother of Mohammed VI. 1408. Muley Mohammed VII. son of Yussef III. 1423. Mohammed VIII. cousin of Muley Mohammed VII. 1427. Mohammed VII. restored, 1429. Yussef IV. Aben Alhamar. Mohammed VII. restored a second time, 1432. Mohammed IX. Aben Osmin (nephew of Mohammed VII.), 1445. Mohammed X. nephew of Mohammed VII. 1454. Muley Ali Abul Hassan, son of Mohammed X. 1463. Abu Abdalla, son of Abul Hassan, 1483. Abdalla el Zagal, brother of Abul Hassan, 1484. Both princes survived the fall of Granada, which took place in 1491.

KINGDOM OF THE ASTURIAS AND LEON.

Pelayo, 718. Favila, son of Pelayo, 737. Alfonso, son-in-law of Pelayo, 739. Fruela I. son of Alfonso, 757. Aurelio, nephew of Alfonso, 768. Mauregato, bastard of Alfonso, 774. Bermudo I. nephew of Alfonso, 788. Alfonso II. son of Fruela, 791. Ramiro I. son of Bermudo, 842. Ordoño I. son of Ramiro, 850. Alfonso III. son of Ordoño, 866. Garcia, son of Alfonso III. 910. Ordoño II. brother of Garcia, 914. Fruela II. son of Alfonso III. 923. Alfonso IV. son of Ordoño II. 925. Ramiro II. brother of the same Alfonso, 930. Ordoño III. son of Ramiro II. 950. Sancho I. brother of the same Ordoño, 955. Ramiro III. son of Sancho I. 967. Bermuda II. grandson of Fruela II. 982. Alfonso V. son of Bermudo II. 999. Bermudo III. son of Alfonso V. 1027. With this sovereign the male line of the house of Leon terminated. Leon and Castille now formed separate kingdoms, the contemporaneous sovereigns of which were:—

Leon.	Castille.
	1026. Sancho el Mayor, king of Navarre; first king of Castille in right of his wife.
	1035. Fernando I. son of Sancho.
1037. Fernando I. king of Castille; king of Leon in right of his wife.	
1065. Alfonso VI. son of Ferdinando I.	1065. Sancho II. son of Ferdinando I.
	1072. Alfonso I. son of Ferdinando I. (also VI. of Leon).
	1109. Urraca, daughter of Ferdinando I., and Alfonso VII. (also sovereign of Leon).
1126. Alfonso VIII. (the emperor), son of Urraca.	1126. Alfonso II. (the emperor), son of Urraca.
1157. Fernando II. son of Alfonso the emperor.	1157. Sancho III. son of Alfonso the emperor.
	1158. Alfonso III. son of Sancho III.
1188. Alfonso IX. son of Ferdinando II.	
	1214. Enrique I. son of Alfonso III.
	1217. Fernando III. son of Alfonso IX. of Leon (afterwards king of Leon).
1230. Ferdinando III. son of Alfonso IX. (also king of Castille).	

History.

KINGDOM OF LEON AND CASTILLE UNITED.

Alfonso X. son of Fernando III. 1252. Sancho IV. son of Alfonso X. 1284. Ferdinando IV. son of Sancho IV. 1295. Alfonso XI. son of Ferdinando IV. 1312. Pedro the Cruel, son of Alfonso XI. 1350. Enrique II. bastard son of Alfonso XI. 1369. Juan I. son of the former, 1379. Enrique III. son of the former, 1390. Juan II. son of the former, 1406. Enrique IV. son of the former, 1454. Isabel, daughter of Juan II. and her husband Ferdinando V. (the II. of Aragon), 1474. Juana, daughter of Fernando and Isabel, and Philip I. of Austria, 1504.

KINGDOM OF NAVARRE.

The first independent count of Navarre was Sancho Inigo, 873. The kings reported to have reigned prior to this period are entirely fabulous. Garcia I. (Iniguez), son of Count Sancho, and the first king, 885. Sancho I. (Garces Abarca), son of Garcia I. 905. Garcia II. (el Trembloso), son of Sancho I. 924. Sancho II. (el Mayor), son or grandson of Garcia II. 970. Garcia III. son of Sancho, 1035. Sancho III. son of Garcia III. 1054. Sancho IV. (also I. of Aragon), 1076. Pedro I. son of Sancho IV. (also king of Aragon), 1094. Alfonso I. brother of Pedro (also king of Aragon), 1104. Garcia IV. 1134. Sancho V. son of Garcia IV. 1150. Sancho VI. son of Sancho V. 1194. Thibault I. nephew of Sancho VI. 1234. Thibault II. son of the former, 1253. Henri, in right of his wife, who was daughter of Thibault II. 1270. Jeanne, queen of Philip IV. king of France, 1274. Louis Hutin (king of France), son of Jeanne, 1305. Philip, brother of Louis (also king of France), 1316. Charles I. brother of Philip (also king of France), 1322. Jeanne II. daughter of Louis Hutin, married to Philip count of Evreux, 1328. Charles II. son of Jeanne, 1349. Charles III. son of the former, 1387. Blanche, daughter of Charles III. and Juan her husband, son of Ferdinando I. king of Aragon, 1425. François Phœbus de Foix, in right of his grandmother, daughter of Juan, 1479. Catherine de Foix, sister of Phœbus, and her husband, Jean d'Albret, 1483. This kingdom united with Castille in 1512.

KINGDOM OF ARAGON.

Aragonese independence is to be dated from 1035, when Sancho el Mayor, king of Navarre and Castille, divided his states among his sons. Aragon fell to the lot of Ramiro I. 1035. Sancho I. (afterwards IV. of Navarre), son of Ramiro I. 1063. Pedro I. son of Sancho I. (also king of Navarre), 1094. Alfonso I. brother of Pedro (also king of Navarre), 1104. Ramiro II. brother of Alfonso, 1134. Petronilla, daughter of Ramiro II. 1137. Alfonso II. son of Petronilla, 1163. Pedro II. son of Alfonso II. 1196. Jayme I. son of Pedro II. 1213. Pedro III. son of Jayme I. 1276. Alfonso III. son of Pedro III. 1285. Jayme II. brother of Alfonso, 1291. Alfonso IV. son of Jayme II. 1327. Pedro IV. son of Alfonso IV. 1336. Juan I. son of Pedro IV. 1387. Martin, brother of Juan I. 1395. Fernando I. brother of Enrique III. king of Castille, elected 1412. Alfonso V. son of Ferdinando I. 1416. Juan II. (also king of Navarre), brother of Alfonso V. 1458. Fernando II. (the V. of Castille), son of Juan II. 1497. This kingdom united with Castille in 1516.

COUNTS OF BARCELONA.

During the early period of Mahommedan domination in Spain, Barcelona and all Catalonia were subject to it. In the year 801, however, the Moors were expelled from Barcelona, and a count named Bera, a native of Gothic Gaul, was nominated head of the independency. The names of his successors, eleven in number, are too insignificant to require mention individually. Alfonso Raymond, the last count, acceded to power in 1131. On his death, Barcelona was united with Aragon.

To give a connected history of these various sovereignties is quite incompatible with our limits. We can only briefly describe those more important transactions affecting the whole country, in which the Christians, by wresting portions of soil from the Moors, compelled them to retire within narrower limits, and thus circumscribed their power. Alfonso and Fruela, the sovereigns who immediately succeeded Pelayo's son, inflicted several severe blows on the Moors, and overran a considerable portion of the flat country. But what proved a more effectual check upon the Saracens than the arms of the Christians, were their own domestic quarrels. So mutable had been the government, that in the space of only forty years from the period of their first landing in Spain, no less than twenty emirs had been called, or had raised themselves, to the seat of power. On the establishment of a monarchy under Abderahman, intestine revolt was quelled for a time; but a more formidable foe from without made his appearance. This was no other than the celebrated Charlemagne, who poured his legions over the Pyrenees into the valleys of Catalonia. We shall not discuss the much agitated question as to the motives which brought this emperor into Spain. He appears to have received an invitation from some discontented Moorish governors; and in acceding to their request, he probably also listened to the dictates of his own ambition. Certain it is that he entered Spain with a powerful army, and, if we can trust his historian Eginhard, subjected the country from the Pyrenees to the Iberus. But he was soon recalled from the Peninsula by the revolt of the Saxons. In his passage through the mountain defiles, the rear of his army was attacked by the Navarrese, and cut to pieces.

It seems certain, that from the period when Charlemagne poured his legions into Navarre, he considered the country as a fief of his crown, and thus gave great umbrage to the Asturian kings. But the inhabitants of the province, averse to the sway of either, longed for independence, and this they succeeded in achieving about the year 885. The rise of this kingdom was another blow to the Saracens. So signal were the successes gained over them by the Christians of Navarre, that in the year 920 not a Mahommedan remained in the whole kingdom north of the Ebro. The kings of Asturias and Leon also rapidly extended their dominions. Ordoño II. invaded the Mahommedan possessions, and gained many advantages. In 932, Ramiro II. made an irruption into the states of the enemy, and ruined Madrid. Arabian writers boast of terrible reprisals having been made on the Christians, and assert that Ramiro himself was defeated. The Saracens having invested Zamora, Ramiro approached with a formidable army. The combatants met, and a battle ensued, more obstinately contested and bloody than any that had been fought since the days of Roderick. There can be no doubt that victory shone on the banners of the Christians, but the success was less splendid than their writers assert it to be. The accounts of all the battles fought between the Moors and the Christians in Spain are to be received with caution. The Arabian writers, to exalt the prowess of their countrymen, exaggerate mere skirmishes into great battles, and temporary and partial checks into decisive victories. In equivocal cases, they seem invariably to claim the advantage; and where they were defeated, they either obscurely hint the fact, or diminish the loss which they sustained. It is to be feared, that in many instances Christian chroniclers are chargeable with similar partiality.

History.

The reign of Abderahman III. (912) has been extolled as the most brilliant period in the history of the Spanish Arabs. Commerce flourished, and riches were accumulated to an unexampled extent. A powerful navy was formed, and maintained in full activity; the arts and sciences were cultivated with ardour, because their professors were rewarded with princely liberality; many splendid works were undertaken in the towns of Mahommedan Spain; and the king himself was the friend of industry and of merit. Still none of the territories which had been lost in previous reigns was recovered, and the Christians were gradually becoming more and more formidable to the Moors, when Mohammed, better known as Almanzor, appeared to restore the glory of the Saracen arms. He was an eminent general, an enlightened statesman, and a patron of the liberal arts. His campaigns against the Christians proved most fatal to them. The towns were ruined, the open country was ravaged, and once more the mountains of Asturias became the inaccessible asylum of the native monarchy. At length the three powers, Navarre, Castille, and Leon, entered into a confederacy to repel the common foe. The armies met at a place situated between Soria and Medina Celi, where a drawn battle was fought. This check, and the fearful loss which he had sustained, so mortified Almanzor, that he sunk under the weight of his despair, and died, some assert by voluntary abstinence from food, in the year 1001. An event of some importance to the Christian cause was the erection of Castille into a distinct kingdom, by Sancho el Mayor, king of Navarre, the most powerful prince of his age and country. Besides Sobrarve, he held the lordship of Aragon; and in 1026, in right of his wife, a princess of Castille, he became king of that country. By his conquests he considerably extended his dominions; and the marriage of his son Fernando to the heiress of Leon gave him influence in the affairs of that kingdom; so that at the period of his death, in 1035, he was virtually master of all Christian Spain except Catalonia. Before his death he divided his states among his sons, and Aragon fell to the share of Ramiro. The independence of Aragon as a separate kingdom is therefore to be dated from 1035, the year in which Ramiro I. obtained possession of the throne.

About the middle of the eleventh century Spain may be said to have been divided into two unequal parts, by a straight line drawn from east to west, from the coasts of Valencia to a little below the mouth of the Douro. The country north of this belonged to the Christians, who as yet had the smallest and least valuable portion, while all the rest belonged to the Moors. In point of wealth and real power, both by land and sea, the latter were much superior to the former; but their perpetual dissensions materially weakened them, and every day facilitated the progress of the Christians. Indeed, had either party been united, the other must soon have been quelled; but the Christians, although they did not constantly make war upon each other like the Moors, continued from time to time to be so embroiled by domestic feuds, as to be unprepared for striking a decisive blow with the combined armies of all the kingdoms; while the same evils, existing to a still greater extent amongst the Mahommedans, rendered it impossible for their monarchs to take advantage of the untoward state of the affairs of the Christians. Among the Moors almost every city was a kingdom; and as these petty sovereignties supported one another very indifferently, they, one after another, fell a prey to their enemies. The rapidity with which the kingdom of Cordova fell to pieces has few examples in history. Alfonso I. king of Aragon, also of Navarre, and for some time of Castille and Leon, is reckoned among the most valiant princes of Spain. From his warlike habits he was surnamed *El Batallador*. He conquered Tudela, Saragossa, Tarragona, Calatayud, Daroca, Mequinencia, and much of the country south of the Ebro. Since the conquest by the Arabs, he was the first who carried the Christian ensigns into Andalusia. In 1134, however, he lost a great battle, and either perished in the conflict or died of grief shortly afterwards. This was a misfortune, but the misfortunes of the Christians were in general soon repaired, although for nearly a century their conquests were less brilliant than those achieved by *El Batallador*. At the commencement of the thirteenth century, indeed, the Moors gained some decided advantages, and reduced several important towns. But the balance was restored on the celebrated plains of Tolosa, where an enormous army of Moors from Africa was nearly annihilated. Alfonso of Castille having made some destructive inroads into Andalusia, Mohammed Abu Abdalla, emperor of Barbary, prepared to punish his audacity. It is related, on credible authority, that one of the five divisions of the army which he assembled mustered 160,000 combatants. To meet this overwhelming host, the Christian kings, fortunately at this juncture brought to terms of amity with one another, united their armies at Toledo, where they were joined by numerous volunteers from Portugal and France. On the 16th of July 1212 the Christian army descended the mountainous chain which divides New Castille from Andalusia into the plains of Tolosa, where the Mahommedan army was drawn up in battle array. The conflict which ensued was obstinate and bloody, but victory at length declared for the Christians, and its immediate consequences involved the ruin of the Mahommedan empire in Spain. The thirteenth century is distinguished by other important advantages gained by the Christians. Ferdinand III. king of Leon, afterwards of Castille, by his numerous victories made himself lord of Spain, from the Bay of Biscay to the vicinity of the Guadalquivir, and from the confines of Portugal to those of Aragon and Valencia. In 1233 he triumphed over Aben Hud, king of Murcia, Granada, Cordova, Merida, and Seville; and from that year to 1248 he successively obtained possession of Toledo, Cordova, the whole of Murcia, Jaen, and Seville. The loss of the city of Cordova, which in the eyes of the Mahommedans was sacred alike from its magnificent mosque, and from its having been so long the seat of their caliphs, was a severe blow to their power. About the same time King Jayme, the greatest name in the ancient history of Aragon, and surnamed the conqueror on account of his victories, reduced the Balearic Isles, and obtained other important victories. At this period Mahommedan Spain obeyed three sovereigns, who hated each other as cordially as they were all detested by the Christians. Mohammed, who ruled in Jaen, was the least powerful, but the most successful, of these petty kings. He successively got rid of his two contemporaries, and fixed his court in Granada, resolving if possible to extend, or at the worst to preserve, his new states against the independent walis or local governors on the one hand, and the Christians on the other. Thus the celebrated kingdom of Granada was founded in the year 1238, for that of Cordova no longer existed. During two centuries and a half, this Mahommedan state withstood the hostile attacks of its Christian neighbours, and only fell when all Spain became united under one sceptre, and was consequently rendered irresistibly superior to the kingdom of the Moors.

The first king of Granada was equally valiant in war and wise in council, but he was not in a condition to contend with Ferdinand of Castille. He submitted to do homage to him as his vassal; and during the lifetime of Ferdinand a good understanding subsisted between him and Mohammed. But in succeeding reigns war again broke out between the Moors and Christians. In 1303 the strong fort of Gibraltar was reduced by Ferdinand IV. king of Castille and Leon. But the reign of this prince was mostly one of disaster. An iniquitous league was formed by two native princes, who proposed to share the kingdom be-

tween them. The kings of France, Portugal, and Granada, were not ashamed to sanction this unhallowed compact. The king of Portugal invaded Castille, the king of Granada spread his ravages into Andalusia, and the fate of Ferdinand seemed on the point of being sealed, and his kingdom partitioned among the combined robbers. But dissensions among the confederates, and the want of money, dissolved the league, and saved Spain. The greatest battle which had been fought between the Moors and Christians since the mighty African host was destroyed on the plains of Tolosa, took place in October 1340, on the banks of the small river Salado. The Christians under Alfonso of Castille were a very small band compared with the enormous host led by the king of Granada; but the former gained a brilliant victory, the loss of the Moors having been immense. The consequence was the surrender of several fortresses; and in the following year the destruction of the Mahommedan fleet was effected by the Christians.

It is now necessary to mention some circumstances in the history of Navarre, relative to the intimate connection which so long subsisted between that kingdom and France, and which had a material influence on the destinies of Spain. The male line of the house of Sancho Inigo, founder of the sovereignty, having ended in Sancho VI., who died in 1234, leaving no issue, the Navarrese elected as their future king, Thibault, a French prince, and nephew to the deceased Sancho. Of this monarch we know little beyond an expedition to Palestine, which he undertook along with several princes of France. His two sons, who successively occupied the throne of Navarre, espoused French princesses, and thus an intimate connection with France was established. The relationship between the two kingdoms became still more close when Queen Jeanne gave her hand to Philip the Fair of France. In short, Navarre became a province of France, and for four reigns has no distinct history. In 1328, however, the kingdoms were again separated, though the sovereigns of Navarre were closely related to those of France. Charles II. surnamed the Wicked, ascended the Navarrese throne in 1349, and shortly afterwards married Jeanne, daughter of King John of France. His reign is one of perfidy, intrigue, and dishonourable alliances. Events which belong more immediately to the history of France, led to the arrest of Charles by the French monarch, and his detention in prison for several years. He effected his escape, and again resumed his old practice of intriguing, particularly against the king of France. In 1366 he entered into a league with the celebrated Black Prince of England, for the restoration of Pedro, surnamed the Cruel, who had been driven from the throne of Castille on account of his many enormities. The expulsion of this detestable monster was the act of an indignant nation, which immediately elevated his bastard brother Enrique, or Henry, count of Trastamara, to the throne of Castille. The exiled king himself appealed in person to the generosity of the English hero, and the consequence was that the Black Prince led a powerful force across the Pyrenees. In his combined army of English and Normans were some of the flower of English chivalry. Henry made every disposition in his power, resolving to hazard all in a battle. The recollection of the cruelties and oppressions of Pedro's government were a strong stimulus to his followers, and might have insured success had he only been opposed by Pedro the Cruel and Charles the Wicked; but he had to contend with the victor of Cressy and Poictiers. The battle which decided the fate of the two kings was fought near Logroño, a few miles south of the Ebro, on the 3d of April 1367. Henry nobly contested the day, as also did his antagonist, who was as brave as he was cruel. The conflict was for a short time desperate, but it terminated in the complete discomfiture of Henry, an event followed by the immediate restoration of Pedro to the Castillian throne. His gallant ally had soon reason to regret his connection with a prince equally perfidious, debauched, and bloody. Edward quitted him in disgust, without receiving payment of the sum promised to the English troops. Pedro, no longer overawed by the Black Prince, who was as humane as he was valiant, immediately set about punishing those whom he either knew or suspected of having been zealous in the cause of Henry. His late disgrace had sharpened his naturally keen appetite for blood; but we pass over the revolting details of the enormities which he committed. They produced their usual effects, the complete alienation of the minds of his subjects from him, and then a conspiracy to put an end to such barbarous tyranny. Henry, who had fled to France, entered Spain with a small force, which, however, soon became augmented to an army. Tyrants have few friends in the hour of adversity, and those who have been bribed by gold or overawed by authority to become their pliant tools, are too easily seduced from their allegiance to be trusted when the day of trial comes. Mohammed V., king of Granada, was induced to take the field in behalf of Pedro; but it was less to aid his ally than to take advantage of the confusion of the times. Pedro's army gradually melted away, and he himself, compelled to flee for shelter to a fortress, and nearly deserted by his followers, was there shortly afterwards slain by the hand of Henry. Although, as we have already noticed, this prince was a bastard, yet he quietly ascended the Castillian throne, which he bequeathed to his posterity.

For nearly a century after these events took place, the history of Spain presents little or nothing that is remarkable. The continued and petty hostilities between the native princes, or between any or all of them and the Moors, merit but slight attention. Henry IV. surnamed the Impotent, ascended the throne of Castille in 1454. The misconduct of this prince, a frivolous and contemptible debauchee, produced a conspiracy amongst his turbulent nobles, to resist his weak and flagitious administration. He was formally deposed at Avila, in a very extraordinary manner; an effigy which represented him being solemnly degraded from the royal dignities, while at the same time his brother Alfonso was proclaimed king of Castille and Leon. Henry was naturally anxious to punish the rebels, but they assumed an attitude too formidable for him. Civil war produced a total relaxation of the laws, and let loose bands of robbers, who pillaged the open country, and not unfrequently attacked and plundered the towns. In the midst of these troubles the Infante Alfonso died, an event for the present highly favourable to the king. Some attempts to raise the Infanta Isabella, his sister, to the throne, proved at first abortive; but she was the person upon whom the nobles had set their eyes as the only legitimate successor to Henry. In 1469 was laid the foundation of a union which was to prove of such unbounded advantage to Spain. Juan II. of Aragon solicited the hand of Isabella of Castille for his son and heir Don Ferdinand, king of Sicily. By distributing largesses amongst the Castillian nobles, and firmly attaching the archbishop of Toledo to his interest, Juan succeeded in his object. On the 25th of October 1469, the royal pair received the nuptial benediction in the cathedral of Valladolid. The negociations had been secretly conducted, and the whole affair was brought to a conclusion without the knowledge of Henry or his queen, a princess as licentious as himself. She had borne a daughter, the Infanta Juana, whom the whole kingdom supposed, on pretty good grounds, to be the fruit of her intrigue with Don Beltran de la Cueva, count of Ledesma, one of Henry's favourites. No sooner was Henry made acquainted with this precipitate marriage, than he resolved to leave no measure untried for securing the crown to Juana. He caused her to be proclaimed heiress of his dominions, and in his last will declared her his suc-

cessor. But popular opinion is too strong even for princes. The country believed her illegitimate, and on the death of Henry in 1474, Ferdinand V. and Isabella were elevated to the throne of Castille and Leon, it being stipulated that the king and queen should reign conjointly. The king of Portugal at first espoused the cause of Juana; but the alliance was productive of no event of importance, and peace was restored between Castille and Portugal in 1479. The very same year, Ferdinand, by the death of his father, Juan II., was called to the throne of Aragon. Having received the homage of his Aragonese subjects at Saragossa, of the Catalonians at Barcelona, and of the Valencians in the capital of that province, he returned into Castille.

The reign of Ferdinand and Isabella is distinguished by great events, events of the highest importance, not only to Spain, but to mankind. It was under their auspices that Columbus brought a new world to light, and it was by their arms that the power of the Mahommedans was for ever extinguished in the Peninsula. Their first object was the regulation of the government and the enforcement of the laws, which, from the license of preceding reigns, had fallen into desuetude, or were openly defied. The king and queen were noted for a rigid administration of justice; neither for money nor favour would they spare the guilty; and there was too much to punish and correct not to give their administration a character of severity, which would have had no existence had the country not fallen into a state of civil and political disorganization almost unprecedented. The local judges were overawed by the nobles, and extraordinary judges or corregidors were appointed to see that they did their duty. This not being found sufficient to eradicate an evil which had existed for centuries, the aid of the Holy Brotherhood was sought and obtained. This association, which had existed since the middle of the thirteenth century, consisted of a number of confederated cities and towns, which maintained a considerable body of troops, in order to protect travellers and pursue criminals, and took cognizance of all violent offences against the laws, appointing courts and judges in various parts of the kingdom. New powers were reposed in this association, so that it became a powerful instrument in the hands of government, and alike terrible to robber and rebel. By this means the territorial jurisdiction of the seignoral nobles was materially abridged, while the royal prerogative was greatly extended. The prompt and impartial administration of justice restored tranquillity and order; and it had been well for the fame of these sovereigns if their salutary severity had been only directed against the disturbers of the public peace. But unfortunately they were equally severe against all who ventured to differ from the established faith. Against apostates, all converts who, after baptism, reverted to Judaism or the faith of Islam, their hatred was implacable. Their intemperate zeal led them to establish, or rather to re-organize, an ecclesiastical tribunal, which became proverbial throughout the civilized world for its enormous cruelties and injustice. This was the court of inquisition.

We now approach what is not only an important event in the reign of Ferdinand and Isabella, but an era in the history of Europe, namely, the conquest of Granada, the last possession of the Mahommedans in Spain. A sovereign so zealous for the Catholic faith as Ferdinand proved himself to be, was not likely to allow such enemies of Christianity to remain long in the Peninsula, if by force of arms he could expel them; and accordingly he early turned his attention to the subject. Every thing conspired to favour his design; the Moorish kingdom was distracted and disunited by a civil war between father and son; and Ferdinand having obtained the bull of Sixtus IV. authorizing a crusade, put himself at the head of his troops, and entered Granada. He continued the war with rapid success; Isabella attended him in several expeditions; and they were both in considerable danger at the siege of Malaga, an important city, which was defended with great courage, and taken in 1487. Baza was reduced in 1489, after the loss of 20,000 men. Gaudix and Almeria were delivered up to them by the Moorish king Alzagel, who had first dethroned his brother Alboacen, and afterwards been chased from his capital by his nephew Abdali. That prince engaged in the service of Ferdinand and Isabella, who, after reducing every other place of eminence, undertook the siege of Granada. Abdali made a gallant defence; but all communication with the country being cut off, and all hopes of relief at an end, he capitulated, after a siege of eight months, on condition that he should enjoy the revenue of certain places in the fertile mountains of Alpuxarras; that the inhabitants should retain the undisturbed possession of their houses, goods, and inheritances; the use of their laws, and the free exercise of their religion. Thus ended the empire of the Arabs in Spain, after it had continued about eight hundred years.

Its overthrow was soon followed by the expulsion of the Saracens from Spain. This expulsion, however, was not entirely effected till the 17th century. Vast numbers of the Moors, indeed, oppressed by their conquerors, abandoned a country where they could not reside with comfort and with freedom. From the reign of Ferdinand of Castille, to that of Philip III. of Spain, more than 3,000,000 of these people quitted Spain, and carried with them, not only a great part of their acquired wealth, but that industry and love of labour which are the foundation of national prosperity.

The conquest of Granada was followed by the expulsion of the Jews, under circumstances of great injustice and atrocity. This unhappy people had engrossed the greater part of the wealth and commerce of Spain, yet not being allowed to take away the value of their property in the precious metals, they were compelled to barter it for the produce or manufactures of the Peninsula, and this could not be effected except at a great sacrifice. One alternative was left them, to embrace Christianity. The inquisition exhausted first its art and then its fury to accomplish this object, but with comparatively little success. Many, indeed, to save their property, always dear to an Israelite, outwardly at least embraced the faith of the cross; but by far the greater number, in profound despair, and stripped of much of their wealth, took leave of the land of their birth. About the same time that this decree was promulgated, their Catholic majesties concluded an alliance with the emperor Maximilian, and a treaty of marriage for their daughter Juana with his son Philip, archduke of Austria, and sovereign of the Netherlands. To this period also belongs the contract concluded with Columbus for the discovery of new countries; an event which more powerfully than any other attracts the notice of posterity to this splendid reign, and which materially tended to raise the Spanish monarchy above any other in Europe. To Isabella must be ascribed the glory of the enterprise, for she it was who borrowed the sum of money necessary for the armament, and bade the great navigator depart. This great queen died in 1504, leaving her daughter Juana, and after that princess her own grandson (the celebrated Charles V.), heirs to the monarchy, but appointing her husband Ferdinand regent of the kingdom till the majority of Charles. The latter years of Ferdinand's life were embittered by family dissensions, which broke out even before Isabella had breathed her last. Juana was undoubtedly queen, for the Salic law, which excludes females, did not exist in Spain. This was well known, and is important, as bearing on events which happened in more recent times. Philip therefore prepared to enforce his right, while Ferdinand, fond of power, and backed by the will of his late wife, showed a determination to maintain his position in the kingdom. But just as the affairs of Spain were assuming a serious aspect, Philip died,

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and Ferdinand gradually resumed his authority over the whole country. Insurrection quailed before him, the laws resumed their empire, and prosperity revisited the people. The remaining events of his reign must be briefly summed up. He solicited and obtained the hand of Germaine, niece to Charles of France, in the hope of leaving a male heir to the throne; but his anticipations were not realized. In several expeditions to Africa, important conquests were made in that country, Algiers, Tunis, and other places submitting to become vassals to the king of Spain. In 1511 he went to Italy to assist the pope against the schismatics under the protection of the king of France and the emperor. But into the interminable affairs of Italy, the critical wars carried on by Ferdinand in that country in defence of his Sicilian and Neapolitan possessions, we cannot enter. This war, however, led to one memorable result, which was the conquest of Navarre. Desirous of carrying hostilities into France, he demanded from Jean d'Albret, king of Navarre, permission to march his troops through that country. The Navarrese refused, but at the same time promised to remain neutral. They broke their engagement, however, and entered into an alliance, offensive and defensive, with France. Determined to accomplish his end by force, and to punish the duplicity of the Navarrese, Ferdinand invaded Navarre, and in a short time obtained possession of the whole kingdom, annexing it to that over which he formerly ruled, and successfully defending it against the invasion of the French. This was the last great event of Ferdinand's life, and was one which was fortunate for the country, as serving to consolidate its power. After a lingering illness, his death took place on the 23d of January 1516. In his last will he declared his daughter Juana heiress to all his dominions in Spain and Italy, and after her his grandson Charles. Cardinal Ximenes Cisneros was at the same time appointed sole regent of Castille till the arrival of his grandson. Ferdinand is justly regarded as the founder of the Spanish monarchy; and although his character has some dark stains upon it, intolerant bigotry being not the least conspicuous, he was certainly the greatest prince of his age, and one of the ablest and best that ever swayed the sceptre of Spain. We shall now glance at the civil and political condition of Spain under the Moors and under the Christians respectively, from the period of the Mahommedan conquest till the death of Ferdinand.

Mahommedan Spain.

Mahommedan Spain originally comprehended nearly nine tenths of the Peninsula. Murcia, which the Arabs call Tadmir, though governed by the Christian Theodomir and his successor Athanagild, was as much dependent on the Saracens as Andalusia or New Castille. The districts over which the barbarian sway never extended were the mountains of the Asturias, Biscay, Navarre, and an angle of Aragon. Thus not only by far the greatest, but infinitely the most valuable, part of the Peninsula was comprised in the Mahommedan kingdom. Under the viceroys of the caliphs, and the immediate successors of the first Abderahman, that is, during the first three centuries, it was the admiration and terror of Europe. The revenues which the kings of Cordova derived from their ample possessions were doubtless immense, and this enabled them to maintain not only a large army of native troops, but great bodies of foreign auxiliaries. These mercenary soldiers are supposed by some of the most distinguished Arabian historians to have been the principal cause of the downfall of that splendid monarchy. The spirit of nationality was not destroyed; it was fostered by transplantation from the original soil; the Egyptians in Beja and Lisbon; the Persians in Huete; the Assyrians in Granada; the Berbers and Slavones in most of the great cities, especially about the court; the inhabitants of Damascus, Emessa, and of Old Palestine, in Cordova, Seville, Niebla, Medina Sidonia, and Algeziras; became so many rival factions, all eager in the pursuit of power, and all mutually hostile. Their frequent quarrels occasioned great disasters in the state, and allowed the ambitious no less than the desperate a long-continued impunity. In this distracted state of the kingdom, rebel chiefs contrived to retain and even to extend their governments; while the Christians, ever ready to take advantage of circumstances, drove the Saracens from city to city, and from province to province, till they finally expelled them from the country. After Cordova fell from its proud eminence, the Mahommedan power declined with great rapidity. The rulers of Toledo, Badajos, Beja, Seville, Ecija, Malaga, Granada, Almeria, Lorca, Murcia, Denia, Valencia, Lerida, Saragossa, and Huesca, all openly aspired to independent sovereignty. Many of these petty states were annihilated by the king of Seville; but his own, with those which still remained, were swept from the Peninsula by Yussef, the first emperor of the Almoravides. This African dynasty was again subverted by the still more ferocious Almohades. In the decline of the latter, the local governors again endeavoured to establish independent kingdoms. The Moorish domination thus became circumscribed within the mountainous region bounded by the sea, and by a line drawn from Malaga through Archidona, Loxa, Guardia, the Sierra de Cazorla, to the environs of Lorca. This small state was still farther limited by the succeeding sovereigns of Castile, from Alfonso el Sabio downwards, till, as we have seen, it was finally subjugated by Ferdinand the Catholic.

In all the states of Spain, whether Mahommedan or Christian, the government was absolute, but not despotic. If the Christian, as a protection against arbitrary power, could appeal to the legal code of the country which he inhabited, the Mahommedan could also invoke the provisions of the Koran, for the laws of the followers of the prophet are founded in their religion. Several of the Mahommedan potentates were the munificent patrons of literature and literary men, the names of some of whom are mentioned with respect at the present day. At the close of the eleventh century, Mahommedan Spain could boast of seventy public libraries, and of colleges, or seminaries of learning, in all the principal cities. Thus learning was much encouraged; and among these numerous collections of books were many hundred volumes by native writers. So great, in fact, was the literary reputation of the Spanish Arabs, that when the caliph of Egypt desired his library to be arranged and indexes to be made, he confided the task to two individuals of that nation. These men of learning comprised historians, poets, grammarians, orators, rhetoricians, mathematicians, astronomers, philosophers natural and moral, physicians, lawyers, and divines. It was in the physical and experimental sciences that the people most excelled, and that too at a time when many of the sciences were wholly neglected or totally unknown in the rest of Europe. Their knowledge of botany was far famed; that of chemistry was still more so. Indeed they are to be regarded, if not the founders, at least the regenerators, of that science in Europe. Their skill in medicine was great; in the mathematics they particularly distinguished themselves; the improvements which they made in algebra are well known. Optics and astronomy were much cultivated by them; nor were the useful arts less attended to, more especially agriculture, including horticulture and planting. The mechanical arts and manufactures were also carried to considerable perfection by the Spanish Arabs. Commerce was deemed no less worthy of encouragement than domestic industry. The fine arts however were less cultivated; but still all the great cities of Mahommedan Spain, Cordova, Granada, Toledo, Valencia, Ubeda, Coimbra, were deeply indebted to the Moorish inhabitants; a fact sufficiently proved by the remains of their past magnificence, which still exist.

History. Christian Spain.

From the foundation of the Christian states, the extent of territory comprised by each was usually variable, dependent alike on their conquests over the common enemy and among themselves. The relative extent of each at different periods may be briefly noticed. 1. When Pelayo established his little court at Cangus, the *Asturian* kingdom could only have occupied the mountainous district immediately surrounding that humble capital. By Alfonso I. this territory was extended into Galicia on the west, probably to Aragon on the east, and to the confines of Toledo on the south. Alfonso III. still further amplified the Asturian kingdom, by extending its frontiers to the Sierra de Cuenza, in the territory of Toledo, to the Duero, in Estremadura and Portugal; in one instance even as far as the Guadiana. The capital regularly continued to shift towards the centre of Spain as new territory was acquired. Thus the Asturian kingdom went on increasing till, on the incorporation of Castille with it, and the subsequent conquest of Andalusia by San Fernando, the capital of the monarchy was fixed at Seville. From the reign of San Fernando may be dated the true era of Spanish greatness. Murcia was conquered by his son Alfonso; and by his successors the Moorish kingdom of Granada was first circumscribed and finally subjugated. 2. *Navarre* (that is, Spanish Navarre), from its origin to its conquest by Ferdinand V. underwent little change in its dimensions; and its capital was always Pamplona. See the article Navarre. 3. The *Lordship of Barcelona*, which for some time continued dependent on the Carlovingian princes, comprehended anciently, not only Catalonia, but likewise Languedoc. The Spanish frontier, however, was subsequently held as a separate government, to which other lordships were subordinate. The dependence on France was of short duration, and appears nearly to have ceased towards the close of the ninth century, when Wifredo II., count of Barcelona, entirely cleared Catalonia from the infidels. That ruler decrees in the sovereign style, and is recognised even by the French as the founder of an hereditary state; which continued as independent a sovereignty as any in the Peninsula, till its union with Aragon, about the middle of the twelfth century. 4. *Aragon* was at first but a small mountainous region at the foot of the Pyrenees, the capital of which was Jaen, or San Juan de la Peña. The conquest of Sobrarve, Ribagorza, and Pallas, by Ramiro I.; of the Mahommedan fortresses from the Pyrenees to the Ebro by Sancho I.; of Huesca by Pedro; of Tudela, Saragossa, Calatayud, Daroca, Mequinencia, &c. by Alfonso I., amplified this little lordship into a considerable kingdom, the capital of which in 1119 was transferred to Saragossa. When Lerida and Fraga were reduced by the prince of Aragon, the Balearic Isles and Valencia by Don Jayme el Conquistador, Aragon became, next to Castille, the most extensive and powerful of the peninsular kingdoms.

The government of all the Christian states was absolute, and in the whole of them latterly it was hereditary. The powers of the sovereign varied at different times; latterly they became very great. He could concede or revoke, interpret or abrogate laws, declare war or make peace, appoint judges, levy and exact contributions, and the like. But still all was to be done *according to the ancient form*, that is, according to established custom. Other restraints were placed upon his power, and it is pretty certain that the Spanish kings were not commonly tyrannical. The true tyrants were the feudal lords, who were at perfect liberty to exercise almost royal authority within their respective jurisdictions. Of their violence and rapacity there are innumerable complaints in the national chronicles, and in the acts of the Cortes. It is worthy of remark, that the queens presided with their husbands in the Cortes, the councils, and the tribunals of justice, and that as judges, not merely as spectators. The only great feudatories of the crown, exercising a local jurisdiction, were the condes, who held different ranks and enjoyed different degrees of power. But, from the thirteenth century, the governors of provinces were termed *adelantados* (now captains-general), while those of cities, towns, and fortresses, were known as *alcaldes*. As conquest gave the Christians additional territory, admirals and constables were appointed, with power over the affairs of sea and land respectively. Of the dignities, whatever their names might be, most were doubtless of a mixed nature, partly civil and partly military. But there were functionaries who exercised an exclusively military authority. Among the officers of administration, those of the law must have occupied a prominent place. The judgment in civil or criminal cases properly depended on the counts or viscounts, who sometimes decided themselves, sometimes in concert with men learned in the law, called counsellors, and at other times they left the duty to the ordinary judges. These counsellors or judges were expressly educated for the office, and otherwise well adapted for such a situation. The forms of proceeding, which were simple and brief, were conducted in public, and the sentence was also openly delivered. From the decision of all the ordinary judges, lay an appeal to the royal tribunal, which also took cognizance of certain offences and cases. Spain can boast of an ample body of laws promulgated during the middle ages.

As the circumstances of the country altered, and the state of society advanced, it became necessary to extend or limit the existing laws, and to enact new ones. To encourage the cultivation of waste lands, the Christian kings promised to the lower orders, that if they reclaimed unoccupied wastes, formed themselves into small communities, building villages and towns, and defended their possessions against the common enemy, they should enjoy certain social privileges in addition to the profits of their industry. Of these privileges the most highly prized were those which rescued the people from the jurisdiction of their feudal tyrants, which empowered them to elect their own magistrates, to form municipal juntas, and to dispose of certain revenues arising from forests and other possessions. It may well be believed that so brilliant a reward attracted many settlers, who were thus at once raised from the rank of serfs to that of citizens. Such was the origin of many *fueros*, or provincial laws, which varied in their spirit according to the liberality of the monarch and the relative importance of the colonies. These fueros were devised with jealous care to preserve the inhabitants from feudal domination. No baron or noble could settle in a community, unless he abandoned his birthright, enrolled himself among the citizens, and owned obedience to the local fuero. So many temptations did these new communities present, in the shape of municipal posts, that many nobles were known to renounce their rank, and class themselves among the plebeians, for the purpose of obtaining them. The defects of such a system were not long in being felt, and a remedy was provided by the introduction of the "Siete Partidas," so called from the seven parts into which it is divided. It is by far the most comprehensive code of Spain, being taken from the code of Justinian, the Visigothic, the Fuero Viejo, the local fueros, as well as from the canon law.

Cortes.

Passing over the much-disputed question regarding the origin of popular representation in Spain, we find that there were present, at the Cortes held at Leon in the year 1188, "the deputies of towns, chosen by lot," that is, representatives of the people, the third estate. On these municipal towns many important privileges were conferred by successive sovereigns, the direct tendency of which was to abridge the powers of the feudal lords. But even at the brightest period of popular representation, which was the fourteenth century, the representation was never definite. Many of the great towns neglected to send any deputies at all, and those which

did return them appear to have observed little proportion in the numbers. Two was the number which ought to have been returned by each, but some towns sent eight, while others of larger size sent only one or two. Indeed it seems highly probable that the privilege of sending deputies was a favour granted by the sovereign to such towns as it was his pleasure to honour. It is preposterous, therefore, to look upon the third estate as consisting of independent representatives of the nation: the members were little better than nominees of royalty, and their numbers could be increased or diminished just as it suited the purposes of government. Much as the popular representation of Castille is extolled by national writers, it seems to have been better adapted for securing and extending the power of the crown, than for protecting the rights of the people. Under Ferdinand and Isabella the last lingering traces of popular liberty were destroyed; but the power of the other orders of the state suffered at the same time a corresponding diminution, as we have already noticed. Such is a brief outline of the government and laws of Castille and Leon, the most important of the peninsular kingdoms, and almost the only ones in which the reader will take much interest, or, indeed, regarding which authentic documents remain. It may be mentioned, however, with regard to the kingdom of Aragon, that, with the exception of the lowest order, the serfs of the soil, the Aragonese possessed a greater share of individual liberty than any other people in the Peninsula. The citizens and nobles frequently coalesced for the purpose of obtaining fueros or privileges from the crown, and when thus united they were generally too powerful to be resisted. Hence numerous concessions were made by successive sovereigns, and an amount of popular freedom obtained by the people which frequently threatened the existence of the monarchy itself. Catalonia and Valencia were always distinct from Aragon, both in government and laws. Each had its Cortes, consisting of three estates, prelates, nobles, and deputies, all no less tenacious of their privileges than those of Aragon.

Literature, science, and religion.

Several historians of note, whose works have come down to us, flourished in the various Christian kingdoms of Spain during the period of Mahommedan domination. Poetry sprung up about the middle of the twelfth century, and some very interesting specimens of these ancient compositions still remain, particularly the *Poema del Cid*. The old Spanish ballads are well known, and celebrated throughout Europe. The scientific state of Spain, as compared with the Mahommedan, exhibits a lamentable contrast; nor does it appear that in any of the useful arts of life the Spanish Christians were equal to the Moors. The most distinguished place in Spanish science during this period has been assigned to Alfonso X. surnamed el Sabio; but even he was greatly indebted to the Arabians for the perfection which he attained. The theologians of Spain, during the middle ages, were more numerous than all her other writers put together, and the writings of many of these shining lights of the church are to be met with in the libraries of Spain. With regard to religion it is only necessary to state, that the Catholic faith prevailed in full force, and was characterized by the darkest bigotry and the fiercest intolerance, as the doings of the inquisition amply testify.

Charles I.

Charles I. (V. of Germany) became king of Spain on the death of Ferdinand, but a regency had been nominated to govern the kingdom until he should attain his twentieth year. If the events and transactions in which this monarch was concerned were to be woven into the history of Spain, it would in fact be the history of almost all Europe during the period of his reign. But our business is with events purely peninsular; or if others of a more general character are occasionally noticed, it will be because they are too closely connected with the former to be separated without violence. His foreign wars, negociations, and other transactions, arose from his position as emperor of Germany, not from his being king of Spain; and an account of them will be found under the heads France, Italy, and England, to which articles the reader is referred.

The Cardinal Ximenes Cisneros, to whom the regency had been left by the deceased king, was bitterly opposed in his administration, principally by the nobles of Castille, who, envious of his dignity, displeased with his firmness and vigour, and hoping for impunity under a young monarch, soon showed a disposition to refuse him obedience. Popular discontent reached a great height; and as his best measures were misrepresented to the king, Charles perceived the necessity of making his appearance in Spain, where he arrived in 1517. Nobles and prelates hastened to meet their sovereign, and among the rest the calumniated Ximenes. But that sovereign he was not destined to see; he suddenly sickened and died, not without suspicions of poison. Charles brought with him a multitude of Flemings from the Netherlands, who soon monopolized the principal situations in church and state, and in all their dealings evinced an unquenchable thirst for gold. The favour extended to these foreigners so incensed the people, that Charles found extreme difficulty in obtaining the homage of the Spaniards. Although they swore allegiance to him, it was on certain stipulated conditions, sufficiently advantageous to themselves. In 1519 occurred an event destined to exercise great influence over his future life, over his hereditary states, in fact over all Europe. This was his election to the imperial throne of Germany, left vacant by the death of his paternal grandfather Maximilian. The Spaniards were pleased that this dignity was conferred on their sovereign; but as the old grievances continued to gall them, they were not so dazzled as to be insensible to their own interests. The leading men of many of the principal cities publicly remonstrated with Charles, and it was only by granting certain concessions that he could keep them from open rebellion. His presence having become absolutely necessary in Germany, he quitted Spain, but proceeded first to England to concert with Henry VIII. the means of humbling the power of the French king, Francis I. This monarch had been a candidate for the imperial diadem; but, disappointed in his ambition, and in hatred of his successful rival, he leagued himself even with the enemy of the Christian faith. He also laid claim to Italy, the Netherlands, and Navarre; so that war was unavoidable, and hostilities immediately commenced; for an account of which see the articles already referred to.

The turbulence of the times was not likely to be assuaged by the absence of the king from his all but revolted territories in the Peninsula. Opposition had now degenerated into rebellion; and what before might have been dignified with the name of patriotism, could only be characterized as crafty schemes of personal ambition. Unfortunately for the interests of order, the regency of Castille, where disaffection had assumed the most serious aspect, was held by a man, estimable and virtuous, indeed, but little fitted for such stormy times. The appointment of this individual, Cardinal Adrian, who subsequently wore the triple crown, had at the first given great offence to the nobles and deputies at court; but the king, though solicited, would not change him for another. The persons upon whom the fury of the mob fell were chiefly the governors and deputies of the cities and provinces. Many were massacred; open insurrection spread from city to city; and no species of crime was left uncommitted. In this critical position of the royal cause, it was fortunate that Aragon, Catalonia, and most of Andalusia, stood aloof from the confederation. Had they joined it, the evils might have been long protracted, and the whole Peninsula plunged in misery and ruin. But the revolted cities followed one another in making their submission to government; and those which did not voluntarily

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submit were reduced by the royal troops, now augmented to a considerable body. An attempt of the French king to seize Navarre was happily frustrated, so that in 1522 the whole country was restored to tranquillity.

In July of that year, the emperor, whose presence had been often requested by the royalists, arrived in Spain. It was expected that summary justice would be inflicted on those who had taken a prominent part in the recent disturbances; but on this occasion Charles showed a degree of clemency almost unexampled in history, very few being condemned to suffer. During the remainder of this prince's reign, the domestic tranquillity of Spain was undisturbed, except by an insurrection of the Moors, which was soon suppressed. Of two expeditions of the emperor to the African coast, to humble, if not to extirpate, the Mahommedan pirates, one was successful, the other disastrous. He compelled the Grand Turk, who penetrated into the centre of Europe, to retreat; and took his great rival, Francis I. of France, prisoner at Pavia. Such were some of his achievements in his foreign wars, by which the fame of the Spanish arms was extended throughout Europe. The mines of the west also had begun to pour their inexhaustible wealth into the country, so that the military and political power of Spain now attained its zenith, and became a source of uneasiness to other nations. In 1525 Charles married the Princess Isabella, sister of Joam III. king of Portugal. The issue of this union was, besides two daughters, the infant Philip, destined to be no less famous than his father. Charles made an ineffectual effort to procure for him the imperial crown of Germany; but in 1554 succeeded in obtaining the hand of the princess Mary of England. That the nuptial ceremony might be performed with greater splendour, he invested his son with the regal title, by abdicating in his favour his Italian possessions, the kingdoms of Naples and Sicily, and the duchy of Milan. This was but a prelude to a still more extraordinary sacrifice. It appears that from the very prime of life the emperor had meditated a retreat from the world; and that on the death of his mother Juana, in 1555, he was determined on fulfilling his long-cherished project. Many reasons have been assigned for this memorable act, but the principal cause is to be traced to his superstitious temperament; something is also to be allowed for the bad success of his arms during the latter years of his reign. Having concluded a truce with Henry, the successor of Francis, and recalled Philip from England, he assembled at Brussels the states of the Netherlands. There, amidst the most imposing solemnity ever witnessed since the days of the Roman Cæsars, he resigned the sovereignty of the Low Countries into the hands of his son. With the same august ceremony he resigned the crown of Spain, and the dominions thereto belonging; and from the monastic retreat to which he retired, he sent his resignation of the imperial diadem. The place which he had chosen for his residence was the monastery of St Justus, one of the most secluded and delightful situations in Estremadura. Here, employed in religious observances, passed the latter years of the life of the most powerful sovereign Europe had seen since the days of Charlemagne and the empire of the west. His character has been variously described by natives and foreigners; the former can see little in it to condemn, the latter nothing to admire. His policy was always close, sometimes crooked, and in not a few instances dishonourable. He was no friend either to civil or religious liberty, and may safely be pronounced a bigot. Under him the condition of Spain was more splendid, perhaps also more prosperous, than in any prior or subsequent reign. Notwithstanding his many wars, the people do not appear to have been overburdened in supporting them, for the New World poured its treasures at his feet. A new impulse was given to national industry by the markets opened for Spanish productions in the transatlantic colonies. But the brightest landscape has its masses of shade. The nobles held a power over the people which was often exercised with violence. Favouritism to foreigners was practised to an unprincipled extent, and the sale of offices became a branch of traffic. Another baneful evil was the multiplication of religious orders. Lastly, the exemption from taxation of the nobles and clergy, which threw the whole weight of public contribution on the third estate, increased the disaffection of that body, and was one of the chief causes of the subsequent decline of the kingdom. For an account of the private life and character of Charles, see the article CHARLES V.

Philip II.

The reign of Philip II. commenced in 1556, and extended to the year 1598. Much of it was occupied in foreign wars, to which we can only briefly advert. For an account of Philip's long, bloody, and inglorious struggle with his revolted subjects of the Low Countries, see the article HOLLAND. The circumstances which led to the invasion of Portugal, and the annexation of that kingdom to the Spanish crown, will be found fully detailed under the head Portugal. An attempt was made by the pope, in conjunction with France, to wrest from Philip his Italian dominions, but without success. The duke of Alva, the viceroy of Naples, put his troops in motion, seized several fortresses of the papal states, and the holy city began to tremble for its security. Philip himself invaded France, and inflicted a severe blow on Henry under the walls of St Quentin. The French army, under the duke of Guise, was recalled from Italy; and the pope, left at the mercy of the duke of Alva, was compelled to purchase his safety by withdrawing from the French alliance. In 1559 peace was made with France; and Philip having become a widower, further ratified the treaty by marrying Elizabeth, sister of the French king. But the Turks continued to harass Naples, although they durst not make a stand before the Spanish forces. In 1565, Philip assisted the Maltese with 10,000 Spaniards in the famous siege which they underwent from sultan Solyman. Five years afterwards, the war between the Venetian republic and the Porte again brought the Spaniards into collision with the latter power, and they had no small share in achieving the glorious victory of Lepanto. The Mahommedans, however, still continued to make descents on the Italian coast, and to harass the African possessions of Philip; but, on the whole, the war with the misbelievers was honourable to the Spanish arms.

We now approach an event of peculiar and lasting interest to every Briton, the projected invasion of England by the famous Spanish Armada. Elizabeth had certainly done much to provoke the resentment of Philip. She had succoured the insurgents of the Netherlands, fomented the disturbances in Portugal, assisted France, and her naval captains had ravaged the dominions of Spain in both hemispheres. Philip's patience being exhausted, he prepared a mighty armament for the invasion of England. A complete account of this famous attempt to plant a foreign standard on our shores, and its disastrous termination, will be found in the article ENGLAND. A second expedition for the invasion of Ireland shared the fate of the former; and this effectually cured Philip of all ambition to attempt the subjugation of the most hated of his enemies.

The revolt of the Moriscos occupies a remarkable place in the native annals of the sixteenth century. These Christianized Moors still remained Mahommedans at heart, making amends for compulsory apostasy by celebrating in secret the rites of their religion. It was the jealous policy of Spain to destroy, if possible, every vestige of their nationality. To effect this end the government had recourse to severe and unjust measures, which produced open revolt and civil war in Granada. Dreadful atrocities were committed by the Moriscos, and fierce was the retaliation of the Christians. The war raged with various success for some time, but how the struggle must terminate

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could never for a moment be doubtful. The Moriscos fled to the mountains, the ancient asylum of liberty; and in the deep caverns with which they abound they deemed themselves secure. But thither they were hunted by the Christians, and, like wild beasts, smoked to death by fires kindled at the mouths of these subterranean retreats. All who were in arms were cut off in this manner, or by the sword. The total expulsion of the Moriscos, however, did not take place till a subsequent period. To some affairs of a private or more trivial nature it is unnecessary to advert, although some of them deeply implicate the character of Philip. This prince died in September 1598, in the palace of the Escurial, of which he was the founder, and which is the noblest monument of his reign. By the last of his four wives, Anne of Austria, Philip left a son, who succeeded by the title of Philip III.; his other male children preceded him to the tomb. Don Carlos, one of these, is generally believed to have been murdered by the command of his bloody and unrelenting father. The character of Philip was gloomy, stern, and cruel; he was suspicious, dark, and vindictive, the irreconcilable foe of civil and religious liberty, for which there can only be brought forward as a palliation his zeal for what he called religion. But Philip was eminently prudent, attentive to public affairs, and what he conceived to be the best interests of his country. It has been supposed that the sceptre of Philip was swayed over 100,000,000 of human beings, including the population of all the foreign possessions of Spain. At this time the state of the inhabitants of the Peninsula was one of comparative comfort. Agriculture, manufactures, and commerce, flourished to an extent even greater than in the best period of the emperor's reign. Yet all his vast resources, especially in the New World, were unhappily wasted by Philip; and his own policy destroyed the very foundations on which they rested, and hastened the decay, or rather ruin, of the kingdom. The measures which exercised so fatal an influence over the destinies of Spain may be briefly enumerated. 1. His persecution of the Flemings and Dutch, which led to a revolt that cost him 150,000,000 of ducats; 2. his war with England, no less expensive and disastrous; 3. the treasures sent to support the abominable Catholic league, and wars in other quarters; 4. the subjugation of the Moriscos, and the proceedings of the inquisition, by which the most productive and useful classes of his subjects were ruined or expatriated. From these and from other minor causes, notwithstanding the enormous revenues and resources of the kingdom, Philip died insolvent.

Philip III.

The greatness of Spain having passed away with Philip II., from this period it declined with fearful rapidity. For a long period there is little to be recorded beyond the reign of worthless favourites, the profligacy of courts, and the feeble efforts of a government struck with mortal paralysis. Our retrospect of these reigns will therefore be characterized by a brevity corresponding with their importance. The most signal event of Philip III.'s reign was the total expulsion of the Moriscos from all parts of Spain where they had sought a home during the struggle recorded in the last reign. The loss to agriculture and commerce, for they were by far the most ingenious and industrious portion of the community, and the blow which would be inflicted on the national prosperity by the withdrawal of so much wealth as they possessed, were never taken into account by the duke of Lerma, the prime ministers, nor any of his inquisitorial councillors. Orders were issued for their immediate expulsion in September 1609, and no fewer than 600,000 individuals were forcibly dragged from their homes, and landed on the African shore, there to be treated even worse, by the most cruel and perfidious of the human family. The foreign transactions of this reign are unimportant. Philip III. died in March 1621, leaving his kingdom to a son who bore his name, and also inherited his imbecility.

Philip IV.

Philip IV. ascended the Spanish throne in his seventeenth year. Profligate extravagance and dissipation soon began to characterize the proceedings of the court, and murmurs and complaints to agitate the people, who were exhausted of their wealth in supporting pantomime and mummery at home, and iniquitous wars abroad. The reins of government were surrendered into the hands of the Conde de Olivares, a worthless favourite. An attempt to enforce an obnoxious measure drove the Catalans to revolt. They sought and obtained the aid of France, and this occasioned a feeble and unimportant war, which languished till 1660, when peace was concluded, but not till Spain had surrendered part of her territory to France. Contemporary with the origin of the Catalan insurrection was that of Portugal, by which the Portuguese freed themselves from the Spanish yoke. See Portugal. During his long reign, Philip was frequently at war with England, Holland, and France, and every power committed fearful ravages on his territories. England took Jamaica during this disastrous and disgraceful period of Spanish history. In Naples, a terrible shock was sustained in 1646, by the insurrection of Massaniello. See the article Sicilies. But the most calamitous of Philip's transactions was the war in the Low Countries, which terminated in his recognising the independence of the seven United Provinces. Philip died in 1665. His character needs no description. Since the days of Roderick the Goth, a more disastrous reign than his had not darkened the annals of Spain.

Charles II.

Charles II. son of Philip IV. succeeded to the throne when only four years of age. As the affairs of the kingdom were then situated, they were not likely to improve under a child; and it was a further misfortune, that throughout his long reign the king remained little better than a child. He was feeble in body, and next to imbecile in mind; in proof of which it may be mentioned, that he believed himself bewitched, and submitted to the exorcisms of his confessor with devout solemnity. Louis of France, who espoused Maria Teresa, sister of Charles II. by a prior marriage, in right of his wife preferred a monstrous claim to the Low Countries, and poured his legions over the frontier to make it good. The union of Sweden, Holland, and England, to oppose the ambition of the Frenchman, saved the whole Netherlands from subjugation; but by the peace of Aix-la-Chapelle Louis retained the most valuable of the conquests which he had made. In this reign the complete independence of Portugal was recognised. In 1672, France invaded Holland, now the ally of Spain, conquered Franche-Comté, which belonged to Spain, made some destructive inroads into Catalonia, and reduced some fortresses in the Low Countries. By the alliance against France, in which England, Germany, and Spain joined, Louis's career of ambition was effectually checked. But subsequently he reduced Valenciennes, Cambray, St Omers, and other places; Ypres and Ghent were assailed with equal success; and a place on the Catalan frontier also yielded to his arms. Most of these places, however, were restored at the peace of Nimeguen in 1678, one of the conditions of which was, that Charles should receive the hand of Maria Louise, niece of the French king. On the death of this princess in 1689, the French again poured the storm of war over the frontier of Catalonia. Destitute of money and of troops, Spain trembled to her most distant extremities. But circumstances of a delicate nature, into which we shall not enter, induced Louis to restore all his conquests at the peace of Ryswick in 1697. The health of Charles, always infirm, now rapidly declined, and he expired on the 1st of November 1700. He was the last of the Austrian dynasty; and glorious as the condition of Spain was under its early sovereigns, those who succeeded them had brought the kingdom to the verge of ruin. From the accession of the third Philip it had declined, from causes already specified.

History. The condition to which it was now reduced was pitiable. The army and navy were in a state of utter disorganization; the walls of towns and fortresses were in ruins; the public revenues had dwindled to little more than a nobleman's income; and trade, manufactures, and commerce, had all but ceased to exist. Another such reign as that of Charles II. would have dissolved the bonds of society.

Philip V. Charles II. was succeeded by Philip V. duke of Anjou, grandson to Louis XIV. of France. He was the eldest son of Maria Teresa, eldest daughter of Philip IV., consequently the most legitimate sovereign; for Charles left no issue, and before his death he had subscribed an instrument, declaring Philip his successor. The foreign events of this reign demand our first attention. The transactions of the war which was soon declared against France and Spain, by England, Holland, and the empire, assisted by Savoy, Portugal, and Prussia, have been already related under the article Britain. The chief objects of the alliance were to obtain satisfaction for the Austrian claims on Spain, the emperor Leopold being not only descended from Fernando, brother of Charles V., but whose mother was the daughter of Philip III.; to rescue the Netherlands from France; to prevent the union of the French and Spanish crowns; and to exclude subjects of the former from the Spanish possessions in the West Indies. The treaty of Utrecht, which terminated the differences between the principal contending powers, was signed in 1713; and in 1715 a permanent peace was concluded between Spain and Portugal. By the celebrated treaty of 1713, Spain was stripped of half her European possessions. Philip was indeed acknowledged king of Spain and the Indies; but Sicily was ceded to the duke of Savoy; Milan, Naples, Sardinia, and the Netherlands, to the emperor; and Gibraltar and Minorca to the English. The Catalans, who had revolted and joined the allies, were likewise guaranteed a general amnesty, but without any stipulations for the preservation of their ancient fueros or privileges, which they had justly forfeited. Philip also renounced, both for himself and his successors, all claims to the French crown. In return for this renunciation, he forced rather than persuaded his council to introduce a measure to which subsequent events in the history of Spain gave great importance. This was to alter the order of succession, and establish a sort of Salic law, by which the most distant male of the family would be called to the inheritance in preference to the nearest female. The innovation was regarded with discontent. By the ancient law, which, in default of direct male issue, called females to the throne, the monarchy had been formed. By it Catalonia had been united with Aragon, and the latter with Castille; and by it Philip himself had inherited the crown.

Philip made an unsuccessful attempt to recover Sicily, Sardinia, and Naples; for he had now rendered both his navy and his army formidable alike by discipline and numbers. His fleet, however, was totally destroyed off the coast of Sicily, by our Admiral Byng, in the year 1718.

By a new treaty in 1720, Sardinia was given to the duke of Savoy, and Sicily to the emperor; and by the treaty of Seville, concluded in 1729, the duchies of Tuscany, Parma, and Placentia, were ceded to Spain. In 1731, the Spanish king invaded Naples, took possession of that kingdom, and conferred it on his son Don Carlos, in consequence of which war was declared between Spain and the empire in 1733. At the end of that year the palace of Madrid was consumed by fire, and all the archives relating to the Indies perished in the flames. In 1739, hostilities were renewed between Spain and Britain; but the only successes obtained by the latter power were the capture of Porto Bello by Admiral Vernon, and that of the Manilla galeon by Commodore Anson. Philip's long and turbulent reign was now drawing to a close. In July 1746, he was hurried to the grave by an attack of apoplexy. One memorable event of his reign remains to be noticed. In imitation of the emperor, he resigned the cares of royalty into the hands of his son in 1724; but finding seclusion irksome, he resumed them again in a very short time. Whatever might be the weaknesses of this prince, he had a sincere desire for the good of Spain, and retrieved it from hopeless ruin by several judicious measures which he introduced, so that the country attained a degree of positive prosperity unknown since the days of the second Philip.

Ferdinand VI. Ferdinand VI. a mild, prudent, and beneficent prince, reformed abuses in the administration of justice and management of the finances. He revived commerce, established manufactures, and promoted the prosperity of his kingdom.

Charles III. Charles III. succeeded Ferdinand in 1759. The famous family compact was concluded at Versailles in 1761, among the four kings of the house of Bourbon. The English, alarmed by the naval preparations of Spain, declared war in 1762, and took Havannah in the island of Cuba, and Manilla in the East Indies. Notwithstanding this success, peace was hastily concluded at Fontainebleau, in November, by which the Havannah was restored. In 1767 the Jesuits were expelled from Spain. An unsuccessful expedition was concerted against Algiers in 1775, the particulars of which it is unnecessary to detail. In the war between Great Britain and her American colonies, Spain, by the intrigues of the French court, was instigated to take up arms in support of the latter. At the conclusion of that calamitous war, Great Britain, in a treaty with Spain, ceded to this power East and West Florida, and the island of Minorca. Charles died in 1788, and was succeeded by his second son Charles Anthony, prince of Asturias, the eldest having been declared incapable of inheriting the crown.

Charles IV. 1788. Charles IV. had not long been seated on the throne before the portentous revolution in France involved Europe in a general scene of political and military contest. The king of Spain joined the general confederacy against the new republic, and in consequence was numbered among the objects of its resentment, by a declaration of war in 1793. The military operations of Spain, however, were extremely languid; and after two campaigns, in which she might be said to carry on rather a defensive than an offensive war against the republican armies, she was compelled to conclude a treaty of peace, which was signed at Basel on the 22d July 1795. By this treaty the French republic restored to the king of Spain all the conquests which she had made from him since the commencement of hostilities, and received in exchange all right and property in the Spanish part of St Domingo.

Engages in the confederation against France. 1793.

War between Spain and Britain. 1796. This treaty was soon followed by a rupture with Great Britain. On 5th October 1796, the court of Spain having published a manifesto against this country, the court of London made a spirited reply; and about the same time was published a treaty of offensive and defensive alliance, which had been concluded about two months before, between the king of Spain and the French republic. In the war which followed between Spain and Great Britain, his Catholic majesty could boast of but little honour or success; and the French republic gained little from its new ally but the contributions of money which it from time to time compelled him to advance. On the 14th of February 1797, a Spanish fleet of twenty-seven sail of the line was defeated by Sir John Jervis off Cape St Vincent, and four of the Spanish line-of-battle ships were left in the hands of the victors. From this time till the temporary cessation of hostilities by the peace of Amiens in 1802, there is nothing remarkable in the transactions of Spain. 1797.

1803. On the renewal of the war in 1803, Spain was again compelled, by the overbearing power of France, to take an active part against Great Britain, and fitted out a formidable fleet, which was united to a considerable naval force belong-

History. 1805. ing to the French. The Spanish declaration of war against Britain is dated at Madrid on the 12th of December 1804; and on the 21st of October 1805, the combined fleets of France and Spain were annihilated by Lord Nelson off Cape Trafalgar. After this terrible blow to the naval power of Spain, nothing of importance took place till 1808, when the liberties of Spain were subverted by the machinations of Napoleon. The designs of the French emperor, long suspected, became sufficiently apparent in 1808. Unfortunately the dissensions of the royal family of Spain were so favourable to his plans, that they may be said to have hurried on their execution. The dark and tortuous policy by which he effected his purpose, and the course which events took in Spain, will be found detailed in the article FRANCE, so that only a brief notice of the leading facts will be given in this place. At this time (1807) the management of state affairs was in the hands of Don Manuel Godoy, the favourite of Charles IV. and his queen, and better known by the name of the Prince of Peace. He had been raised from the humblest station to be the richest and most powerful subject in the kingdom, and to fill its highest posts. Ferdinand, the prince of Asturias, had refused to marry the sister-in-law of this fortunate minion, and to secure himself from his vengeance he wrote to Napoleon asking for protection. At the same time he exposed the administration of Godoy, in a letter to his father, and requested to be allowed some participation in the government. This so enraged the queen that she ordered his immediate arrest; but, on asking pardon of the king, Ferdinand was restored to liberty, not however before Charles had taken the fatal step of appealing to Napoleon regarding his son's supposed treasonable conduct. The emperor of France was thus constituted umpire between father and son. French troops poured into Spain, which was thrown into a ferment by the rumour that the royal family were preparing to fly to America. Popular indignation was kindled against the hated favourite, who narrowly escaped with his life. At length Charles abdicated in favour of his son, but two days afterwards privately protested against his own act, and sent a copy of this strange paper to Napoleon, who afterwards made it a pretext for his ulterior designs.

Ferdinand VII. The prince of Asturias, now elevated to the throne under the title of Ferdinand VII. made his triumphal entry into Madrid. Shortly afterwards he was induced to undertake a journey to Bayonne to meet Napoleon, and consult about the affairs of the kingdom. This memorable interview took place, and the eyes of Ferdinand were now thoroughly opened to the designs of the French emperor, by finding himself a captive in his hands, and his right to be considered king of Spain rudely denied. The rest of the royal family eagerly rushed into the snare set for them by the master of toils at Bayonne. Here father and son surrendered the crown of Spain into the hands of Napoleon, by whom it was transferred to the head of his brother Joseph. But such a momentous event as a change of dynasties, effected under circumstances of such atrocious perfidy, could not take place without rousing every loyal and every indignant feeling in the bosoms of the Spanish people. No sooner was the fact of the renunciation known, than the northern provinces burst into open insurrection. Asturias and Galicia set the example; and it was soon followed by almost every part of Spain not immediately occupied or overawed by the armies of France. One of the first steps taken by the leaders of the insurrection was to assemble the juntas or general assemblies of the provinces. When these were organized, they issued proclamations, calling on the Spaniards to rise in defence of their sovereign, and in the assertion of their own independence. Besides these proclamations from the provincial juntas, addresses were published in almost every province by the leaders of the popular cause; in particular, the province of Aragon was addressed by Palafox, a name celebrated in the annals of the Spanish revolution, in a bold and spirited manifesto. The junta of Seville, which assembled on the 27th of May, formed itself into a supreme junta of government, caused Ferdinand to be proclaimed king of Spain, took possession of the military stores, and issued an order for all males from sixteen to forty-five, who had no children, to enroll themselves in the national armies. On the 4th of July the alliance of Great Britain with the Spanish nation was proclaimed, and a struggle began which terminated in the complete expulsion of the French from the Peninsula. The events of this celebrated war will be found recorded in the article BRITAIN.

The loss of the royal family, by which they were deprived of a directing power, a legitimate head to give the constitutional stamp to their proceedings, plunged the Spaniards in great difficulties. Unity of opinion was wanting to the junta, and vacillation and weakness marked its proceedings. It was unfortunate, that while one spirit animated the mass of the people against the French, many of the nobles and other influential individuals had given in their adhesion to the French dynasty. The successes of the latter were attributed, probably not without some reason, to treachery; and more than one Spanish general fell a victim to public indignation, whether justly or unjustly cannot now be known. But whatever victories the French gained, they only remained masters of the places which they occupied. A vast system of guerilla warfare had been organized and vigorously prosecuted, which served to preserve the energy and confidence of the nation unbroken. The guerillas everywhere surrounded and harassed the French; no line of communication was safe for them. These petty achievements, however, could not compensate for the loss of battles on a large scale, and the capture of fortresses, the strongholds of the kingdom. The supreme junta fell under suspicion, and, unable to sustain the weight of government and the storm of public indignation, it was agreed that the Cortes should be convoked, and a regency appointed. The manner in which this celebrated Cortes was constituted has been a subject of keen disputation; but the circumstances in which the kingdom was placed at the time, rendered it impossible for the members being chosen according to the ancient forms. It has been alleged that this assembly was of a much more popular and democratic nature than the regular Cortes, which is undoubtedly the fact. It ought to be recollected, however, that the nobles were a suspected body, and therefore the burgesses and others might consider it dangerous to admit their voice in a matter which involved the liberties of the kingdom. But, we repeat, the situation in which Spain stood at this eventful moment made it a matter of necessity for those who directed the affairs of the nation, to act as they did. Had not the progress of the French armies dispersed the central junta, and concentrated the fugitive patriots at Cadiz, it is more than probable that the Cortes would have been assembled according to the ancient forms, and that the privileged classes, supported by the majority of the nation, would have defeated any attempt to alter the old constitution. But Cadiz offered to that party which has been since known by the name of liberal, the most favourable opportunity of striking a deadly blow at the very root of the monarchical power under which they had so long groaned in hopeless yet silent restlessness. Cadiz was not only in itself a place much more democratic than any other in Spain, but during the usurpation of the French it had become the asylum of all who professed liberal principles. As they generally belonged to that numerous class of the Spanish gentry who look up to the patronage of government for the means of subsistence, the court drew them together from the provinces. On the prospect of the political changes which the captivity of Ferdinand opened to the country, these men attached themselves to the central junta, and finally followed its members in their flight from

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Seville to Cadiz. Hither, too, flocked all the stragglers of the philosophical party; and on the dissolution of that dull, dilatory knot of ill-assorted men, who, under the veil of dignified gravity, had for a time concealed their unfitness to direct the nation, the Spanish speculatists found themselves in the midst of a population highly disposed to listen to their doctrines, to approve their views, and constitute them the organs of the new laws which were to remodel the kingdom.

New constitution.

The majority of the first Cortes being composed of liberals, the project of a constitution was immediately set on foot, and a committee of the ablest members appointed to draw up the fundamental code of the monarchy. Such a task, at all times arduous, was, in the present circumstances of the country, beset with peculiar difficulties. Encouraged by the absence of the king, placed beyond any check from the privileged classes, and the weight of the landed property of the country, it is not surprising that the framers of the constitution allowed their zeal to carry them too far, especially when it is considered that the Spanish people were almost entirely unaccustomed to the exercise of civil rights. The government was wholly remodelled, so that from being the most absolute monarchy in Europe, it became the most strictly limited of all limited monarchies. As this constitution, with the exception of a few alterations, is nearly the same as that which is now in force, our introducing it in this place will serve to give greater clearness to the subsequent narrative of events. It was drawn up by 184 members of Cortes, on the 18th March 1812. On the 20th of the same month the regency, which consisted of Cardinal Bourbon and two other apparently incapable individuals, took the oath to maintain it. This constitution was acknowledged by the allies of Spain, namely, Great Britain, Prussia, Russia, Sweden, and other states.

By one of the first articles in the code, the sovereignty is declared to reside essentially in the nation, which, being free and independent, neither is nor can be the patrimony of any person or family. All Spaniards, without distinction, are subject to taxation. "The religion of the Spanish nation is, and shall be for ever, the Catholic, Apostolic, and Roman, which is the only true religion." "The nation," it is added, "protects it by wise and just laws, and forbids the exercise of any other whatever." The government of the Spanish nation is stated to be "a limited hereditary monarchy." The power of making laws is vested "in the Cortes, jointly with the king." In describing the class of Spaniards who enjoy the privileges of citizenship, persons "reputed of African origin, either by the father or the mother's side," are excluded. A similar exclusion is given to Spaniards who obtain naturalization in another country, or who, without leave, absent themselves five years from Spain. The only basis for the number of representatives in the Cortes is *population*, to be taken from the census of 1797, till one more correct can be made. For every seventy thousand souls there is to be one deputy in the Cortes. The returns of the members are made by three successive elections. Every parish appoints electors for the district to which it belongs. These repair to the chief town of the district to choose another set of electors, who, lastly, meeting in the capital of the province, make the final appointment to the Cortes. The Cortes are triennial. No member can be elected for two successive representations. No debate can be carried on in the presence of the king; his ministers may attend and speak, but are not allowed to vote. There is a permanent deputation, or committee of the Cortes, composed of seven members, appointed by the whole body, before a prorogation or dissolution, whose duty is to watch over the executive, and report any infringement of the constitution to the next Cortes. It also belongs to them to convoke an extraordinary meeting of the Cortes in the cases prescribed by the constitution.[1]

The powers of the Cortes are chiefly these: 1*st*, To move and pass the laws, and to interpret and alter them when necessary; 2*d*, to administer the constitutional oaths to the king, the prince of Asturias, &c.; 3*d*, to determine any doubt or fact relative to the succession; 4*th*, to elect a regency, and define its power; 5*th*, to make the public recognition of the prince of Asturias; 6*th*, to appoint guardians to the king while a minor; 7*th*, to approve or reject treaties previous to ratification; 8*th*, to allow or refuse the admission of foreign troops into the kingdom; 9*th*, to decree the creation or suppression of offices in the tribunals established by the constitution, as well as of places of public trust; 10*th*, to fix, every year, by the king's proposal, the land and sea forces; 11*th*, to regulate the military code in all its branches; 12*th*, to fix the expenses of the government; 13*th*, to impose taxes, contract loans, and direct every thing relating to the revenue; 14*th*, to establish a plan of public instruction, and direct the education of the prince of Asturias; 15*th*, to protect the *political* liberty of the press; 16*th*, to enforce the responsibility of the secretaries of state, and other persons in office.

Laws may be proposed, in writing, by any one of the deputies. Two days after the motion, the bill is to be read a second time. It is then determined whether the subject is to be debated, or to be referred to a committee. Four days after the bill has been voted worthy of discussion, it is read a third time, and a day is appointed for the debate. A majority of votes decides the fate of the bill; the members present on these occasions must exceed half of their total number by one.[2]

The powers of the king are, 1. To suspend the passing of a law, by withholding his sanction. He can exercise this power against any decree of the Cortes for two consecutive sessions; but is compelled to give his assent if the same law is passed by three Cortes successively. 2. The executive power resides exclusively in the king, and extends to whatever relates to the preservation of public order in the interior, and to the external security of the state, according to the constitution and the laws. The privileges and duties of the executive are thus detailed in the constitution. The king may issue decrees, regulations, and instructions, for the more effectually enforcing of the laws; it is his duty to watch over the administration of justice; he declares war and makes peace, under the control of the Cortes; he appoints judges to all the civil and criminal courts, on the presentation of the council of state; all civil and military employments are of the king's appointment; he presents to all bishoprics, ecclesiastical dignities, and benefices which may be in the gift of the crown, all by the advice of the council of state; the king is the fountain of honour; the army and the navy are at his command, and he has the appointment of generals and admirals; he has the right of coinage, and the privilege of impressing his bust on the metallic currency of the realm; the king can propose new laws, or amendments to those in existence. It belongs also to him to circulate or withhold the pope's rescripts and bulls. He can choose and dismiss his own ministers.

The following checks are imposed on the king's authority by the constitution.

1. The king cannot prevent the meeting of the Cortes at the periods fixed by the constitution, neither can he dis-

[1] The Cortes were separated into two bodies in 1836, and the election was made direct, not indirect.

[2] Some alteration in the powers of the sovereign was made in 1836, when this constitution was adopted. It was then decided, that the crown should have an absolute veto in the enactment of laws, and should likewise have the power of convoking, proroguing, and dissolving the Cortes; but in the latter case to be under the obligation of assembling others within a given time.

solve them or disturb their sittings; his advisers and abettors in such attempts are guilty of treason. 2. If the king should quit the kingdom without the consent of the Cortes, he is understood to have abdicated the crown. 3. The king cannot alienate any part of the Spanish territory. 4. He cannot abdicate the crown in favour of his successor without the consent of the Cortes. 5. He cannot enter into any political alliance, or make commercial treaties, without the consent of the Cortes. 6. He cannot grant privileges or monopolies. 7. The king cannot disturb any individual in the enjoyment of his property, nor deprive him of his personal liberty. If the interest of the state should require the arrest of any individual by virtue of a royal order, the prisoner must be delivered over to a competent tribunal within eight and forty hours. 8. The king cannot marry without the consent of the Cortes; he is supposed to abdicate the crown by taking a wife against their will.

The council of state is composed of forty individuals, viz. two bishops, two priests, and four grandees; the other thirty-two must not belong to any of these classes. The members of the council of state shall be chosen by the king, out of a triple list presented to him by the Cortes. The councillors of state cannot be removed without a trial before the supreme court of justice. Their salary is fixed by the Cortes. The functions of this council of state are to advise the king on all important matters of government, and especially upon giving or refusing his sanction to the laws, declaring war, or making treaties. The king, besides, cannot bestow any ecclesiastical benefice, or appoint any judge, but at the proposal of the council of state, who, upon every vacancy, are to confine his choice to one out of three individuals, whose names they are to lay before his majesty.

The laws for the security of personal liberty are these: 1. No Spaniard can be imprisoned without a summary process, in which he is credibly charged with the infraction of some law that subjects the offender to corporal punishment; 2. the arrest cannot take place without the warrant of a competent judge; 3. prisoners are not to be examined upon oath; 4. the gaoler shall keep a register of the prisoners, expressing the warrant, and the alleged cause of his confinement.

The rapid series of misfortunes which had shaken the imperial throne of France to its foundations opened the way for the return of the captive Ferdinand to Madrid. The constitutionalists looked forward to his appearance in the country with no favourable eye, and the arrival of despatches from him to the regency threw them into great consternation. Ferdinand announced that he had concluded a treaty with Napoleon. This assumption of absolute power on the part of the king, without the knowledge of the Cortes, was aiming a direct blow at their authority, and violating the constitution recently established; and they accordingly rejected the treaty. They likewise suspended the king from the exercise of all power till he should take the oath which the new constitution prescribed. He entered the Spanish territory on the 24th of March 1814, and took up his residence at Valencia. On his way he had not been slow to discover that the lower orders were in general indifferent to the constitution. The fact is, the new political principles had scarcely struck root among the people; and with a very considerable party, consisting of grandees, dignitaries of the church, and others, the king was still absolute, and these flocked around their master. In the Cortes itself there was a strong body opposed to the new order of things. A petition, signed by sixty-nine members, was presented to the king, in which the Cortes was described as a mere tool in the hands of a republican party, without freedom of debate, and acting under the control of a mob regularly hired to take possession of the galleries. Nothing, therefore, could be more favourable to Ferdinand's resuming absolute power. Accordingly, on the 4th of May 1814, a decree was solemnly promulgated, in which the Cortes were declared illegal, and all their laws consequently rescinded. Some of the leading members were arrested, as a prelude to what was shortly to happen. Under their usual leaders, the priests, the lower orders broke out into fierce demonstrations of joy when the news of these events reached the chief towns, and the king proceeded in a sort of triumph to Madrid. Further arrests of the deputies of the late Cortes took place; property was sequestrated and papers were seized; judges were appointed to try obnoxious members; but justice proving too tardy for the king's eager spirit of revenge, he himself pronounced sentence on the prisoners in a wholesale manner, in open defiance of all law and justice. A few were capitally punished, and a great many more were consigned to dungeons. The inquisition was restored, and was urged to exert its powers against all persons suspected of liberal opinions. Monks became once more the sole directors of the king's conscience, and the reign of absolutism and bigotry was completely restored.

But these arbitrary acts roused the dormant spirit of the Spanish people, and a revulsion of feeling was the consequence. In vain did the court party silence the press or bribe it into their service; facts which could not be concealed from the people daily pleaded the cause of liberty. Bribery and venality were soon observed to prevail around the throne; the treasury was completely drained, and the army remained unpaid; while, to add to the difficulties and dangers of Ferdinand's position, armed bands of guerillas, now become organized banditti, swarmed over the country, setting the helpless magistrates at defiance, and committing all sorts of atrocities. Free-masonry was abolished, and effectually kept in check; but a far more dangerous society, the members of which assumed the name of *Comuneros*, was secretly formed, and, in spite of the inquisition and its emissaries, held meetings in most of the principal towns, and kept up an active correspondence among their lodges. The constitution was publicly burned; but this served only to spread disaffection, and to give it an importance in the eyes of the people which it did not formerly possess. Cadiz having been fixed on as the head-quarters of the liberals, a regular plan for the overthrow of the government was there formed, and its secret influence was extended throughout the provinces. Our limits do not permit us to mention the numerous conspiracies which were discovered, and quenched in blood. They were sufficient to alarm any monarch but one wholly abandoned to the guidance of weak, wicked, or fanatical counsellors. Those who ventured to remonstrate with the king were banished or thrown into prison. The promise which he had made of granting a constitution founded on liberal principles remained unfulfilled, and for six years (1814-1820) Ferdinand reigned with absolute power. During that time there had been no less than twenty-five changes in the ministry, mostly sudden, and attended with severities. They were produced by the influence of the *camarilla*, or individuals in the personal service of the king. Every attempt to save the state was frustrated by such counsellors; and the overthrow of the government, now apparently inevitable, became accelerated by the loss of the American colonies.[1]

The army was the instrument of its fall. Amongst the officers several conspiracies had been organized for the restoration of the new constitution, at the head of which were

[1] It is unnecessary to do more in this place than merely allude to the revolution in the Spanish colonies of South America, which broke out in 1808, and finally terminated in the achievement of complete independence. Under the heads MEXICO, PERU, PLATA, &c., the revolutions in the various provinces will be found described.

Porlier, Mina, Lacy, and Vidal. Mina had succeeded in making his escape, but the others were taken and executed, their friends at the same time being put to the torture or thrown into prison. But these severities had no effect in repressing the discontent of the army; for the cause which immediately produced it was not removed,—the arrears due to the troops still remained unpaid. The money which might have been employed for this purpose was foolishly lavished in fitting out an expedition to destroy the liberties of the revolted South Americans: by a singular destiny it became the instrument of the overthrow of despotism at home, and the restoration of Spanish freedom. The troops which were to embark in the autumn of 1819, were indisposed to the American service; and the officers, favourable to the constitution of the Cortes, took advantage of this state of feeling to effect their own purposes. Whole regiments had determined not to embark; and the commander himself, O'Donnell, count del Abisbal, was in the secret. But he basely betrayed the cause, and had the principal conspirators arrested in front of the troops. For this devotion to despotism he was rewarded by the court party by being removed from the command of the expedition. Such ungrateful conduct towards a man who had forfeited his honour to save them, could not fail to bring the *Serviles,* as they were designated, into general contempt. A favourable opportunity soon occurred for the liberals carrying into execution the same plan which had failed through the perfidy of O'Donnell. The yellow fever having made its appearance at Cadiz, the safety of the troops which were there assembled demanded that they should be removed to some distance, thus leaving the members of the secret societies and other patriots at liberty to prosecute their schemes without fear of violent interruption. The embarkation of the troops had been fixed for January 1820; but on the first of that month, Riego, who had been placed at the head of the insurrection, gained over several battalions, and proclaimed the constitution of 1812. He arrested Calderon, the successor of O'Donnell; and finally joining Quiroga, a liberated patriot, and at the time in command of some troops, the combined force, amounting to 5000 men, marched on La Caracea, which was occupied. They had previously taken possession of La Isla. But still the country showed no disposition to second this bold movement of the army. In vain Riego led a flying column through the provinces, proclaiming the constitution, and expecting support from the inhabitants; few or none joined him. But several fortunate circumstances which occurred at this time materially contributed to the success of the insurrection. Mina, who had been obliged to fly to France, entered the Spanish territory of Navarre on the 25th of February, and a numerous band immediately surrounded his standard. Risings simultaneously took place in different quarters in favour of the constitution, which was publicly proclaimed in Galicia, Saragossa, Valencia, Murcia, Granada, and many other places. General Freyer, who had been appointed to the command of the troops in Seville, was himself obliged to publish the constitution in that city.

These insurrections could not fail to appal the weak, ignorant, and unpopular party which surrounded the throne. Ferdinand himself saw no general of sufficient ability or loyalty to be trusted with the command of a large army, which could soon have been concentrated, for there still existed fidelity among a sufficient number of the troops. It was however an expiring feeling, which could only have been re-animated by a great leader, but which, in the present destitution of the country, a mere breath might extinguish. And it was extinguished. Ferdinand was abandoned by his troops. Even O'Donnell, who had acted the part of traitor to the liberal cause, became one of its principal supporters. At Ocaña he proclaimed the constitution; an event which produced a great sensation in Madrid. The royal palace was surrounded by a crowd, who called on Ferdinand to accept the constitution, and he now found that no alternative was left to his choice. The humbled monarch appeared at the balcony, holding a copy of the constitution in his hand, as a pledge of his readiness to swear to its observance. This occurred early in March 1820. To give efficacy and legality to the restoration of the constitution, it was necessary that the Cortes should be convoked, and the oath of the king to uphold the new order of things taken in their presence. The Cortes assembled on the 9th of July, and all the formalities were regularly observed. Meanwhile the constitutional system had been put into complete operation. During its proclamation at Cadiz, a bloody and disgraceful transaction took place; some of the royal troops present wantonly fired on the unarmed multitude, and about 500 were killed or wounded. The inquisition was abolished, as inconsistent with it, the state-prisoners were liberated, and new ministers were appointed. In place of the Council of Castille, and that of the Indies, a supreme judicial tribunal, with appropriate subordinate courts, was established; national guards were organized in the provinces, and the municipal authorities were made to conform to the constitution.

The meeting of the Cortes of 9th July, and their subsequent proceedings, mark the establishment of a new order of things, destined however to be of short duration. This assembly acted with extreme moderation, the measures of retaliation being infinitely less severe than those which followed the king's triumph over the constitution. The members strove to temper the violence of the liberals, and endeavoured to restore the *afrancesados* (those who took the oath to support the French dynasty) to their rights, to counteract the machinations of the serviles, and to heal the wounds of the country. But some of their proceedings were characterized by less judgment and humanity. The suppression of many of the convents and of the *majorates,* the banishment of the nonjuring clergy, and some other of their measures, excited discontents. Various parts of the country became disgraced by popular excesses, while on the frontiers of Portugal the royalist party formed a junta for restoring the privileges of the crown and the church. Conspiracy and openly avowed disaffection to the new order of things spread so widely, that when the second session of the Cortes opened in April 1821, the country was declared to be in a state of danger. The command of the army having been intrusted to Morillo, quiet was in some measure restored; but still it was found necessary to summon an extraordinary meeting of the Cortes in September. Spanish affairs in America had now assumed their gloomiest aspect; and the government wished to compromise the matter by acknowledging America as a kingdom independent of Spain, but united with her under a common sovereign, Ferdinand VII. Such an absurd proposal was rejected with scorn. The absolutists, although beaten everywhere by the troops of the government, could not be entirely suppressed; and even the adherents of the constitution began to complain of the weaknesses and mistakes of the ministry. The Cortes requested the king to appoint abler men; and to this he reluctantly yielded in 1822. Notwithstanding the errors of the Cortes, considering that the king was with them, and that his brother Carlos, although approving of the conduct of the absolutists, had not ventured to join them, it is probable that the struggles, after continuing for a few years, might have ended in a compromise, had not the whole power of France been thrown into the scale of the serviles.

The events which immediately preceded Ferdinand's restoration to absolute power, and the complete annulment of all the acts of the Cortes, were so various and complicated, that, if fully detailed, they would of themselves more than occupy all the space within the limits to which this

outline of Spanish history must be confined. Into particulars, therefore, we shall not enter; only the most important transactions can be noticed. Disaffection to the government in the northern provinces, where a strong body of French troops was stationed as a sanitary cordon during the prevalence of pestilence in Spain, terminated in open revolt. The national guards were called out to suppress it, and they were everywhere victorious; but the pecuniary resources were chiefly in the hands of the supporters of despotism. In Madrid an occurrence took place in July 1822, which threatened the most disastrous consequences. This was a daring attempt of the friends of absolute government to overthrow the constitution. They were supported by the royal guards, while the national guards were ranged on the popular side. A conflict took place, in which nearly the whole of the royal guards were cut off. But insurrection, although thus suppressed in the capital, still prevailed to an alarming extent in Biscay, Navarre, and Catalonia, where armed bands, under the name of apostolical troops, *feotas*, or soldiers of the faith, committed revolting cruelties. Near the French frontier, and under French influence, the absolutists appointed a regency, which issued orders in the name of the "imprisoned" king, as they thought fit to call Ferdinand, although he had recently, under no compulsion, and seemingly in the most voluntary manner, again declared his adherence to the constitution. The avowed object of this regency was the restoration of every thing to the state in which it had been prior to the 7th of March 1820. But this band of outrageous serviles, unsupported by the nation, was compelled to fly to France in November 1822. The foreign relations of Spain now fell into a state of dreadful disorder; and the principle of armed intervention pronounced by Austria, Russia, and Prussia, in relation to this unhappy kingdom, was threatened to be acted upon by France. The restoration of Ferdinand to the full enjoyment of sovereign authority was demanded by the four powers named, while England advised the Cortes to yield, and offered her mediation. But the Spanish government repelled with indignation this attempt of foreign powers to interfere in its affairs. The consequences were the recall of the foreign ambassadors by their respective courts, and the march of 100,000 French soldiers across the Bidassoa. The duke of Angouléme, by whom this army was commanded, established a junta, consisting of Eguia, Calderon, and Erro, who formed a provisional government, declaring the king the sole depositary of sovereign power, and that no change in the government should be recognised but such as the king should make of his own free choice. All the decrees of the Cortes were declared void; in short, the object of French interference was simply to restore the reign of absolute power. Unfortunately the Cortes had no ally. The relations of Portugal to Great Britain did not allow her to conclude a defensive treaty with Spain. Britain remained neutral; but the exportation of arms and ammunition to Spain was allowed, and, in parliament, Canning called the attempt of the French unjust, and wished the arms of the Cortes success; an expression of sympathy which led the Spaniards for a time to hope that Britain would take a part in the war. Ferdinand, for greater safety, had removed to Seville, and on the 23d of April 1823 he formally declared war against France; but he in vain called on the nation to support the constitution. The great mass of the people were completely under the influence of the most bigoted priesthood in the world, who of course were absolutists, and hailed the arrival of the French; the adherents of the constitution were confined to the educated class, the army, and the inhabitants of cities. The Spanish army might be equal in strength to that of the French, but a considerable part of it was disposed in garrisons and fortresses, scattered over a large surface of country. The military operations of the French, during their advance upon Madrid, were the siege and capture of several strong towns, and a few partial engagements, in one of which, at least, that of Logroño, they were defeated. The southern provinces, where the absolutists had always a preponderancy, were occupied by the invaders with hardly any resistance; but in Lower Catalonia, where Mina commanded, they were kept in check for a considerable time. The main body of the French army under Angouléme hastened to the capital, which was occupied on the 24th of May. One of the first steps taken was to appoint a regency, which put every thing on the same footing as before March 7, 1820. But the regency had no pecuniary resources, and no power, if they had the will, to prevent the furious ebullitions of party hatred. The Cortes had in vain tried to excite a general guerilla war; it was but too plain that the mass of the people, at once miserably ignorant and furiously bigoted, without any just notions of what rational liberty was, or in what the new constitution consisted, were content to surrender themselves entirely to the guidance of the priesthood, and consequently everywhere opposed the constitutionalists. Their hatred was still further increased by the seizure of all the property of persons of the opposite party, by a large forced loan, and by the coining of the superfluous church plate, to which measures the want of money compelled the Cortes to have recourse. The war had now spread from the south to the north over the whole breadth of the land, and was actively prosecuted in Andalusia and Estremadura. An attempt at mediation on the part of the English ambassador, Sir W. A'Court, failed; and the king having refused to go to Cadiz, the Cortes, acting on that part of the constitution which provides for the moral incapacity of the sovereign, appointed a regency with royal powers. We cannot regard this proceeding in any other light than as a gross indignity offered to the king, and most impolitic at the time. However, Ferdinand accompanied the Cortes to Cadiz, and the regency ceased to exist. On the other hand, the members of the Cortes who had declared the king morally incapable, were denounced as traitors by the regency of Madrid, which now became recognised by foreign powers, Austria, Prussia, and France, as the only legitimate government of Spain.

Meanwhile the war was briskly carried on, but nothing would induce the people to join the constitutionalists, who accordingly were gradually driven from stronghold to stronghold, although in some places they made a gallant resistance. Defection among the officers of the army materially contributed to the downfall of their cause. Morillo and Sarsfield were among the deserters. The regency of Madrid conducted themselves in a cruel and outrageous manner towards the friends of the constitution, notwithstanding the strenuous efforts of the French generalissimo to restrain their fury. The duke of Angouléme took possession of the city of Cadiz on the 4th October 1823. Previously to this, the Cortes had reinvested Ferdinand with absolute power, and requested him to remove to the French head-quarters, where he was received with becoming pomp. The first measure of the king was to declare all the acts of the constitutional government from March 7, 1820, to October 1, 1823, null and void, on the ground that during that period he was acting under compulsion. The war terminated in November; and on the 22d of that month the duke of Angouléme took his leave of the army of the Pyrenees. Among the crowds of fugitives were Mina and the count of Abisbal; and among the victims capitally punished was Riego, who suffered at Madrid on the 7th of November 1823.

The party which now succeeded to power, although weak from want of means, was powerful enough to exercise a persecuting and vindictive policy towards the former partisans of the constitution. The French wished to secure

History. mildness and moderation, but the bad faith of the Spanish government frustrated these objects. To restrain the violence of party fury, which so widely prevailed, a treaty was concluded with France, by which that power agreed to maintain a large military force in the country, until the Spanish army could be organized. This was certainly a wise measure in the circumstances; for Spain, if left to itself, would probably have fallen into irretrievable confusion. It was divided by two parties, who mortally hated each other; and the bonds of society, already shaken loose by years of war and unrestrained licentiousness, required little more to dissolve them altogether. The reports from the provinces were appalling; the treasury was empty; home and foreign credit were alike destroyed; and trade and commerce were paralyzed. The personal moderation of the king led to the formation of a plot by the absolutists, to compel him to abdicate, and to raise his brother Carlos to the throne. This was the origin of the Carlists, who make so conspicuous a figure in the sequel. An attempt to restore the inquisition was happily frustrated. In May 1824, a decree of amnesty appeared; but it was a mere mockery, for it contained so many exemptions, that those who were to enjoy its benefits seemed rather to form the exception than the rule. The year 1825 was disturbed by several insurrections of the Carlists, which were attended with numerous executions. The independence of the American colonies was recognised by foreign powers, but Spain herself did not acknowledge it till the year 1836. The general interruption of commerce and industry, with the flight of many persons of property, occasioned much distress. The disturbances continued for some years, attended with the same marks of feebleness on the part of the government, and a continuance of general distress. It was a period of terror for the liberals, who were plundered and imprisoned on the slightest pretexts. The army, purged of all officers suspected of liberalism, was recruited by a motley throng of adventurers, friars, smugglers, mechanics, publicans, and muleteers, who had been officers in the guerilla bands of Catalonia and Navarre. The ranks being replenished in this manner, the French troops were enabled to evacuate Spain in 1828. Some insurrections, which had broken out during the preceding year, were suppressed without much trouble; and in spite of the arbitrary rule of the Carlists, their tortuous policy, and their open violence, the country began to show some symptoms of improvement.

In May 1829, Ferdinand lost his queen, and on the 9th of November following, her place was supplied by a Neapolitan princess, Christina Maria. Unblessed with issue by his three former marriages, the hope and the desire of having a child of his own to inherit his honours and preserve the throne to his dynasty, probably hastened the nuptials of Ferdinand. The French revolution of 1830 caused much less sensation in Spain than might have been expected. The fact is, the liberal party had been so devoured or dispersed by the sword, the scaffold, exile, and the dungeon, that in the country itself it was not powerful; but a rash and ill-judged attempt in the constitutional cause was made from without. General Mina assembled a body of refugees and others, and invaded the Basque provinces; but they were speedily repelled, and sought refuge in France. Meanwhile, some events of momentous importance had taken place in the royal family. The Infant Don Carlos was presumptive heir of the throne; the succession to the Spanish crown had been subjected to the Salic law by Philip V., so that, as matters stood at present, no daughter of the reigning king could interrupt its descent to his brother. The queen of Ferdinand was about to make him a father, and in order to secure the crown to his own child, should the issue prove a female, he resolved on revoking the Salic law, which excludes females. It is important to observe, that, in 1789, Charles IV. issued a pragmatic sanction, having the force of law, and establishing the regular succession History to the crown of Spain in females as well as males. The Cortes of 1812 likewise solemnly revoked the law of Philip V., and re-established the old law of the Partidas. But as Ferdinand had annulled the acts of that assembly, and as the decree of Charles IV. might be cavilled at by the fierce and intolerant party who wished that Carlos should succeed to the throne, the king obtained the records of the Cortes of 1789 regarding the succession, and on the margin opposite the decree of Charles IV., with his own hand, wrote a decree to the same effect. The minister, Calomarde (a Carlist at heart), remonstrated with the king against its publication; but Ferdinand was firm, and ordered the resolution to be carried into effect. In compliance with this demand, the whole was forwarded to the council; and in the gazette of the 6th of April 1830, the edict was published to the world. It was likewise regularly proclaimed in the streets of Madrid with the usual formalities. Ferdinand's foresight was justified. The infant with which the queen presented him was a daughter, born on the 10th of October, and christened Isabella Maria Luisa.

But the Carlists did not wait for the expected birth of the heir to the throne to show how terribly the publication of the decree had staggered them. They rushed into hasty plots against the government, which were detected before they were ripe for execution; and in various ways showed their chagrin and irritation. In order to render the succession still more secure, Ferdinand called a meeting of the Cortes, before which the edict of Philip V. was again repealed, and his daughter, the Infante Isabel, recognised as princess of the Asturias. An insurrection broke out in Cadiz in 1831, at the head of which was General Torrijas. It was soon quelled, and the leader, with fifty-three companions, fled to Malaga, where they were taken prisoners, and all shot in cold blood. The other events of this year are unimportant, with the exception of a sudden illness of the king, which so excited the hopes of the Carlists, that they strenuously urged their master to take advantage of the circumstance, and at once seize the crown. This remarkable fact shows with what spirit they were animated. It was not a love of justice, but ambition, and a spirit of vindictive hostility to the constitutionalists, who now began to be tolerated, that instigated them to attempt the exaltation of Carlos to the throne, and that at all hazards, even before he possessed the semblance of a claim to it; for while Ferdinand lived, by what right could he grasp at his sceptre? Yet his partisans extol his magnanimity in refusing it at this time.

In the course of the year 1832, Ferdinand had an alarming relapse of his disease, during the paroxysms of which a transaction took place of the utmost importance in itself, and which has been very differently represented by different parties. It was the signing of a decree by which he restored the Salic law to full operation, and the further confirming the disinheriting of his daughter, by annulling his testament in her favour. It is certain that the ministers strenuously urged him to adopt this measure; and that they were under Carlist influence, is no less certain. Every thing was accomplished to their wishes; the document was signed and properly secured, and the king appeared to have fallen into the sleep of death. His dissolution indeed was announced; but, contrary to all human expectation, the disease took a favourable turn; all symptoms of immediate danger disappeared, and consciousness and understanding were restored to Ferdinand. The use which he made of the lucid interval thus vouchsafed to him, was to dismiss his ministers, to appoint the queen regent during his illness, and to undo what he had lately done regarding the succession, thus restoring to his daughter her right to the throne. The decree to this effect was issued on the last day of the year. The former ordinance, he declared, had been extort-

History. ed from him, not only when he was in the agonies of expected death, but under false misrepresentations that all Spain demanded it, and that the inviolability of the monarchy required it; whereas it had only been desired by an ambitious and unscrupulous faction, and was opposed to the fundamental laws of the kingdom. A more liberal ministry was formed, and some liberal measures were adopted; high expectations were raised that milder times were at hand, and the funds in Madrid rose ten per cent. Early in 1833, Ferdinand was able to resume the reins of government. On the 20th of June he assembled the Cortes to swear allegiance to his daughter, and do homage to her as their future sovereign. This solemnity was performed with great pomp in the church of the royal monastery of St Jerome. Don Carlos refused to take the oath; but previously to this he had taken up his residence in Portugal, where Don Miguel was playing the same desperate game which he himself was about to undertake. Ferdinand survived the ceremony of the *jura* only a few months. He expired on the 29th of September 1833, leaving a will, in which he appointed his daughter Isabella heir to the crown, and her mother regent during her minority.

No sooner was Isabella II. proclaimed queen, than Don Carlos announced his claim to the throne, and the flames of civil war burst out in the northern provinces, where his partisans, assembled in great numbers, stood ready armed for the contest. Of the bloody and protracted struggle for the throne which ensued, we can afford room for few details; indeed, an account of the numerous battles, skirmishes, sieges, and other warlike operations, would prove a very uninteresting and monotonous portion of the modern history of Spain. Isabella was acknowledged without opposition throughout all the provinces of Spain, and by the leading powers of Europe. The question of the Spanish succession, apart altogether from the bloody war to which it gave rise, has been keenly agitated in this and many other countries. It may be briefly stated as follows. Carlos's right rested upon the Salic law, which had never the force of law in Spain. The Salic law was not the ancient rule of succession; it was first introduced by the Bourbon Philip V., the great-grandfather of Don Carlos. Females could always succeed in Castille, Leon, and Portugal. It was by marriage with the heiress of Navarre that a king of France obtained a claim to that kingdom; and although females were excluded in Aragon, yet it was through a princess that its inheritance passed to the counts of Catalonia. It was by the right of female succession that the house of Austria reigned in Spain; it was by the same right that the Bourbons themselves occupied the throne. It formed a part of the Partidas, or system of constitutional law, which Philip swore to observe on his succession to the throne. The Salic law, on which Carlos grounds his claim, could only be established in two ways; by the old forms of the constitution, or by the despotic will of the sovereign. If the advocates of Don Carlos take their stand on the former ground, the answer is, that the forms as well as the substance of the constitution were violated when Philip V. established his law of succession; and that, conscious of its invalidity, he did not register it in the form usual with similar acts; while again, if we pass over the Cortes of 1789 as secret and irregular, we have the Cortes of Cadiz in 1812, which abolished the decree of Philip, and restored the ancient law of the Partidas. But Ferdinand having annulled the proceedings of this body, its re-establishment of the right of female succession must fall to the ground with its other decrees. There is however Ferdinand's own decree, constituting his daughter his successor, which was just as regularly sanctioned by the Cortes as Philip's law of succession. If, on the other hand, the sovereign is to be regarded as despotic in Spain, the question is at an end; for even Carlos must acknowledge that Ferdinand had a right to regulate the succession according to his own royal pleasure. This view seemed to have been taken by the king's confessor, and his minister Calomarde, when, during his dangerous illness at La Granja in 1832, they induced him to sign a new will, settling the crown on Don Carlos. Ferdinand's recovery disconcerted their plan; but their effort plainly shows that the partisans of Don Carlos at that time felt that the Salic law was a very weak support to their favourite's claims. The transaction by which Ferdinand (supposed to be on his death-bed) transferred the crown to his brother, is admitted by the Carlists to have been a perfectly legal proceeding. Can the subsequent transaction, by which, under exactly similar circumstances, the king appointed his daughter his successor, be considered otherwise than as an equally legal proceeding? If the constitution be referred to, the question is decided against Don Carlos; the will of the sovereign is against his claim; and, what is of yet more consequence, as the event has shown, the will of the majority of the nation is against him. History.

It was in the northern provinces, in Navarre, Guipuscoa, Biscay, and Alava, that the strength of Don Carlos lay. Here he was immediately proclaimed in several towns by the title of Charles V., and bands of Carlist guerillas assembled to maintain his right to the throne. He himself still hovered a fugitive on the frontiers of Portugal, his movements being closely watched by a royal force under General Rodil. Another strong division of the queen's army, under General Sarsfield, marched against the disaffected provinces. The Carlists retired before him; Bilboa and other towns were occupied and garrisoned; the constitutional party was restored in several places where it had lost ground; and the insurrection seemed at first to have been happily put down without much loss. But early in 1834 the affairs of the Carlists assumed altogether a new aspect. Hitherto their operations were carried on in an unconnected manner; this system was now exchanged for one of steady unity of design. Indeed so numerous were the adherents of Don Carlos in the north, that there was only required a firm hand to seize the reins, control local jealousies, and direct aright the energies of the provinces. Such a man was Don Thomas Zumalacarregui, who now assumed the chief command of the Carlists. He was admirably skilled in the desultory warfare of these provinces, and well acquainted with the country and with the character of the inhabitants. By his activity and enterprise he repeatedly inflicted severe blows upon the forces of the queen, or the Christinos, as they were generally called. His method of fighting was to surprise the enemy in an unprotected position, and cut off as many of them as he could before they recovered from their panic. His troops would then suddenly separate and fly, but only to unite again at a predetermined point some miles in the rear. By this mode of warfare he caused great loss to the Christinos, while his own small band suffered little. The Christino army under General Rodil, who had now obtained the chief command, might amount to 20,000 men, and was thus sufficiently strong at least to have confined Zumalacarregui to the mountains; but it was greatly reduced by several thousand troops having been distributed among a number of petty fortresses, most of which, one after the other, fell a prey to the Carlist chieftain. It was further weakened by being divided into different corps and scattered over the country. Rodil found it necessary to resign the command, which now devolved upon Mina, from whom much was expected. Nor did he disappoint the hopes which were formed of him. Just before his appointment, Generals O'Doyle and Asina had severally been defeated with great loss by Zumalacarregui, which occasioned much alarm at Madrid, and loud outcries against the ministry. But the old warrior, though broken by sickness and infirmities, restored confidence by making head against the hitherto victori-

History. ous Carlists, and bringing victory to the standards of the queen.

In the mean while, Don Carlos, after paying a short visit to England, made his appearance in Spain; and his presence among his partisans greatly strengthened his cause in the northern provinces. France and Britain had acknowledged Queen Isabella II. These two powers, along with Portugal, entered into a treaty with Spain, the conditions of which quadruple alliance were, that France should watch the frontiers, so that the insurgents might receive no aid from that country; that Britain should supply such arms and munitions of war as the Spanish government should stand in need of, whilst at the same time she should guard the northern ports of Spain, so as to prevent the insurgents from receiving any assistance in men, money, or ammunition, and also assist the queen with a naval force; and that Portugal should co-operate by every means in her power: but that country was at the time in too embarrassed a situation to render any efficient assistance. As soon as the arrival of Don Carlos in Navarre was known, the four powers who had been parties to the treaty renewed its stipulations, in respect that its object had not yet been attained. This imparted confidence and vigour to the cabinet of Madrid, of which it stood greatly in need. A variety of measures occupied the attention of government during the year 1834, not the least important of which was the plan of a new charter or constitution. It is quite unnecessary to enter into any details of what the Cortes proposed should be done, as every thing was overturned and put upon a new footing by a revolution which occurred two years afterwards. The financial state of Spain, particularly the large debt which the government owed to foreign nations, formed a subject of protracted discussion. Doubts were raised as to whether a part of it was legitimately owing; but the debates in the Cortes terminated in the whole being recognised as justly due. This contributed to restore the credit of Spain in foreign money-markets, where it had been greatly shaken, and enabled the government to contract for a new loan. Another measure of importance which engaged the attention of the Cortes, was the passing of a bill of exclusion from the throne against Carlos and his descendants. During the year the ministry had undergone a complete change, chiefly through the instrumentality of a popular leader of the name of Llauder. Zea was superseded in the office of prime minister by Martinez de la Rosa, supposed to be a person of more liberal predilections.

The military operations of 1835 were prosecuted with great vigour on the part of the Carlists. Several important towns and fortresses fell into their hands, and siege was laid to Bilboa, the capital of Biscay. After sustaining a furious bombardment for several days, the place was relieved, principally through the instrumentality of some British gunners under Lord John Hay, commander of a ship of war then on the coast of Biscay. It was during the attack on Bilboa that Zumalacarregui received the wound of which he died on the 23d of June. The death of this chief threw a gloom on the affairs of Don Carlos: it was the severest loss which his cause had sustained, and he never properly recovered it. Among the Christinos this event diffused a joy and hope which they made no efforts to conceal. Worn out by long service, by age, and by disease, the veteran Mina resigned the command, which ultimately devolved upon General Cordova, under whom was the celebrated Espartero. The Spanish government having been permitted to levy a body of mercenaries in Great Britain, several thousand recruits were raised in this country, and were led to the theatre of war in Spain under the command of General Evans. The British legion soon took an active part in the war, and distinguished itself upon various occasions. The Carlist army, although it abandoned the siege of Bilboa, still continued in the neighbourhood, prepared to take advantage of circumstances. An opportunity soon occurred for attacking the Christinos at the village of Arrigoriaga, which they made an attempt to pass. The royalists were driven back with considerable loss, and this check for the time interrupted the movements of Cordova's army. On the other hand, the Christinos laid claim to more than one victory gained over their enemies; but these doubtful and unproductive skirmishes, which in the flush and enthusiasm of triumph were magnified into decisive battles, are too insignificant to require a detail in this place. At the close of 1835, matters stood much as they did at the commencement of the year. But the war was now carried on with more humanity than formerly. A strong remonstrance on the part of the British government, against the barbarous practice of putting prisoners to death, had the desired effect, at least for a time, of staying the effusion of blood in this inhuman manner. History.

Those parts of Spain exempt from the horrors of war, were for the most part subjected to the scourge of political anarchy. The new government of the queen-regent had been founded on an abandonment of the old system of unmitigated despotism. Her daughter's throne was to be identified with more liberal institutions, and was thus to be protected by all political reformers, all who were inimical to absolutism. But the extent to which the old system was to be abandoned, and the form in which a popular government was to be established, were questions regarding which every possible diversity of opinion prevailed. The unquiet elements thus at work showed themselves first in a military revolt, and then in the revolt of several provinces, in which the democratic party sought to usurp the powers of government. For a time they set the lawful authorities at defiance, for the government of Madrid was helpless. Even here disaffection had spread to a most alarming extent, the urban militia having openly revolted. In vain were royal decrees issued, and strong measures put in force to repress the disturbances; an open war between the government and numerous sections of the liberals seemed on the eve of breaking out. Fortunately this was averted by a change of the ministry, which was loudly demanded by the factious opposition. The life and soul of the new ministry was Mendizabel, a man of great vigour, and very popular among the people, on account of his liberal principles. He condemned the repressive measures which had been acted upon, adopted a more lenient system of dealing with the malcontents, and proposed various alterations in the constitution, the mere mention of which sufficed to restore the country to comparative tranquillity. But all the deliberations of the ministry and the Cortes were rendered abortive by the military revolution which broke out at Malaga on the 25th of July 1836. The object of the ultra liberals had uniformly been the restoration of the constitution of 1812. Without this no change of ministers could satisfy them, and no vigilance on the part of government could prevent them from covertly prosecuting their designs. It was with the national guard that the revolt originated. In Malaga the governor was assassinated, and a junta was appointed to proclaim the constitution. Intelligence of these events spread throughout the country with the greatest rapidity. Cadiz and Saragossa took up the signal nearly at the same moment; and they were instantly followed by Seville, Cordova, Granada, and Valencia. At length the capital itself joined the insurgent cities; and on the 13th of August the queen, now deserted and helpless, was compelled to issue a decree, promising the restoration of the constitution of 1812. But all men who were reasonable and honest in their politics felt and admitted that some alterations in that code were quite indispensable. The Cortes accordingly appointed a committee to consider and propose

such alterations as were necessary and advisable; and this they accomplished in a highly satisfactory manner. The changes recommended and finally adopted by the Cortes were, 1st, that the part of the constitution which contained mere regulations and forms, and regarded organic bodies and laws, should be entirely suppressed: 2dly, that instead of the Cortes continuing to form, as they did under the constitution of 1812, only one body, they should now consist of two bodies, differing from each other in the personal qualification of their members, &c. but neither to be hereditary nor privileged: 3dly, that the crown should have an absolute veto in the enactment of laws, and should likewise have the power of convoking, proroguing, and dissolving the Cortes; but in the latter case to be under the obligation of assembling others within a given time: 4thly, that the election of members of the Cortes should be direct, and not indirect, as established by the constitution of 1812.

While Spain was thus undergoing the most momentous political changes, the very existence of the queen's government was threatened by the Carlists, who were making alarming progress in the very centre of the kingdom. During the early part of the year the Christinos attacked the position of the Carlists at Arlavan, but with so little success that they were compelled to make a retrograde movement. However, early in May, the British legion, under General Evans, gallantly carried the Carlist lines before St Sebastian; but unfortunately this victory, like many others gained, was productive of no important result, chiefly through the sloth and inactivity of the Spanish generals. The circumstance which created the great alarm to which allusion has been made, was the march of a large body of Carlists under Gomez through the very heart of Spain. This chief penetrated from province to province, to the centre of Andalusia, laying the country under heavy contribution, and carrying off loads of booty from every place which he visited. The audacity of this enterprise seems for a time to have paralyzed the royalists. Consternation spread over Spain from Madrid to Gibraltar. Gomez attacked and carried several towns, and some bodies of troops who attempted to arrest his progress were totally destroyed. No less than three distinguished Spanish generals, each with a large army, were despatched to cut him off; but all their efforts to entrap him and his daring band proved fruitless. He was repeatedly surrounded, and apparently on the eve of being taken, but always succeeded in effecting his escape. At length, however, he was hemmed in to the sea-coast at San Roque, and his destruction seemed inevitable; but, by a daring and masterly movement, he broke through the line which encompassed him, and secured his retreat to the strongholds of the north.

Towards the close of 1836, the town of Bilboa was again invested by the Carlists, to whom it was an object of great importance, as being a city of sufficient consideration to give dignity to the court of Carlos, and an appearance of permanence to his establishment. It was, besides, the capital of Biscay, and inseparably connected, in the eyes of the Basques, with their *fueros* and local parliament. The siege was carried on with an ardour corresponding with the importance attached to the place. The defence was equally spirited and heroic. During the sixty days which the investment lasted, the fortitude of the besieged was put to the severest test, not only by the long-continued fire of the Carlists, by their repeated attacks, and by their mining operations, but by want of proper food and by sickness. At length General Espartero succeeded in compelling the Carlists to retire with the loss of all their guns and *matériel* for the siege, and Bilboa was relieved. The intelligence was received at Madrid with unbounded enthusiasm, and honours and rewards were heaped upon the defenders, and those who had so opportunely relieved them. The Christinos, however, as usual, neglected to follow up the success, allowing the Carlists to remain unmolested in the neighbourhood. Near St Sebastian they mustered very strong during the early part of 1837, and here they were attacked by the Anglo-Christinos under General Evans, and driven back with some loss; but receiving a great accession of strength, the Carlists in their turn compelled the royalists to retreat with at least equal loss. The affair of Hernani would have been much more disastrous, but for the steady bravery of a small body of British marines, who checked the advance of the Carlists, and retired to St Sebastian in good order. In a subsequent attack on Irun and Fuentarabia, General Evans was completely successful; but it seems perfectly clear that this officer was never cordially supported by the Spanish commanders. The defeat before Hernani would never have taken place had Espartero and Sarsfield supported him according to the concerted plan. The time for which the British legion volunteered its services expired in the month of May, and shortly afterwards it disbanded, nearly the whole returning to England in the most destitute condition. Meanwhile Don Carlos had followed the example of Gomez, by marching an army through the central parts of the kingdom. Our limits will not permit us to follow him in this daring but useless expedition. One body of Carlists advanced within a few leagues of Madrid, and all was consternation in the capital. But the Christino generals concentrating their forces, compelled the main body of the Carlist army to retire from the provinces into which it had made so fierce an irruption. Disunion also began to show itself in the camp of Don Carlos, so that, disappointed and disheartened, he retreated to his old fastness beyond the Ebro, accompanied however by a large convoy of booty. Besides these military operations, prosecuted on a large scale, there was a system of desultory warfare maintained all over the country, more destructive in its effects upon the inhabitants than the regular operations of an army. Brigandage, never viewed with much horror in Spain, had now become as common as a lawful trade. Remorseless cruelty characterized the proceedings of all parties; and civil life, except in the large towns, seemed for the time suspended.

The civil and parliamentary history of Spain for 1837 presents little that is of any importance. The new constitution formed a fruitful theme of discussion in the Cortes. After undergoing the alterations already mentioned, and some others of less moment, it was solemnly ratified by the queen-regent in the Cortes, and proclaimed to the nation. It is worthy of being noticed, that an attempt to introduce toleration in religious matters, by an amendment to the article which establishes the Catholic faith, met with the strongest opposition. This striking fact shows how deeply rooted the old Spanish bigotry remains in the national mind. During the year, bills were passed for the suppression of religious houses, and the abolition of the payment of tithes, the maintenance of the clergy being left to the government. Several judicious ecclesiastical reforms were projected; and among other important measures passed by the Cortes, was the abolition of the local parliaments in the Basque provinces. Ministerial changes repeatedly took place during the year, but into these we shall not enter.

The military operations of the Carlists in 1838 were less successful and less enterprising than they had been during the two previous years. Cabrera, indeed, a general who had frequently signalized his talents for war, had firmly established himself in Aragon and Valencia, and the bands of partisans allowed no respite to the distracted provinces; but we have to record none of those daring and brilliant flying expeditions which more than once traversed Spain in all directions with such celerity and success as to command the attention of Europe. Something of this kind was indeed attempted by Basilio Garçia, and by Tallada, but

both these generals were signally defeated. The cause of Don Carlos was now visibly declining: the best and bravest of the chiefs who had served him had successively incurred his displeasure, and were either in disgrace, exile, or confinement; above all, the country was beginning to be favourably disposed to the queen. Her troops however were very unsuccessful in the field. General Orad was defeated at Morella, and General Alaix also suffered a repulse. But the principal battle fought between the Carlists and Christinos was that of Maella, where General Cabrera completely routed the queen's troops under Pardinas, but sullied his victory by butchering nearly two hundred prisoners in cold blood. The war throughout had been disgraced by similar atrocities, notwithstanding the efforts of Britain to put a stop to them. Both parties appear to have been equally guilty of this inhuman practice. The operations of Espartero were feeble and uncertain. He did little but march a large army from place to place, without striking a decisive blow. As usual, almost every part of Spain continued to be ravaged by guerilla bands, who swarmed over the provinces with no other objects in view but plunder and bloodshed. During the year, the Cortes had twice met; their deliberations chiefly referred to the state of the finances and the negociation of a loan, which was not effected. The ministry, always feeble, had now become more feeble than ever, notwithstanding that changes were continually taking place. The queen-regent found it impossible to form a strong government in the present political state of the country. Its helplessness was such that the generals commanding in the different provinces found it necessary to act independently of its arrangements, and to appropriate the revenues of each province to the payment of the military expenses incurred in it, instead of allowing the monies to pass into the treasury. Thus General Van Halen, who had organized a fine army of 40,000 men, called the army of the centre, after declaring the kingdoms of Aragon, Valencia, and Murcia, in a state of siege for the rest of the war, and that in future the civil were to consider themselves in subordination to the military authorities, proclaimed, that the entire revenues of those provinces should be paid into the military chest, and exclusively appropriated to the expenses of the war. This was probably the very wisest measure that could have been adopted for bringing the war to a speedy termination. Want of pay had repeatedly paralyzed the operations of the Christino armies; it had dispersed the British legion; and at this very moment it was exciting discontent, if not revolt, in the camp of Don Carlos. To place the pay of the queen's troops upon a sure footing, was therefore the first step to secure ultimate triumph in the field.

During 1839, the cause of Don Carlos rapidly declined, notwithstanding the desperate efforts made by Generals Cabrera and Maroto to maintain it. Espartero, the commander-in-chief of the queen's troops, after some hard fighting, cut off the Carlists completely from the plains of Alava, while Diego Leon likewise expelled them from the rich country between the mountains and the Ebro. Many towns and fortresses of importance, one after another, submitted to the triumphant Christinos, so that almost the only parts of Biscay which now owned the authority of Carlos were rugged mountainous tracts of country, whither no regular army could follow the fugitives. An armistice was at length concluded between Maroto and Espartero, which was followed by twenty-one Carlist battalions laying down their arms. Don Carlos himself, reduced to the last extremity, fled for refuge into France, where he formally renounced his pretensions to the throne of Spain, under certain conditions alike reasonable and necessary. The question relative to the fueros of the Basques and Navarre, which, it will be recollected, had been abolished, caused much uneasiness. It seemed perfectly evident that these important provinces would not be satisfied, or completely surrender themselves to the queen's authority, unless their local privileges were restored. After some debating in the Cortes this measure was agreed to, government stipulating that it would so modify the fueros as to reconcile the interests of these provinces with those of the nation, and with the constitution of the monarchy. The only Carlist chief who gave any uneasiness to the government was Cabrera, who, little affected by the pacification of the northern provinces, still maintained his footing in Valencia, determined to support the cause of Carlos while an army remained to back him.

In 1840 the war against Cabrera was vigorously prosecuted under the auspices of Generals Espartero and O'Donnell, and at length the Carlist chief was reduced to such extremities, that he crossed over to France, where he was immediately arrested by the French authorities.

Early in July of that year the queen-regent, accompanied by her royal daughter, set out for Barcelona, and was at first received with great rejoicing and every mark of respect; but in a few days the scene was changed, and she was hooted and insulted by the populace as she rode through the streets in her carriage. The national guard were called out, and a conflict took place between them and the mob; but the insurrection was not put down till Espartero brought a body of troops of the line against them and put them to flight. The chief cause of this unpopularity of the regent was her determining to have a bill passed which would place the chief municipal appointments in the hands of the crown, and thus deprive the inhabitants of the various towns of any control over their civic functionaries. The regent carried her measure, and the next day Espartero, who was strongly opposed to it, sent in his resignation as general of the forces. It would be tedious and uninteresting to detail the political intrigues and changes that were occasioned by the obstinacy of the queen. The popular excitement against the measure was so strong, that the ministry were obliged to resign, and at length the queen had to yield and send for Espartero, to whom she gave full power to form a cabinet. To every condition imposed upon her she gave her consent, except to that of having any one associated with her in the regency. She declared that, rather than submit to that she would abdicate altogether; and accordingly, though strongly dissuaded from such a step, she abdicated on the 12th October 1840. She then set out for Marseilles and thence to Paris, where she was received with every honour by the French king, and had apartments provided for her in the Palais-Royal. About the end of this year a dispute arose with Portugal respecting the navigation of the Douro, which was likely at one time to lead to hostilities between the two countries, but which at length was fortunately settled.

When the Cortes met in April 1841, Espartero was, by a majority of votes, elected sole regent. The queen-mother was also requested to relinquish the guardianship of her daughter, but she would only consent to this on conditions which the government could not agree to, and they accordingly declared the office vacant, and afterwards appointed Senor Arguelles guardian of the young queen and her sister. The ex-queen, however, was not without friends in Spain, and early in October an insurrection broke out in Pampeluna, where General O'Donnell succeeded in gaining possession of the citadel. A similar outbreak took place in Vittoria, and on the night of the 7th October a desperate attempt was made in Madrid itself to get possession of the young queen's person, and but for the loyalty and courage of the guards, would have been successful. By the tact and energy of Espartero, however, the insurrection was speedily suppressed, and O'Donnell, finding his cause hopeless, evacuated the citadel of Pam-

peluna, and crossed over to France. The ex-queen, who was still in Paris, was generally supposed to have encouraged or countenanced this rebellion; and having refused to publish a declaration that it was without her authority and against her wish, Espartero issued a decree suspending payment of her pension. The cortes was opened by Espartero on the 26th December 1841, but its proceedings present little of interest; and nothing of importance occurred in Spain till the following November, when a formidable insurrection broke out in Barcelona, occasioned by the arrest of some individuals connected with a republican newspaper. The national guard sided with the populace, and the soldiery being called out, a sanguinary conflict took place, in which the latter were defeated and compelled to retire into the citadel. Espartero, on hearing of this, set out in person for Barcelona, and on nearing the place, a deputation of the inhabitants waited upon him, offering to surrender upon certain conditions, including a free pardon to all concerned. Espartero, however, demanded an unconditional surrender, and as they would not agree to this, he proceeded to bombard the town. On the evening of the second day of the bombardment the town surrendered. A few of the ringleaders were executed, and a contribution was levied towards the expense of the war; but altogether the inhabitants had no cause to complain of being harshly treated by the conqueror. The regent made his public entry into Madrid on his return from Barcelona on the 1st of January 1843.

That year, however, was to witness the overthrow and exile of the hitherto successful regent. Though he had ever pursued a liberal and enlightened policy, and had effected many useful reforms in the state, yet he had given great offence to the clergy by his having sanctioned the appropriation of part of the ecclesiastical revenues to secular purposes. The fire smouldered for a time, but it at length found vent in open rebellion. Barcelona, as formerly, took the lead in this movement, and was immediately followed by Malaga, Grenada, Seville, and other towns. Espartero, seeing the emergency, prepared to head the forces in person, and issued an address to the people vindicating his conduct as regent. His usual energy, however, seems to have deserted him, and his movements were vacillating and aimless. A battle was fought on the 22d of July at Torrejon, between the insurgent leaders Narvaez and Aspiroz, and Generals Seoane and Zurbano, on which occasion, after a short engagement, Seoane's army went over in a body to the enemy. This victory was followed by the surrender of the capital. Espartero was besieging Seville when the news of this reached him, and he immediately raised the siege and set out for Cadiz, pursued by General Concha. At Port St Mary he took refuge on board an English frigate, and subsequently arrived at Woolwich, where he was received with every mark of respect. On arriving in London, where he took up his residence, the corporation of that city honoured him with a banquet.

The absence of Espartero, however, did not serve to restore peace. The jarring factions continued to contend with unabated fury, and disturbances broke out in various parts of the country. The city of Barcelona revolted against the new government, and was followed by several other towns. These disturbances, however, did not lead to any important result, Barcelona and the other towns which had taken up arms being obliged to capitulate. One of the first acts of the new cortes, which met on the 15th October, was to pass a decree declaring the young queen of age, although by law her minority did not terminate till the 10th of October 1844. She accordingly took the constitutional oath on the 10th of November.

In the beginning of 1844 an insurrection broke out at Alicante, and spread so rapidly, that in a short time the whole province of Murcia, and a great part of Valencia, had declared against the government. Vigorous measures, however, having been adopted, it was at length suppressed. Alicante surrendered to the government forces in the beginning of March, and Carthagena about the end of that month. In the meantime the ex-queen returned to Spain, and was met by her daughters and the principal ministers at Aranjuez. They entered Madrid with great pomp on the 23d of March.

The marriage of the ex-queen to Munoz, who, a short time previously, had been created Duke of Rianzares, took place on the 13th of October. In the beginning of November General Zurbano again took up arms against the government, and as usual the disaffection spread rapidly. It was, however, without strength; two of Zurbano's sons were taken and shot; and, at length, he himself, a lonely fugitive, was discovered in the neighbourhood of Legroño, and suffered a like fate.

Apart from the usual ministerial changes, nothing of importance connected with Spain occurred in 1845, except the public renunciation by Don Carlos of his claim on the Spanish crown in favour of his son, Charles Louis, Prince of Asturias, who took the title of Comte de Montemolin. The following year Narvaez, who had been at the head of more than one ministry, fell into disgrace, and was obliged to leave the country. A serious insurrection also broke out in Galicia; but General Concha, having defeated the insurgents in a decisive engagement, it was speedily suppressed. This year, also, the marriage of the young queen was a subject which occupied much attention, not only in Spain, but likewise in other countries; and it at one time threatened to bring about a serious misunderstanding between France and England. The professed position of these two countries regarding this question was that of strict neutrality. France, however, insisted that the choice of the queen should be restricted to a prince of the house of Bourbon. The imposition of any such restriction was strongly opposed by England; but the matter was at length set at rest by its becoming known that the queen was about to marry her cousin, Don Francisco d'Assis, eldest son of her uncle, Don Francisco de Paula. It was generally believed that this marriage was brought about by French influence, and that the inclinations of the queen had been little consulted in the matter. It was also arranged that the queen's sister should, at the same time, marry the Duc de Montpensier, the youngest son of the French king. The two marriages were celebrated on the 10th of October, which was the queen's birthday. Charles Louis, son of Don Carlos, thinking that the queen's marriage afforded a favourable opportunity for appealing to the nation, issued a proclamation, calling upon them to support his cause; but not the slightest movement resulted from this manifesto. At the same time he escaped from France, where he had been living under a kind of surveillance, and came to England.

The unhappy consequences of the queen's marriage soon began to appear. The royal pair became completely estranged from each other, neither appearing together in public, nor having the slightest communication in private. Every effort to bring about a reconciliation between them for the time failed. Towards the end of 1847, Narvaez, who had returned to Spain, was placed at the head of the government, and he at length succeeded in bringing about a formal reconciliation between the queen and her husband. Espartero was also recalled, and entered Madrid on the 7th of January 1848. A dispute with England occurred soon after. Lord Palmerston having recommended Sir H. L. Bulwer, the British minister at Madrid, to advise the adoption of a more liberal system of government by the Spanish ministry, the latter naturally resented this interference; and this, together, it is said, with other reasons of a private

nature, led to Sir H. L. Bulwer's receiving, on 19th May, a peremptory notice to quit the kingdom within forty-eight hours. General Mirasol, who was sent by the Spanish government to explain the private reasons for the dismissal of the English minister, was not received by Lord Palmerston, and diplomatic relations between the two countries were not renewed till August 1850. In May 1848, a body of about 600 of the military in Madrid declared against the government, and were joined by a number of the citizens. They were, however, defeated in an engagement which took place, and obliged to surrender, when a number of the leaders were shot. About the end of June a Carlist insurrection broke out in the northern provinces, headed by Cabrera. It did not acquire any strength, though it was maintained in a desultory way during the rest of the year, no important advantage being gained by either party. On the 12th of July 1850 the queen was delivered of a son, who, however, only survived a few minutes; and the same month Charles Loüis, Comte de Montemolin, was married to Princess Caroline, sister of the king of Naples. On the 20th December 1851 the queen was delivered of a daughter. On the 2d of February 1852 a desperate attempt was made to assassinate the queen by a fanatic named Martin Merino, a priest of the Franciscan order. The queen was on her way from the royal chapel in the palace to her own apartments, when the priest, in his robes, knelt before her, as if to present a petition, and instantly drew a dagger from beneath his dress, and struck her on the side. The wound, though considerable, was not dangerous, but it caused a good deal of sensation, and the culprit was summarily tried and executed.

On the 5th January 1854 her Majesty gave birth to a princess, who only survived three days. This year was characterised by another of those revolutions which are so common in Spain, and which led to the expulsion of the queen-mother, and the restoration of Espartero to power. In the beginning of the year the ministry then in power were giving great dissatisfaction to the nation, as being mere instruments in the hands of the queen-mother; and generals Concha, O'Donnell, and Gonzales Bravo, as heads of the opposition or moderate party, demanded their dismissal. The only answer vouchsafed to that request was an order to the generals to retire to the Canaries or Balearic Islands. General O'Donnell, however, refused to obey, and contrived to keep himself concealed about Madrid. About the middle of February, General Hore, with the soldiers under him in Saragosa, raised the standard of revolt. General Rivero was sent against him, and, in a desperate engagement which took place, General Hore was killed, but his soldiers managed to maintain their position. Finding, however, that there was little hope of any farther success, they retreated to the French frontier, and there dispersed. Though the government was successful in putting an end to this attempt at revolution, the spirit of discontent spread to an alarming extent during the next few months, and an attempt to raise a forced loan speedily brought matters to a crisis. The corruption and mismanagement that prevailed in every department of the government had reduced the finances of the country to the very lowest ebb; and the inability of the ministers to raise any farther sums made them have recourse to the expedient of a forced loan, under the pretence of collecting the taxes six months previous to their falling due. The revolt first broke out in Madrid. On the 28th of June, General Dulce, inspector-general of cavalry, assembled 2000 horse in the Campo de Guardias in the outskirts of the city, as if for inspection, and then exhorted them to revolt. They were speedily joined by General O'Donnell with three battalions of infantry, and the whole took up a position at the village of Canalejas, 4 miles from Madrid. On the morning of the 30th a strong body of troops, under the command of General Quesada, attacked the insurgents near the village of Vicalvaro, but they were speedily compelled to retreat with great loss. On being reinforced, however, by fresh troops, they renewed the attack, and maintained the struggle till nightfall, when the insurgents drew off their forces, and the queen's troops retired into Madrid. The insurgents lost in killed and wounded about 1000 men, and the royalists about 1500. O'Donnell's force, however, was too weak to enable him to maintain his position in the vicinity of Madrid, and he accordingly retired by railway to Aranjuez, breaking up the rails after him to prevent pursuit. A body of 5000 men was sent in pursuit, before which the insurgents continued to retreat. O'Donnell and the moderado party, however, soon found that they were not sufficiently popular to gain their object without assistance, and hence they made proposals to the progresista party, which were agreed to. A proclamation was accordingly issued, declaring their object to be the re-establishment of the constitution of 1837 with its constituent Cortes, the maintenance of the throne of Isabella II., the dismissal of the present ministry and the queen-mother, and the reorganisation of the national guard. On this all the most important towns that had hitherto stood aloof from the insurrection immediately declared in its favour. In Madrid, on the 17th of July, the people rose in insurrection, attacked the prefecture, possessed themselves of the arms there, and immediately proceeded to attack the government and other buildings. A junta was formed, and a petition drawn up and presented to the queen, who promised to give the matter due consideration. A lull in the outbreak then took place; but General Cordova, who is said to have pledged himself not to molest the people that night, ordered two battalions to open fire upon them in the Plaza Major. The mob, now infuriated, sacked, pillaged, and set on fire the hotels of several of the ministers. They also attacked the palace of the queen-mother, and effected an entrance into one of the wings, threw out the furniture to feed a bonfire, and then set fire to the palace itself. By this time, however, some troops had arrived, who, after firing a few volleys, succeeded in clearing the square, and in confining the conflagration to the wing in which it had commenced. On the 18th, barricades were erected in all the main streets debouching on the Puerta del Sol, behind which the insurgents kept the troops at bay for eighteen hours. The queen sent for Espartero, who was then at Logroño, to come and form a ministry, which he agreed to do, upon condition of the banishment of the queen-mother, and the assembling of the constituent Cortes. The queen having agreed to these conditions, Espartero set out for Madrid, and, in the meantime, General O'Donnell, who had defeated the troops sent out against him, was retracing his steps to Madrid. They entered the capital together on the 29th of July, escorted by the national guard and thousands of the people. Peace being thus at length restored, the Cortes was convoked, and Espartero became head of the new government. The queen-mother left for Lisbon, and afterwards proceeded to Paris, where she had apartments assigned for her in the palace of Malmaison.

Espartero continued at the head of the government till 14th July 1856. His liberal measures were offensive to several of his colleagues, and, through the intrigues of O'Donnell, he was led into a ministerial difficulty, and felt himself called upon to tender his resignation, which was accepted, and O'Donnell was appointed president in his stead. One of the first acts of the new government was to declare the whole of Spain under martial law. The people, however, would not submit to this without a struggle, and an insurrection broke out in Madrid, in which the national guard sided with the populace against the soldiery. After some fighting, however, it was overcome; and similar outbreaks in other towns were also speedily suppressed. The Cortes passed a vote of no confidence in the O'Donnell

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ministry; but the next day a royal decree appeared, declaring the Cortes to be closed. One of the next steps of the new government was the abolition of the national guard. O'Donnell did not, however, continue long in power, for he had to resign on the 13th of October, and a new ministry was formed under General Narvaez. On the 28th November 1857 the queen gave birth to a son, who, as heir to the kingdom, takes the title of Prince of the Asturias.

The recent history of Spain, like the preceding, is marked by frequent ministerial changes, and a generally unsettled state of the country; but presents us with nothing calling for special notice except the present war with Morocco. It is impossible at present to enter into any account of this struggle, which is probably only begun. It was undertaken contrary to the remonstrances of England, the alleged cause of it being piracies committed off the coast of Morocco. Spain, however, seems desirous of establishing a footing in that part of Africa; for, on the fall of Tetuan, one of the conditions of peace proposed by her was, that she should retain possession of all the conquered portion of Morocco.

List of Kings and Queens of Spain since the Union of the separate Kingdoms.

1512. Ferdinand V.	1724. Philip V., restored.
1516. Charles I.	1746. Ferdinand VI.
1556. Philip II.	1759. Charles III.
1598. Philip III.	1788. Charles IV.
1621. Philip VI.	1808. Ferdinand VII.
1665. Charles II.	1808. Joseph Buonaparte.
1700. Philip V.	1814. Ferdinand VII., restored.
1724. Louis I.	1833. Isabella II.

(J. F. S.)

STATISTICS.

The kingdoms of Spain and Portugal together form what is called the Pyrenean Peninsula, or, briefly, the Peninsula, the most southerly, and at the same time the most westerly, portion of Europe. Except on the north-east, where it is connected with the rest of Europe by an isthmus about one hundred miles in breadth, this peninsula is wholly surrounded by water. Spain (*España*), which occupies by far the greater part of it, has for its boundaries on the south and south-east the Strait of Gibraltar and Mediterranean Sea; on the west, partly the long and narrow territory of Portugal, partly the Atlantic Ocean; on the north, the Bay of Biscay; and on the north-east the Pyrenees, a chain holding the second rank among the mountains of Europe, and forming a well-defined line of separation between France and Spain. Its extent north and south is from Tarifa Point, in the Straits, in 35° 57′ north latitude, to Cape Ortegal, in Galicia, 43° 46′, making 7° 49′ of latitude, or about 540 English miles. From east to west the extreme points are Cape Creus, in Catalonia, 3° 12′ of east longitude, and Cape La Roca, 9° 17′ of west longitude, the distance in this direction being 560 miles. The Peninsula thus forms almost a square, allowance being made for the irregularity of its outline; and the entire extent of Portugal being excluded, it is reckoned to contain about 193,000 square miles English.[1]

Boundaries.

Coasts.

Without reckoning numerous small inlets, the coast line of Spain is nearly 1400 miles in length, of which the Atlantic, with the Bay of Biscay, forms above 600, and about 770 is washed by the Mediterranean. From the Bay of Gibraltar to the mouth of the Guadiana on the south-west, the distance is about 140 miles. On the north-west, from the mouth of the Rio Minho to Cape Ortegal is 160 miles; and the north coast, from Cape Ortegal to the French boundary, extends 300 more. The Bay of Gibraltar, with the exception of the rock itself, is low and sandy. Proceeding thence in a westerly direction, the coast rises moderately towards Algesiras and Cape Trafalgar. Passing from the admirable Bay of Cadiz to the mouth of the Guadalquivir, the land becomes swampy and low. From Huelva, the harbour of which receives the small rivers Tinto and Odiel, to Ayamonte, at the mouth of the Guadiana, the shore continues low, and abounds with sandy islets. The northern coast, extending from the French boundary towards Cape Ortegal, is, generally speaking, rocky, a wall of rock forming a line of from 20 to 300 feet in height along the coast. Further west a few inlets occur, with a few headlands. Between Capes Ortegal and Finisterre to the Minho, the coast, though rocky, is less elevated, and the inlets entering into, and the headlands stretching from the land, form, as at Ferrol, Vigo, and Corunna, several large harbours.

From Gibraltar east to Motril the coast is tolerably level, and in some places even low; but to the east of this last it rises in some places to the height of several hundred feet. This elevated line continues to Cape Gata, and thence northwards to the town of Mojacar. From this town to Cape de Palos the line is of less elevation. Along this coast are found the harbour of Malaga, the open bay of Almeria, and the excellent harbour of Cartagena. The coast continues sandy and low, with no harbours between, from Cape de Palos to the roadstead of Alicante. Thence to Denia the coast is rocky and more elevated. From Denia to the mouth of the Ebro the coast is again low and sandy, excepting at Castellon de la Plana, where it becomes higher. Along this coast many lagoons, called Albuferas, occur; but no harbours, except the open one of Valencia, and, south of the Ebro, the Puerto de los Alfaques. Proceeding towards the French boundary from the Ebro, the coastline alternates between high and low spaces, presenting the good harbours of Barcelona and Rosas, sufficiently deep for larger vessels, and that of Reus and others, fit only for smaller ones.

Geology.

According to M. de Verneuil, so well known as the friend and associate of Sir Roderick Murchison during his geological labours in Russia, the central part of Spain is distinguished by three chains of mountains, which constitute the skeleton of the country—the *Guadarrama*, the *Montes de Toledo*, and the *Sierra Morena*. Having emerged before the secondary period, these ridges formed islands composed of granite, gneiss, and of Silurian or other palæozoic rocks, and around which were accumulated the younger deposits.

Primary Rocks.—One of the highest of these, the Guadarrama, is principally composed of granite, gneiss, and other crystalline schists. Towards the E. these disappear under the Silurian and Devonian formations, whilst to the W. they proceed to the frontier of Portugal. The primary rocks occur in two other and very distant parts of Spain. The province of Galicia is principally composed of granite, gneiss, and mica-schist, occasionally surrounding patches of slate and limestone; these rocks are of great antiquity, and form a sort of expansion of the palæozoic chain of Cantabria. The Sierra Nevada, S.E. of Granada, offers an example of a great mass of crystalline schists. The abundance of garnets in the mica-schist, the crystalline structure and magnesian condition of the thick band of limestone which surrounds the central part, indicate the energy of the *metamorphic* action which has here taken place.

Palæozoic Rocks.—The Sierra Morena is the tract in which most of the Silurian fossils have been discovered. This range is composed of slates, psammites, quartzites,

[1] According to Balbi, 137,400 geographical square miles. Miñano gives it 15,762 square leagues of 20 to a degree, Minutoli only 15,002, and Moreau de Jonnès 18,890. Hassel estimates it at 25,145 square leagues of 25 to a degree. In the *Censo* of 1857, just published, Spain, including the Balearic Isles and the Canaries, is placed at 16,356·00 *léguas quadradas*, or about 195,000 Eng. sq. miles.

and sandstones; the strata often placed by violent dislocations in a vertical position. Making a section across the chain, N. to S., from Almaden to Cordova, the formations succeed each other in an ascending order. The oldest or lowest traces of life, trilobites, occur in black shivery slates. The upper Silurian rocks are poorly represented in the Sierra Morena; the Devonian rocks more fully. The carboniferous deposits, situated towards its southern part, contain great masses of limestone. The two sides of the Sierra Cantabrica, in Leon and the Asturias, present deposits full of well-preserved Devonian fossils, and offer points of pilgrimage for all palæontologists. These Devonian rocks constitute the axis of the Sierra Cantabrica and its southern side, and are covered in the Asturias, or on the N., by the richest coal-field of Spain. In general the carboniferous strata are vertical; this disadvantage, in extracting the coal, is lessened by the mountainous relief of the country, in some parts of which the beds of coal can be worked 1200 or 1300 feet above the level of the streams. The depth of the whole group may be estimated at 10,000 or 12,000 feet.

Secondary Rocks.—The trias may be traced from the Pyrenees through Catalonia, Aragon, Valencia, and Murcia, to Andalusia, and is the principal store for salt and gypsum. It is principally composed of conglomerate, sandstone, limestone, and red clays, or marls of various colours. When the series is complete, it may be divided into three or four groups, but is often reduced to two or three. Fossils are exceedingly rare, and have been found only in the limestone; the species are those of the muschelkalk of Germany. They have been discovered by M. de Verneuil, Casiano de Prado, and Collomb, in ten or twelve different places, from the mouth of the Ebro to the mountains of Jaen. Some species have been also recently discovered by Professor Vilanova, at Carlet, near Valencia. The jurassic and cretaceous groups extend over most of the north-eastern and southern part of Spain, covering vast areas in the Basque Provinces, in Catalonia, Aragon, Valencia, Murcia, Malaga, and Ronda. Lying upon the red sandstone, they constitute most of the high lands and mountains which, to the east of Madrid, make the water-parting between the Atlantic and Mediterranean. Surrounding the central and more ancient parts along the Guadarrama, the chalk penetrates into the very heart of the country. In the eastern parts, mountains more than 5000 feet high are composed of jurassic or cretaceous rocks. The two most fossiliferous members of the Jura are the Lias and the Oxfordian group. The lower lias is wanting in Spain, and all the fossils hitherto found are those which characterise the middle and the upper zone. To the Jura, M. de Verneuil refers the Moncayo, the highest in the Ebro Mountains, then the high ranges north and south of Teruel, the latter called Camarena, the Sierra of Albarracin, and those of the N.W. of the province of Valencia. Very often concealed in the south of that province, as well as in the east of Murcia, the jurassic deposits re-appear, and reach great altitudes in the Mountains of Cazorla and Segura. Situated N.N.E. of the Sierra Nevada, these mountains form a high country, the culminating point of which bears the name of Sierra Sagra, near Huescar, and is 2400 mètres high. The jurassic beds are broken near Czorlaa, and form magnificent cliffs. After an interruption where the low country is occupied by the trias, and where passes the Rio de Guadix, the Jura again forms the high mountains of Huelma, Jaen, Cabra, Lucena, Antequera, and extends to the celebrated Serrania of Ronda, in the highest parts of which M. de Verneuil has recently discovered lias and Oxfordian fossils. West of these mountians the Jura disappears under the tertiary basin of the Guadalquivir, in which stand the cities of Arcos, Jeres, Medina, Sidonia, and Veger. It is well known that the isolated rock of Gibraltar is jurassic. The chalk accompanies the Jura in the eastern provinces of Catalonia, Aragon, Valencia, and Murcia, but does not extend so far west in Andalusia, and has not been found in the Ronda Mountains; on the contrary, it occupies a much larger area than the Jura in the Basque Provinces, as well as in Navarre and Santander.

In these last provinces the series has not received its full development, being represented only by the various members which lie *above* the gault, whereas, in the eastern provinces, those *below* the gault, or the neocomian beds, are prevalent. The high *plateau* called the Maestrazzo, S.W. of Tortosa, between that place and Teruel, is entirely cretaceous, and in greater part neocomian. The highest peak, the Peña Golosa, 1800 mètres high, composed of orbitolite limestone, is seen from a great distance. Above the chalk, and having apparently been submitted to the same disturbances, lie the nummulitic rocks, the true lower eocene. They form an uninterrupted band or zone along the south side of the Pyrenees, from the Mediterranean near Gerona to Pamplona. These nummulitic beds disappear some miles east of Vittoria, where the whole chain is composed of chalk, with young tertiary basins. At San Vicente la Barquera and Columbres, not far from Santander, the same beds are seen, but occupying a small area. One of the most striking features of the nummulitic group is, that it surrounds the great interior plateau, never penetrating into the heart of it. It occupies the coast-range south of Valencia, extends into Murcia to the south part of the great Cazorla Mountains, and forms all the promontories between Algesiras and Tarifa. At Malaga, and in many other places, a great discordance may be seen between the nummulitic limestone and the miocene or younger tertiary deposits, the first being highly contorted, and the second slightly inclined.

The younger *tertiary* rocks cover vast areas in Spain, generally horizontal, and extending in vast plains, they contrast strongly with the secondary and nummulitic, or older tertiary beds, which are always contorted, and form undulating or mountainous countries. All the great valleys of the Ebro, the Douro, the Tagus, the Guadiana, and the Guadalquivir, have been bottoms of seas, estuaries, or extensive lakes. The purely fresh-water deposits cover a larger area than the marine ones, extending over Old and New Castile, from the Cantabrian chain to the Guadarrama, and from the Guadarrama to the Sierra Morena, through the great plains of the Mancha. In some places these deposits reach the altitude of 4500 feet; thus proving how great elevation Spain has undergone even in recent times; recent in effect, to judge by the fresh-water fossil shells, identical with those living now, and by the bones of great mammoths discovered in the *Cerro San Isidro*, near Madrid. Most of the marine deposits, and especially those of the basin of the Guadalquivir, are miocene, and upon them lie here and there some small pliocene, or newer pliocene (modern) deposits, formed on the maritime shore, and composed of pebbles and fragments of Pecten and Ostrea. In some places there are clays in which some good fossils have been preserved, as in the neighbourhood of Malaga. It is probably in the most recent of these periods that the extinct volcanoes of the Peninsula broke out. Three foci of eruption are known, one at the Cape of Gata, the other in the neighbourhood of Ciudad-Real, and the third near Olot, in Catalonia.

The geology of Spain is not sufficiently advanced to attempt a classification of its mountains, considered with respect to their periods of elevation. The Sierra Morena is probably the most ancient, for in both its sides the tertiary strata in contact with the old rocks are horizontal. Near Cordova, for example, the miocene beds, with the huge *Clypeaster altus*, are to be seen in that position; and on the northern side, at Santa Cruz de Mudela, horizontal

Statistics.

bands of fresh-water limestone, loaded with helix, lie upon highly inclined, trilobite Silurian schists. More recent movements have taken place in the Guadarrama, since at the southern foot of that high range, and on the road from Madrid to Burgos, the same fresh-water limestone is slightly elevated. In the Pyrenees, as well as in the mountains which rise in the most southern part of Spain, the subsoil has been fractured by violent and recent disturbances. The tertiary formations of the Ebro, and those of Leon along the Cantabrian chain, are often much elevated. In Leon they are even vertical near the chain, but soon resume their horizontal position, to range over the great plains of Castile.[1]

Mountains.

The country may be considered as composed of a series of mountain-terraces, which, projecting successively their rugged edges towards the south, present a flight of gigantic steps from the Pyrenees to the Mediterranean. The chains of mountains which terminate and divide the great plains of the Peninsula are branches of the immense ridge that, from the most elevated part of Tartary, runs across Asia and Europe, penetrates into the south of France by Switzerland, and, entering Spain in the direction of the valleys of Roncal and Bastan, separates Navarre from Guipuscoa, Biscay from Alava, the highlands of Burgos from the plains of Old Castile, and Asturias from the kingdom of Leon; then crosses Galicia, and dips into the ocean at Capes Ortegal and Finisterre.

The Pyrenees are lateral ramifications of this great trunk, which run east and west on the eastern side of Spain, and take a south-west and north-west direction on the confines of Aragon and Navarre. The accumulated mass of these mountains presents, towards the Peninsula, the convex side of a spherical segment, which, like a shield with its boss to the south, rounds its edges near the Atlantic and the Mediterranean, and rears the highest part of its curve on the Spanish territory, between the springs of the rivers Cinca and Ara. This eminence, called *Mont Perdu* by the French, is known, in Aragon, by the appellation of Tres Sorores, alluding to its three peaks, distinctly seen from Saragossa, of which the highest rises 11,270 feet above the level of the sea. The line of perpetual congelation is there at the height of 8010 feet.

In the minor branches which strike off from the Pyrenees in a south direction, without forming a part of the great secondary chains, which we shall presently describe, there are some mountains too remarkable to be left unnoticed. Such are the Monsen, on the coast of Catalonia, near the town of Arenys de Mar, and the well-known Monserrat, which rises, on the same coast, to the height of 4050 feet above the sea; such the Sierras of Ribagorza, Barbastro, Huesca, and Jaca, which take their names from the principal cities in their neighbourhood; such, finally, those numerous spurs of the great ridge which run into Navarre, whose various appellations would only tend to confuse the reader.

Great Iberian chain.

Of the main ridges which run across the Peninsula, that which rises to the west of the source of the Ebro was called *Idubeda* by the Romans, and formed the limits of the ancient *Celtiberia*. In its course towards the Mediterranean, the natives, according to a general custom, distinguish the various portions or great links of the chain by the appellation of *Sierras*, adding the name of some town or notable height in their vicinity. Such are the Sierra de Oca of Urbion (the *Distertiæ* of the middle ages), of Moncayo (*Mons Caunus*), of Molina, Albarracin, and Cuença. Part of this chain forms the limits of Aragon and Castile; it then penetrates into Valentia, Murcia, and Granada, and ends in the Capes Oropésa (Tenebrium), Martin, Palos, and Gata. The small town of Alcolea, in the province of Soria, stands on this chain, at the height of 4074 feet above the sea. Its mean elevation, on the road between Molina and Teruel, in Aragon, is 4328 feet.

The first point where this great ridge splits into the minor chains, which lose themselves in the Mediterranean, is to the north of Albarracin, in Aragon. Of these branches the most remarkable is that which, entering the province of Valentia, is again subdivided into the smaller ridges which terminate at Peñiscola and Cape Oropesa. The waters that descend from these heights, to the north, mix finally with the Ebro, while the Turia and the Mijares are swelled by those which flow from the southern declivities. On the branch stretching towards Peñiscola, and in the limits of Aragon, rises the Muela de Ares, a conical mountain deprived of its apex; whose top is an extensive plain covered with luxuriant pasture, and surrounded by fearful precipices, at the elevation of 4280 feet above the sea. This is one of the highest spots in the Peninsula. The Tagus, the Jucar, and the Cabriel, take their rise among these mountains, and divide the waters which flow from their sides between the Atlantic and the Mediterranean. Numerous flocks of sheep, both itinerant and stationary, find, in the valleys formed by this chain, the most abundant summer pasture.

From Albarracin, this chain strikes into the territory of Cuença, in a direction nearly north and south. It then sends off a branch to the east-south-east, on which the Collado de la Plata, or Silver Hill, rises 4378 feet above the sea. It contains a quicksilver mine, which was formerly worked. From the neighbourhood of this town the Sierra de Espadan runs, like an unbroken bulwark, to the sea near Murviedro, in a direction between south-east and north-west. These hills are described as singularly grand and picturesque.

Near the source of the Tagus, the Iberian ridge sends off another branch, which, stretching in almost a southern direction, separates La Mancha from the province of Murcia, to the west of the town of Albacete, and rises into the lofty mountains of Alcaras and Segura (the ancient *Orospeda*), dividing the waters between the Guadalquivir and the Segura, the two main streams which severally and finally convey them to the ocean and the Mediterranean. One of the two great limbs which terminate the Iberian ridge runs into the sea at Cape Cervera; the other, bending to the south, skirts the kingdom of Granada, and disappears at Cape Gata. To the latter belongs the mountain called Cabezo de Maria, between Carthagena and Cape Gata, one league west of the town of Vera, on the coast of Granada. It rises 6265 feet above the sea, and has its summit covered with snow during one-half of the year.

Smaller branches of this chain project between the Turia and the Cabriel, which loses itself in the Jucar at Cofrentes. A ridge runs between the last-mentioned river and the Alcoy, another stream, which flows into the sea near Gandia. A minor chain separates the Alcoy and the mouth of the Segura. The province of Valencia is, in fact, divided by mountains into most fertile strips, watered by numerous streams, and enjoying every blessing which nature grants to the most favoured climates.

Ridge between Douro and Tagus.

The great ridge whose summits divide the waters between the Douro and the Tagus grows out of the Iberian chain, not far from the sources of the Jalon and the Tajuña, to the south of the city of Soria, and the site of the ancient Numantia. Where it divides the province of Guadalajara from that of Soria, it is called Sierra de Parades, and Altos de Barahona. On one of the hills north of Sigüenza, rises the Henares, which gives its name to the ancient

[1] See works of P. Torrubia, Francisco Lujan, Ezquerra del Bayo, Paillette, Casiano de Prado, d'Archiac, Hausmann, Coello, De Botella, Schulz, Wilkomm, Scharenberg, Rossmaessler, Pratt, Ribeiro, Sharpe, De Verneuil, the *Revista Minera*, &c.

Statistics. *Complutum*, now Alcalá de Henares, the seat of a university. Near the source of the Lozoya, a rivulet which runs into the Jarama, these mountains are called Somosierra, till, more to the west, they bear the name of Guadarrama; an appellation which they preserve throughout the long course in which they skirt the provinces of Segovia, Avila, Guadalajara, and Madrid. The Puerto de Navacerrada, the highest point on the road from Madrid to the summer palace of San Ildefonso, is 6037 feet above the sea.

The mountains of Guadarrama are a very striking object when seen from the neighbourhood of Madrid, on the road to Old Castille. They principally consist of naked, fractured granite rocks, heaped up together, and adorned only towards their bases with single evergreen oaks, while the upper parts are bleak, dreary, and barren, presenting fantastic prominences, and in many places covered with perpetual snow. This chain, in its course towards Portugal, where it ends in the Rock of Lisbon, rises into some remarkable elevations. We shall notice that of Peñalara, between the sources of the Eresma and the Lozoya, 7764 feet above the sea; the Puerto del Pico, in the province of Avila; the Peña de Francia, and Sierra de Gata, in the northern limits of Spanish Estremadura.

Chain of Tagus and Guadiana. Almost parallel to the mountains of Guadarrama, we find the ridge which divides the waters between the Tagus and the Guadiana; but it rises to no great height, and is altogether of minor importance.

Ridge of Guadiana and Guadalquivir. The third great branch of the Iberian ridge is the Sierra Morena (*Montes Mariani*), which divides the waters between the Guadiana and the Guadalquivir. It begins in the vicinity of Alcaráz, near the eastern limits of the province of La Mancha, issuing from that spur of the Iberian chain which terminates in Cape Palos, and, trending in a direction north-east and south-west, with La Mancha and Spanish Estremadura to the north, and Jaen, Cordova, Seville, and Algarve in Portugal, to the south, ends in the ocean at Cape St Vincent. The pass named Puerto del Rey, where the road from Madrid to Andalusia crosses these mountains, is 2249 feet above the sea. Near Cordova, where the bold skirts of the *Montes Mariani* are seen, within a short distance to the north, like a screen raised to protect the rich and extensive plains watered by the Guadalquivir, the ridge borrows the name of the neighbouring city. On the southern limits of Estremadura, and to the north of Seville, it is called Sierra de Gaudal-canal. The chain now bends to the south-west, forms the northern boundary of the Portuguese province of Algarve, and, through the Sierras of Caldeiraon and Monchique, connects itself with Cape St Vincent.

Ridge of Granada and Ronda. The brink of the last mountain-plain towards the south of Spain is skirted by the ridge of Granada and Ronda, which, striking off at the extremity of the Iberian chain, is successively called Sierra de Gador, Sierra Nevada, Bermeja, and de Ronda, till it ends in various points of the coast, but most conspicuously in the Rock of Gibraltar.

Part of the Sierra Nevada rises above the highest Pyrenees. The Cumbre de Mulhaçen is 11,654 feet above the sea, the Picacho de Veleta 11,377 feet. The line of perpetual congelation is found in these mountains at the height of 9055 feet.

Rivers. The six great streams which water the plains lying between the great mountain-ridges, are the Miño, the Ebro, the Douro, the Tagus, the Guadiana, and the Guadalquivir.

Miño. The Miño, or Minho (*Minius*, or *Bænis*), rises in the district of Lugo, from a beautiful spring called Fuente Miña, runs through Galicia in a south-west direction by Lugo and Orense, and from Melgaza to its mouth in the Atlantic, forms the boundaries between Spain and Portugal. This river, 60 leagues in length, is navigable only to Salvatierra, two leagues above Tuy.

Ebro. The Ebro rises, near Reinosa, out of a spring so copious that it turns a corn-mill a few steps from its source. After a course of 120 leagues, it flows into the Mediterranean at Alfaques. From the boundaries of Navarre to the sea, the Ebro makes a progress of 1° 12′ 42″ towards the south. The chief towns on this stream are Logroño and Calahorra, in the province of Rioja; Tudela, in Navarre; Saragossa, in Aragon; and Tortosa, in Catalonia. It is a misfortune for Spain that this great river presents such strong obstacles to navigation, both in its course and where it reaches the sea.

Douro. The Douro, or Duero, has its source to the north of the city of Osma, in a deep lake, at the summit of that portion of the neighbouring chain of mountains called Sierra de Urbion. Its course is at first to the east, towards Hinojosa, then towards the south, passing by Garray and Soria, where it turns to the west, continuing in that direction till it reaches Miranda. From this town to Moncorvo the river falls again into a south direction. It lastly takes a decided course to the ocean, which it reaches near Oporto, having traversed a distance of 130 leagues. This river is navigable up to the tower of Moncorvo, a distance of 30 leagues. The navigation, which was formerly obstructed by rapids, has been expedited through the exertions of the Portuguese company of the Alto Douro. Among its chief tributary rivers are the Ebros, the Rejas, the Jaramillo, the Pisuerga, the Esla, the Cea, and the Agueda. Some of the smaller streams flowing into the Douro rise at remarkable heights. The Adaja, which descends from the northern slope of the great chain between the Douro and the Tagus, is, at Avila, 3482 feet above the sea; the Eresma, when it flows by the castle of Segovia, is 3033 feet above the same level.

Tagus. We have mentioned that elevated part of the chain between the Tagus and the Guadiana which takes the name of Albarracin, and the truncated mountain called Muela de San Juan. An inconsiderable spring, denominated Pie Izquierdo, is the source of the majestic Tajo, or Tagus. In its course through the province of Cuença it is considerably augmented by the contributions of several streams. Before its waters reach Aranjuez, they surmount the rocky edge of its native mountain, and, dashing upon the plain beneath, sink into a pool of great depth, called Olla de Borlaque. The Tagus, now running placidly through the plains of Zurita and the royal gardens of Aranjuez, at the elevation of 1700 feet above the sea, directs its course to Toledo, passes by Talavera, Alcantara, Abrantes, and Santarem, losing itself finally, after a course of 170 leagues, in the sea near Lisbon. To its chief tributary rivers belong the Oceseca, the Gallo, the Jarama, the Guadarrama, the Alberche, the Alagon, the Herja, the Guadiela, the Araya, and the Sever.

Guadiana. The sources of the Guadiana are found north of Alcaraz, in La Mancha, at the pools of Ruidera. The course of the river is first to the north-west for 8 leagues. It is then absorbed by the soil, and disappears for 7 leagues. The first gathering of its waters, after their subterraneous dispersion, takes place near Daimiel. The spot is called Ojos (Eyes) del Guadiana. The stream now proceeds to Ciudad Real, the chief town of the province of La Mancha, to Merida and Badajos. In the neighbourhood of Badajos it turns to the south, and forms for some length the boundaries between Spain and Portugal. It enters Portugal at one part of its course, but at Jeres de Guadiana is again adopted as the boundary line, and continues such till after a course of 150 leagues, it enters the Atlantic at Ayamonte. It is navigable to Mertola in Portugal, about 45 miles from its mouth. Among its tributary rivers are the Gigüela, the Rubial, the Estena, the Burdalo, and the Montiel.

Guadalquivir. The Guadalquivir occupies the centre of the plain which lies between the Sierra Morena and the chain of Granada,

Statistics. where it takes its course to the north-east of Jaen. The chief towns on its banks are Andujar, Cordova, Seville, and San Lucar (*Templum Luciferi*). At the ferry near Menjivar, on the road from Madrid to Granada, the Guadalquivir is 556 feet above the sea. After running about 100 leagues it empties inself into the Atlantic. This river is navigable for vessels up to Seville; but its bed being constantly raised and obstructed by growing shallows, the navigation is extremely tedious. Among its subsidiary rivers are the Guadalimar, the Jandula, the Jenil, the Corbones, and the Guadaira.

To these principal streams we may add the Bidasoa, which has its sources in Navarre, and flows into the sea at Fuenterrabia, forming the boundaries between France and Spain, and is considered a neutral stream by both countries. The Bilbao, which is navigable for part of its course for small vessels; the Orinnon, the Mira, the Suanes, the Ulla, the Umia, and the Caldelas: these three latter are coast rivers of Galicia, and form at their mouth small bays and harbours called rias. The Tinto, which runs in the Sierra Morena, and flows into the bay of Huelva after having received the Puerco: its yellow, copper-coloured waters, in which no animated being has yet been found, petrify wood, and destroy every vegetable they touch. The Guadarranque; the Guadiaro; the Segura, a very fine river 45 leagues long, which waters the beautiful Huertas of Murcia; the Jucar, 74 leagues long, but not navigable; the Guadalaviar; the Palancia; the Francoli; and the Fluvia.

Lakes. If we except the series of small lakes from which the river Guadiana takes its rise, there are in Spain few lakes that merit particular notice. The most remarkable of these is the lake of Abufera, in the province of Valencia. This lake begins near the village of Catarroja, about a league south of the city of Valencia, and extends nearly four leagues, as far as Cullera. When it is full, it is about four leagues in length, and two in breadth; but is so shallow that small boats can scarcely float in it. To supply the deficiency of water an engine is employed, by which the neighbouring waters are drawn into the bed of the lake; and any superabundant water occasioned by heavy rains is carried off by means of an artificial opening. This lake contains a great many fish, and numerous aquatic birds make it their haunt. There are some extensive swamps and morasses; as the Gallocanta in Aragon, the pestilential Nava in Palencia, and the lagunes of Ruidera, Benavente, Bejar, and San Martin de Castaneda.

Springs. Mineral springs are so numerous in Spain, that we find their number stated at more than 1200; but regular and comfortable watering and bathing establishments scarcely exist: an hospital is generally the only sanitary establishment in a Spanish watering-place. The mineral springs at Trillo in New Castile, are used for drinking and bathing; those of Vierra-Vermeja in Granada, contain iron, vitriol, and sulphur; and those of Busot in Valencia, sulphur, iron, and salt. The baths of Archena in Murcia, and Caldas de Monbuy, were known to the Romans.

Soil and climate. Viewing Spain as a whole, a threefold principal difference is to be observed. The northern zone, which extends to the Ebro, differs entirely in its characters from the middle zone; and this again is completely different from the southern zone, which is bounded on the north by the Sierra Morena and a part of the Ostrandes. The northern zone, which includes Galicia, the Asturias, the Basques, Navarre, the northern part of Aragon and Catalonia, is a widely extended, mountainous, and hilly country, with a temperate but variable climate. The snow-fields and glaciers of the Pyrenees on the one side, and on the other the north and north-west winds, have a marked influence in lowering the temperature of the atmosphere, and in increasing the supply of water: the annual rainfall in these districts is about 30 inches. The increased humidity is favourable to vegetation, which on the whole very much resembles that of the south of France; and the variety of rocks containing lime, clay, and sand, and also their frequent alternations, operate beneficially on the soil. Everywhere it invites to cultivation, and the inhabitants of this region are active husbandmen. The middle part of Spain, which comprises Old and New Castile, a part of Aragon, Leon, and Estremadura, is not so favourably circumstanced. Generally speaking, it is deficient in either beauty or variety of aspect. The broad and lofty table-lands, of a mean elevation of 1900 feet, present a uniform and monotonous surface, destitute of trees, scorched by the rays of the sun in summer, and subject during the winter to a piercing wind, called the *gallego*, which blows from the north-west. The corn-fields are wretchedly cultivated, and desert heaths of the rockrose (*cistus*) meet the eye. Plantations of olive-trees are rare: here, in short, every kind of vegetation dwindles for want of water. In most cases the rivers carry but little water in comparison with the extent of the land and the number of considerable mountain-chains. The causes of this great deficiency are principally the extreme dryness of the atmosphere; the inconsiderable covering of snow on the mountains, and its short continuance; the absence of forests and great moors on the heights; and the comparatively inconsiderable breadth of the mountain-ranges. The people are principally employed in pastoral occupations, migrating with their flocks from place to place according to the seasons. The mean annual temperature of the central table-land is 60°, the mean summer temp. 76°, and that of winter 43°. The southern and south-western part of Spain, which comprehends Andalusia, Granada, and Murcia, is very different from that just described. On the opposite side of the Sierra Morena the whole land has a more southern aspect, which announces itself not only by the vegetable, but likewise by the animal kingdom. The great difference of climate is produced by the southern situation, the exposure of the acclivity of the south and south-west to the African winds, and the strong reflection of the solar rays from the lofty naked mountain-walls. The mountain-ranges are more closely aggregated, the valleys more deeply cut; and there is also a greater difference in the rocks and in their position, so that extensive table-lands cannot be formed. The south of Spain thus possesses not only a much higher temperature, one fit for the olive, the orange, and the palm, but also a more varied and more favourable soil for cultivation. In East Valencia and Murcia, in the south of Andalusia, and the Algarves, in Western Alentejo and South Estremadura, a sort of perpetual spring prevails, and the rich and varied vegetation rivals that of the fertile plains of Syria. In Andalusia frosts are unknown, and the snow, if it ever falls, melts the moment it touches the soil; so that it is not surprising that, in the cultivated districts, the Spaniards, so famous for their maritime expeditions of yore, should have introduced many vegetables from remote parts of the world, thus giving a perfectly tropical appearance to the country. There is, however, a deficiency of moisture; and a hot pestilential wind called the *solano*, similar to the *sirocco* of Italy, often blows from the south-west for severals days in succession, withering vegetation, enfeebling the animal frame, and spreading epidemic diseases.

Productions. Passing over such productions of the soil as are only interesting to the botanist, we here enumerate those which come under the cognizance of the husbandman. Spain may be reckoned one of the most fruitful countries of Europe, and it presents a great variety of products. Wheat, secale, barley, hemp, and flax, are cultivated in almost all the provinces, the most productive being Valencia, Catalonia, Murcia, and some of the northern ones. Oats are neglected, barley being given to the cattle instead of that grain. Oil and soda are the principal products of the

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southern shores of the Mediterranean; the others are sumach (*rhus*), and different esculent plants of a superior quality. In the same part of the country are fields of saffron, plantations of rice, which stretch out like so many plains, and the cotton-shrub thrives as on its native soil. The mulberry-trees are very luxuriant, and their leaves afford rich nourishment to the silk-worm, which easily accounts for the superior quality of the silk. In the south of Spain there is an immense variety of the most delicious fruits, not only such as are common in temperate climates, but many which naturally belong to the tropical regions. The sugar-cane grows near the cotton-plant, and numerous olives furnish the oil which forms so important a branch of commerce. Kali, from which barilla is extracted, is produced in great abundance in Valencia; the liquorice-plant near Seville and at the mouth of the Ebro; anise, maize, and different dye-stuffs in Murcia; and the honey of Cuença is still as celebrated as it was in the time of the Romans. Among the vegetable products, we may briefly mention chestnuts and a variety of other nuts, the cork-tree, palm, lemon, orange, banana, date, pomegranate, fig, citron, cherimoyer, laurel, bay, cypress, almond, and strawberry tree; potato and other culinary vegetables; forests of oak, pine, and other trees, chiefly in Catalonia, the Asturias, Galicia, and the Sierra Morena. Extensive valleys covered with rich pastures are found in Navarre, and numerous herds are fattened on them. In the Asturias, the Pyrenees, the Sierra Morena, and the Sierra Nevada, considerable forests still exist, chiefly of evergreen oaks, from which naval timber is obtained. But of all the vegetable productions of Spain, the vine is the most important, the lands being almost everywhere favourable to its culture. The excess of the vintage above the quantity consumed in the country forms a considerable branch of the export trade, and it is capable of being greatly extended. The wines of Spain are more vigorous than those of any other country in Europe; but with the exception of those of Jeres, Rota, Malaga, Alicante, Benicarlo, &c., which are intended for exportation, they are still prepared in a careless and imperfect manner. In the district of Jerez, the centre of the wines so well known as sherry, there are 12,000 acres, and between Jera de la Frontera and Puerta de Santa Maria there are about 25,000 acres under cultivation. The richest Malaga wine is the sweet lagrimas made from the juice which oozes, without pressure, from the rich grapes hung up in nets or in bunches. In 1857, however, nearly 2,000,000 acres of land were devoted to the culture of the vine, while the quantity of wine exported exceeded L.4,000,000 in value.

Zoology.

The native zoology includes a great number of species. In the mountains of Asturias the ibex is not uncommon, and the Alpine squirrel (*Sciurus Alpinus*) is only found in the Pyrenees. In the southern parts, bordering on the African shore, a few species of warblers have been found, which are but little known to the rest of Europe, and the flamingo is sometimes seen in the vicinity of Valencia. The European bee-eater frequents the vicinity of Gibraltar in large flocks during the season of migration. Among the domesticated animals, the horse and sheep deserve particular notice, as having been long celebrated throughout Europe. The best horses are generally about four feet six or eight inches in height; they have all the fire, docility, grace, and action of the beautiful Arabs of Barbary, and there can be no doubt of these noble animals having been introduced by the Moors and crossed with the native breed. Those of Andalusia, Granada, and Estremadura, are the most distinguished. The Asturian horse is less elegant, but larger, stronger, and better adapted for common purposes. But little care has been bestowed in keeping up the more noble breed, so that fine horses are not so common in Spain as prior to the French invasions. The mule and the ass are, in so mountainous a country, particularly useful; the breeds of the latter are very fine, and are hardly excelled by those of Egypt. Spain is still celebrated for its Merino race of sheep. The flocks are constantly travelling during the greater part of the summer, but are carefully kept in winter. This race, subdivided into breeds, is extended over the greater part of Spain, but those of Cavage and Negrate are the best. A third breed, the Sowan, appears more hardy, and passes the winter in Estremadura, Andalusia, and New Castile. These three constitute what is called the Transhumante, or travelling race, to distinguish them from the Estautes, or those of a somewhat inferior breed, which do not migrate. The best fleeces are those which appear almost black on their surface, caused by the dust adhering to the peculiarly greasy pile; for it is invariably found that such fleeces are of the purest white beneath. The amount of wool produced annually has been estimated at about 40,000,000 lbs. There is a very large breed of oxen in the country round Salamanca; but the cattle of Spain have been much neglected, the mountaineers deriving much milk and butter from goats. Fine cattle, however, are reared in the Asturias and in Andalusia; and pigs are very common on the Asturian mountains. In 1857, the total number of cattle, &c., was 20,104,000; of which 13,795,000 were sheep; 1,381,000 cattle; 2,734,000 goats; 1,018,000 swine; 492,000 asses; 416,000 mules; and 268,000 horses. The wild-boar, the wolf, the bear, the chamois, and the lynx, still find shelter in the Pyrenees, but are gradually becoming extinct. Cochineal is raised in the south, chameleons are found in the vicinity of Cadiz, and monkeys on the rock of Gibraltar and in the Sierra de Ronda.

Minerals.

Spain has long been celebrated for its richness in minerals, and rich silver and lead mines have been recently discovered in the Sierra Almagrega in Almeira. Lead is found in considerable quantities; the principal veins, as the lead-glance veins of Linares, being found in granite. In 1856, upwards of 1,000,000 quintals of lead in bars were exported. The principal mines are near Tortosa, in Catalonia; at Zoma, Benasques, and Plan, in Aragon; in Estremadura, in Murcia; in Old Castile, in Seville; and in the district of Linares, in Jaen. Mercury is also found, and at Almaden there is a rich mine of this valuable mineral, which is wrought in the clay-slate. Sulphur abounds in Murcia, and asphalte has been discovered and is now worked by a company in Soria. Iron ore occurs in very large quantities, principally in the northern provinces. In the Pays Basque, the lias formation is very rich in iron ore; and that of Mondragon yields 40 per cent. Veins of copper, antimony, and sulphur, are occasionally discovered, but not in such quantities as to be worth working. Coal also exists in considerable quantities in many provinces; and this mineral is gaining in importance every year, owing to the introduction of railways, and other fuel being scarce.

Agriculture.

Although Spain possesses all the advantages of climate, and the soil is generally fertile, the agriculture of the country is in a state of considerable backwardness. A variety of causes has been assigned for this, one of which is what has been appropriately termed the curse of the Mesta. This is a privilege granted to the proprietors of flocks to conduct their sheep into different provinces for the sake of pasturage. In their progress the sheep commit considerable depredations on the crops. The law of entail, which exists in Spain in its worst form, also hinders improvement in agriculture. The estates of the dukes of Osuna, Alba, and Medina Coeli alone include the larger portion of Andalusia. But perhaps the most serious obstacle to improvement is the want of internal communication, and the indolence of the rural population. The farms are generally small, and the farmers of a district live together in miserable villages. There is no rotation of crops, and the wheat, after a slight ploughing, is sown at the commencement of the rains.

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The operation of thrashing and cleaning the grain is performed in the open air, and the grain is left in the fields, or concealed in *silos* or caves till sold. Public granaries, or *positos*, are also found in various districts. Implements of husbandry are of the rudest description; fanners are unknown except about the sea-coast, and the spade is still in use in some of the mountainous parts of the country. The most careful cultivation is to be found in the *huertas* of Granada, Murcia, and Valencia, which are well irrigated by the waters of the Jenil, Segura, and Jucar. Rice is produced in Valencia, and a mild red pepper is the chief vegetable cultivated in Murcia. These three provinces are considered as the gardens of Spain, and annually yield three and four crops of vegetables, maize, and a mild red pepper. The sugar-cane also grows well in Granada and in Valencia. The mulberry thrives in the south; those of Granada are black, while those of Murcia and Valencia are white. In spite of this fertility, however, it is calculated that the entire lands of Spain do not yield more than from 1½ to 2 per cent. to the proprietors. Some improvements have recently been introduced, but even now scarcely a third of the surface of the country is applied to any profitable use. A far greater extent of land is devoted to pasturage than is required for the maintenance of the cattle; and only about a twelfth of the superficies is occupied by wood. In Biscay, agriculture has made many improvements; and in spite of the disadvantages of soil, the population of this district is more numerous, and the grain cheaper, than in the fertile plains to the south and east of Seville, which, if properly cultivated, might supply all Spain. The kingdoms of Old Castile and Leon may be justly considered the granaries of Spain. They have their outlets in the north by various ports from Gijon to St Sebastian, the principal being Santander and Bilbao. The provinces of Burgos and Palencia are the nearest points from which these ports get any considerable supply; the distance being from 130 to 140 English miles from each. The elevated and rich *campos* which extend from Logroño to Burgos, and thence on each side of the Arlanza and Pisuerga, and along the Cauvion, and numerous other streams which water the provinces of Palencia, Valladolid, and Zamora, yield immense quantities of wheat; and farther to the west, and on the south side of the Douro, the provinces of Toro and Salamanca may be considered as forming a portion of the richest wheat country in Spain, or perhaps in the world. A portion of the great properties of the church having been of late years confiscated and sold, the division thus created has tended materially to stimulate improvements in agriculture.

The following table gives the quantities of the different kinds of grain exported from Spain in each of the years 1851, '53, '55, and '56:—

	1851.	1853.	1855.	1856.
Wheat ....(bushels)	138,999	1,202,358	5,359,477	1,480,735
Rice................(cwt.)	29,877	65,057	96,640	121,348
Rye & barley (bushels)	77,070	451,492	450,973	166,367
Beans (French)..(cwt.)	...	40,383	42,790	10,275
Tares.............. „	...	39,957	9,725	18,791
Maize..........(bushel)	194,025	37,263	227,392	1,458
Pulse........... „	48,618	91,881	54,563	52,513
Other kinds......(cwt.)	1,192	13,971	8,726	7,128
Flour & meal...... „	563,590	925,187	1,831,778	1,262,329

In 1855 the quantity of wheat imported into the United Kingdom, from Spain, was 201,716 quarters; of wheat-meal, and flour, 847,558 cwt.; but in 1858 the quantities were only 5197 quarters and 584 cwt. respectively.

Manufactures.

The manufactures of Spain have participated in the general progress which has been made of late years, and have recovered from the depressed state into which they had previouly fallen. Possessing the finest wool in Europe, the woollen manufactures of Spain ought to be unsurpassed: the chief towns engaged in them are Mauresa, Tarragona, Guadalajara, and those of Valencia and Aragon. The cotton manufactures have also exhibited an extraordinary improvement, and are still increasing. Vast quantities of silk-worms are reared in Granada, and there are extensive silk-manufactories in Barcelona, Valencia, Almagro in La Mancha, Seville, Madrid, and other towns; but with regard to both cotton and silk, though the fabrics made are excellent, the colours are not good. Tanning, a branch of trade for which Spain has always been famous, is actively carried on in the northern provinces. At Seville, there is a considerable trade in leather, a species of which, prepared with gall-nuts, is in much request. Ferrol and Vittoria possess considerable tanneries: at the former varnished leather is made; and Cordova gives its name to the kind known as Corduan. There are large cigar manufactories, employing many thousand persons at Malaga, Seville, &c. Potteries are numerous, but the articles produced are generally of an inferior description. There is a royal porcelain manufactory at Madrid, the produce of which is very superior, but it costs the government more than it returns. Hat and paper manufactories have also been established, and have met with considerable success. The manufacture of arms forms a part of the trade of Spain, but the quantity made is by no means great. There are two large factories in Biscay; at Abacete and Toledo swords are made; at Segovia, firearms; and at this latter place, as well as at Seville and Placencia, there are good foundries. Iron manufactories are very numerous in Biscay, but they are not conducted on an extensive scale. In almost every village in this province some kind of iron ware is manufactured; horse-shoes, fusils, locks, and bedsteads being the chief articles, which are sent to the interior. Several other iron manufactories have been established throughout the country, the principal being at Pederoza and Martulla in Andalusia. Iron ore is prohibited from being exported, but considerable quantities are nevertheless sent to France. Spain is extremely rich in saltpetre, and the gunpowder, manufactured in great quantities in Valencia, Granada, La Mancha, and Navarre, is excellent. A kind of rush, grown near Almeria, and made into coarse matting and cables, known in England as "bass," is exported in large quantities. Manufactures are, however, still much checked in Spain by the system of monopoly, some of the largest manufactories being in the hands of the government, and consequently conducted at a loss.

Commerce.

The commerce consists chiefly in the exportation of wines, cereals, wool, brandy, fruits, silk (raw and manufactured), lead, iron, mercury, barilla, and other articles, amounting in all, according to a government return in 1856, to the value of L.10,636,171. Iron, in bars, is exported in considerable quantities from Bilbao, Cumana, and Vittoria, chiefly to Bayonne and Bordeaux. Malaga and Alicante wines are also important branches of commerce; and the coarse wines of Murviedro are extensively exported. The quantity of wine exported from Cadiz alone amounted in 1859 to 45,919 butts. The export of dried fruits gives activity to the ports of Alicante, Malaga, Seville, and Valencia; and the latter town is famous for its dyes. The imports of Spain consist of sugar, salt, fish, spices, wood, rice, butter, cheese, hides, wool, cotton, and almost every manufactured article. The transport of salt from Cadiz and Torrevieja, for the fisheries of Galicia, is an important branch of commerce, and, along with the fisheries themselves, employs a great number of hands, producing the best sailors, and giving to the towns and villages on the coast an activity which is seldom seen in the interior. It has been difficult to arrive at any correct estimate of the value of the exports and imports of Spain, from the want of official documents; and even when these were obtained, little reliance

Statistics. could be placed on them; but, in 1851, the value of imports into Spain was estimated at L.7,406,596; the exports being L.5,333,079—balance *against* Spain of L.2,073,517. In 1858, the value of imports into Spain was estimated at L.12,345,698, the exports being L.13,905,472—balance *in favour of* Spain, L.1,559,774. According to Arcas, the commercial marine amounted, in 1858, to 5173 vessels, with a tonnage of 349,762, and with nearly 80,000 men and boys. The number of lighthouses in actual operation was 61; while 76 more were proposed, or under construction. The amount of customs duty, collected on articles imported into Spain and the Balearic Islands, in 1856, was L.1,867,116. It remains but to add, that, owing to the heavy duties still levied on the productions of foreign countries, smuggling, to a considerable extent, continues, more especially across the Pyrenees, through Portugal, and from Gibraltar. In 1858, the value of the imports into the United Kingdom from Spain was L.2,238,288; from Cuba and Porto Rico, L.3,798,778; and value of the exports from the United Kingdom to Spain was L.2,071,219; to Cuba, L.1,797,219.

Commercial marine.

Banking, &c. Banking, in its English sense, is almost unknown in Spain, the principal merchants doing the business of bankers. Several banks have, however, been recently established in the large towns, and the circular notes used by travellers are pretty generally negotiable: there is an extensive circulation of inland bills of exchange, but in ordinary transactions there are no substitutes for cash. The difficulty of transmitting specie is the cause of the bills of exchange being much used, merchants preferring rather to pay a premium than run the risk of losing the specie altogether. The rate of exchange of course varies with the supply of bills in the market, and also with the character of the houses offering the paper. Most of the bills are at short dates, generally within one month. Some are as short as two days, and these are allowed eight days' grace, unless the word *fixed* is written on them. Interest generally varies from 3 to 4½ per cent. on discounting bills; but this mode of negotiation is not much practised. Interest on mercantile transactions is understood to be fixed at 6 per cent., and 3 per cent. on mortgages; but the law is easily evaded, there being no penalty inflicted on those who charge more than the legal interest. The money in ordinary use consists of cuartos, reales, pesetas, duros, and gold pieces of 80 to 100 reals in value, the real being equal to about 2½d. English. 1 real = 8½ cuartos; 1 peseta = 4 reals = 1 franc; 1 duro = 20 reals. French five-franc pieces and gold Napoleons circulate everywhere in Spain.

Canals. In internal communication, Spain lies under great disadvantages, both from the mountainous nature of the country and the obstructed navigation of the rivers. In the hands of an enterprising people, such difficulties, may, however, soon be overcome. Irrigation, in a country so exposed to droughts as Spain, is of the highest importance, and has been carried to a great extent in Valencia, Catalonia, and Granada. Several small irrigating canals, remnants of Moorish industry, exist in some of the provinces. The only navigable canals of importance are—the canal of Aragon, projected in 1528 by Charles V., intended to connect Navarre with the Mediterranean, finished to Saragossa, and navigable for vessels drawing 10 feet of water. The canal of Castile, to unite Santander with the Douro, is only partly finished. That of Segovia connects that town with the river of the same name; and the canal of San Carlo is constructed to give a port to Tortosa.

Roads. With the exception of the royal roads (Caminos reales), the highways are badly kept. There are eight of these royal roads, all radiating from Madrid; that to Barcelona by Valencia; to La Junquera by Saragossa; to France by way of Vittoria and Irun—kept in excellent condition considering the mountainous nature of the country through which it runs; to Oviedo; to Corunna; to Portugal by way of Badajoz; to Cadiz by Seville, over the Sierra Morena, well kept; and that to Granada. The two roads from Madrid to Burgos, one through Valladolid, and the other through Aranda de Duero, are kept in good condition. In Biscay and Navarre the roads are under the superintendence of the provincial administration, and are more numerous, better constructed, and more carefully managed than any others in the country. The following table from the *Anuario de España*, by Arcas, Madrid, 1859, gives the length and direction of the principal roads:—

	Leagues.
1. Madrid, by Burgos, Vittoria, San Sebastian, Irun, to the frontier of France	84
2. Madrid, by Valladolid, Benavente, Astorga to Corunna on the Atlantic	102
3. Madrid, by Talavera de la Reina, Trujillo Merida and Badajoz, to the frontier of Portugal	69
4. Madrid, by Cordova, Seville & Cadiz, to the Atlantic	113
5. Madrid, by Bailen, Jaen, Granada, to Malaga, in the Mediterranean	93
6. Madrid, by Albacete and Almansa, to Valencia, on the Mediterranean	84
7. Madrid, by Guadalajara, Saragossa, Barcelona, and La Junquera (Gerona) el Potus, to the frontier of France	131

Railways. Railways are being constructed in various directions; those finished and working in December 1859 are the under-mentioned:—Barcelona to Arenys, 23 English miles; to Granollers, 18¾; to Martorell, 15; to Tarrasa, 22½; Cadiz to Jerez, 22; Madrid to Alicante, 282; to Guadalajara, 35¼; Reinosa to Alar del Rey, 32; Santander to Los Corales, 12; Tarragona to Reuss, 8; Valencia to Magente, 50½—total, 521 Eng. miles. There are numerous others, the works of which are far advanced, which are constructed principally with the aid of French companies, but the greater part of the capital is found in Spain, the government and the provincial authorities subscribing largely to them. Those *under construction*, and *conceded*, as given in the *Anuario Estadistico de España*, published by the Royal Statistical Commission in 1859, are:—

Under construction.—2. Madrid to Valadolid; Burgos to Irun; Valladolid to Burgos; San Isidro de Dueñas to Alar; Alar to Santander; Tudela to Bilbao; Madrid to Saragossa; Saragossa to Alsásua; Saragossa to Barcelona; Montblanch to Reus; Granollers to Santa Coloma; Arenys de Mar to Santa Coloma; Almansa to Jativa; Seville to Jerez; and Puerto-Real to Cadiz.

Conceded.—3. Alcázar to Cuidad-Real; Cuidad-Real to Mérida; Mérida to Badajoz; Mérida to Seville; Mérida to Alconétar; Albacete to Cartagena; Valencia to Tarragona; Manzanares to Cordova, Malaga, and Granada; Ventas de Alcoléa to Espiél and Belmez; Palencia to Corunna; and Medina to Zamora.

Telegraph. The electric telegraph has been established during several years; the total length of the communications being 3800 miles in 1858, with 120 stations.

Religion. The Roman Catholic religion exclusively prevails in Spain, where in all ages it has assumed a most bigoted and intolerant form. The church establishment includes ten archbishops and fifty-nine bishops, with a large multitude of canons, prebendaries, and other ecclesiastics, under various denominations. In 1768, the number of priests amounted to nearly 210,000; in 1787, it was reduced to about 180,000, while in 1858, it was estimated at 43,000. In 1837, the convents, then about 1940 in number, and containing upwards of 30,000 monks and lay brothers, were, with a few exceptions, suppressed, and their revenues, subject to a provision for existing members, confiscated to the state; the nunneries, however, amount to about 600, and contain about 12,000 nuns. The total value of church property is estimated at L.25,000,000; and the annual cost to the state under the head of clergy and religious worship is about L.1,550,000.

National education in Spain has recently greatly im-

Language. The language generally spoken, Castilian, is composed of many elements, but principally based on Latin, with a great number of Arabic and Gothic phrases and words: it is manly, sententious, and imposing; full, however, of orientalisms, which mean little, and should not be translated literally. Character. The character of the Spaniards is grave, adventurous, romantic, honourable, and generous, but they display a great hatred of labour, and refuse to work unless positively necessitated; yet, if roused by proper incitement to activity and industry, they show great vigour and exertion, and may achieve independence and reputation. The soldiers are courageous, and, if well commanded, will brave any danger. They are not a naturally melancholy people, Amusements. as the spirit with which they throw themselves into the national amusements will sufficiently prove. Their dances, especially those of the lower classes, have a national character, and are accompanied by the castanet, in the use of which they show remarkable skill and dexterity. Their music principally consists in the singing of ballads, with the guitar as accompaniment. The bull-fight is still the great national amusement, and is carried on in precisely the same manner as formerly: horsemen or picadors, assisted by others on foot, attack the bull with spears, the *coup de grace* being given by the matador, a footman, who plunges a sword into its spine between the head and shoulders. The Spanish theatre has very much declined, and the performances are generally very insipid. The pleasures of society are chiefly sought at evening parties, where only slight refreshments are presented; and indeed, both in eating and drinking, the Spaniards are remarkably temperate, perhaps more so from an habitual necessity than from virtue. Architecture. In architecture Spain is particularly rich, the chief element being Moorish, with a mixture of Norman and Gothic. The most remarkable architectural monuments are—the Escurial, built in the Roman or Vitruvian style, in the sixteenth century; the Alhambra, built by the Moors in the thirteenth century; the Cathedral of Seville, and many other fine edifices. Spain, in comparison with Italy, has produced few great painters; but Murillo, Velasquez, Zurbaran, Luis de Vargas, and others, have achieved for their country a high place in the literature of the fine arts. There is at Madrid an Academy for Painting, Sculpture, and Architecture; and there are extensive collections of pictures at Madrid, Seville, and Valencia. During the French invasion, however, a great number of the finest specimens were carried off.

Literature. The literature of Spain, in the days of her greatness, was on a level with that of any other country in Europe; but it has since sunk to a low condition. The ballad is what the early Spanish writers most excelled in; and this is characterized by romantic fervour, frequently of an oriental character. The language is peculiarly fitted to express the dignified and the pathetic, but its solemn dignity frequently seduces the writer into bombast. No nation has such a store of ballads as the Spanish; but they are, particularly the early ones, little more than mere relations of chivalrous deeds. The wars with the Moors form the subject of an endless number of these ballads, which the chivalrous nature of the people of Spain during the middle ages brought to a state of excellence unequalled in any country in Europe. The song was the natural growth of the warlike period of Spain, and served to commemorate warlike exploits; but they were of a very simple character until the period of the conquest of Naples, when they assumed a more lyrical form. The national drama has always been peculiar, consisting chiefly of religious comedies founded on the lives of saints. There are, however, some noble comedies of an historical nature. The perfection of the intrigue is what the Spanish writers chiefly value; but their plots are constructed without any regard to the unities. The drama acquired its greatest celebrity from Lope de Vega and Calderon. In romance, Spain has accomplished much. The perfection of Spanish prose is to be found in the works of the inimitable Cervantes. After his time, and when the Bourbons ascended the throne, literature declined with the state, and may be said to have remained ever since in a similar state of inactivity. Spain possesses at the present day few writers known beyond their own country. Jovellanos on political economy, Campany in philology, Llorente in history, Moralez in mathematics, and Coello and Madoz in geography, have done much to rouse a spirit of reflection. Juan Valdez is called the Anacreon of Spain.

Authorities. Besides the authorities already mentioned, see—

Alcedo; Antillon; Argüelles; Bory de St Vincent; Bowles; Breton; Carr; Castellanos; Coello; Cortez y Lopez; D'Anville; English Cyclopædia; Gazetteers of Blackie and Fullarton; Laborde; Madoz; Malte-Brun; Mannert; Miñano; Miraplores; Moreau de Jonnes; Napier; Navarette; Portulano; Townsend; Tofiño; Urcullu, &c. (N. S.)

SPALATO, or SPALATRO, a seaport of the Austrian empire, capital of a circle in Dalmatia, about 100 miles S.E. of Zara. It stands on a small peninsula, on the north shore of the strait that separates the islands of Zirona, Solta, and Brazza from the mainland. The site of the modern town is that chosen by Diocletian as the place of his retirement after abdicating the purple. The village of Salona, about 6 miles to the north, was then a large and prosperous city, the capital of Dalmatia, and the birthplace of Diocletian himself. On the shore of a small bay rose the magnificent palace of the emperor. In form it was quadrangular, covering nearly ten acres; and within its spacious precincts stood temples and theatres, halls and porticoes; the whole being enclosed by walls flanked with sixteen imposing towers. When the Goths in the sixth century, and the Avars in the seventh, laid waste Salona, its inhabitants fled before them to the adjacent islands; and returning after the storm had passed, they found that the solid walls of the palace had alone withstood the fury of the barbarians. Within these, accordingly, they established themselves; and founded a new town, whose name, from Palatium, was corrupted into Spalato. In the middle ages the town gradually increased in size and prosperity, and spread beyond the limits of the ancient palace walls. Under the Venetians, it was at one time fortified; but, having been subsequently found indefensible, the walls and gates have been allowed to fall into decay. The market-place of the modern town was one of the halls of Diocletian's palace; the temple of Jupiter has been turned into a cathedral; and that of Æsculapius is now the baptistery of St John. The streets of the town are narrow and crooked, and the houses for the most part old-fashioned. East of Spalato stands, on a rock, the fort of Clessa, which commands the broad fertile valley leading into the interior of the country. It is strongly fortified, and commands a wide and beautiful prospect. The harbour of Spalato is large, convenient, and safe. A considerable trade is carried on, both by land and sea, in corn, oil, wine, fruits, cattle, horses, &c. The people are partly employed in fishing, and partly in the manufacture of silk, leather, woollen cloth, and other articles. Pop. 9000.

SPALDING, a market-town of England, Lincolnshire, in a fenny country on the left bank of the Welland, 34 miles S.E. of Lincoln, and 122 N. of London. It has four principal streets, and most of the houses are well built. In the centre of a large market-place stands a brick town-hall. The parish church is old, and has a fine tower and spire. Spalding contains also several places of worship for Dissenters, a theatre, alms-houses, and a grammar-school, of which the great Bentley was at one time head-master.

The river has been made navigable for small vessels up to the town; and an active trade is carried on in corn, timber, coal, wool, flax, and hemp. Spalding is connected with London by the Great Northern Railway, on which it is a station. Pop. of the parish, 8829.

SPALDING, JOHANN JOACHIM, one of the best pulpit orators of Germany, was born on the first of November 1714, at Triebsees, in Swedish Pomerania. After having studied with success at Rostock and Griefswalde, he rose through various posts until, in 1757, he was appointed first preacher at Barth. He likewise began to publish his various theological works about this period, which were received with high approbation by the German public. His fame both as an author and as an orator had become so great, that he was invited to be provost and preacher at the Nicolaikirche in Berlin, and he was subsequently chosen a member of the chief consistory. The sermons of Spalding were characterised by profound thought, animated feeling, luminous arrangement, and eloquent and forcible language. Although written at a comparatively early period in the history of the German language, they contain few words that a modern reader would wish to blot. The "Religionsedict" subsequently issued by the mystics put a check upon the free thought and free expression of Germany, and as it came recommended by royal mandate, Spalding had to resign his various offices. He went into retirement, and died on the 2d of March 1804, at the great age of 90 years. The principal of Spalding's works are: — *Ueber die Bestimmung des Menschen*, 1748; *Gedanken über den Werth der Gefühle in dem Christenthum*, 1761; *Ueber die Nutzbarkeit des Predigtamts*, 1772; *Religion, eine Angelegenheit des Menschen*, 1797; and his *Selbstbiographie*, 1804. His son, Georg Ludwig Spalding, edited the latter volume with notes. Born at Barth in 1762, the younger Spalding pursued his studies at Göttingen and Halle. After returning from a tour through Germany, Switzerland, France, England, and Holland, he returned to Berlin, and was appointed professor in 1787. He subsequently became engrossed in an edition of Quintilian which he had engaged to complete, and he refused numerous situations of more emolument and of greater influence, solely on account of this elegant old author. After spending nineteen years on it, during which time he only published 3 volumes, he died in 1811, and left his darling task to be completed by other hands.

SPALDING, *William*, an esteemed writer on logic, rhetoric, and other branches of literature, was born in 1809. He was the son of an advocate in Aberdeen, in which city he spent his youth, and received a very complete classical and philosophical education at the grammar school and in Marischal College, where he took the degree of A.M. He attended the divinity hall for two years, not with a view to entering the church, but to widen the range of his acquirements, and prolong his opportunities for study. He attained to great proficiency in the learned languages, and loved the study, which he held to be an excellent discipline for exercising the powers of the youthful mind, and a good foundation for the highest species of mental culture at a later period. In this, and in all the other divisions of the curriculum of arts, he was a bright example of unwearied diligence, and of the success which attends it. Well aware at the same time of the vast utility of those modern tongues, which along with our own are the great repositories of scientific and philosophic thought, he acquired a thorough knowledge of French, Italian, and German, was able to converse in either of these languages, and made himself familiar with the classic authors, both in poetry and prose, of all the three. In the end of 1830 he came to Edinburgh, and went into the office of Carnegie and Shepherd, writers to the signet, with whom he remained till he was called to the bar in the summer of 1833. In that year he published a *Letter on Shakspeare's authorship of the Two Noble Kinsmen*, a drama commonly ascribed to John Fletcher. The intimate knowledge of the old dramatists displayed in this *brochure*, and the critical acumen with which the great poet's share in the play (for it was a joint performance) was traced out, and separated from the heavier work of his coadjutor, Fletcher, attracted the notice of Jeffrey, and was followed by an invitation to Mr Spalding (of which he afterwards availed himself) to become a contributor to the *Edinburgh Review*. But his thoughts had often been occupied with the project of a tour on the continent, which he resolved to carry into effect before settling down to the business of the bar. He commenced his journey in the summer of 1833, passed a short time in Paris, thence proceeded by Geneva and the Pass of the Great St Bernard to Turin, Milan, Genoa, Florence, and Rome. After a minute exploration of the ancient capital, he went on to Naples, crossed the Apennines to Ancona, visited Bologna, Mantua, Venice; then crossed the eastern Alps by Inspruck, spent some time in Leipsic and Berlin, and returned home by Hamburg, after an absence of fifteen months.

The fruits of his sojourn beyond the Alps were given to the public in 1841, in 3 vols., under the title of *Italy and the Italian Islands, from the Earliest Ages to the Present Time*. It is such a book as only a man of rare acquirements could have written; nor is it perhaps too much to say, that, in proportion to its scale, it is the most complete account of all that is interesting in the annals and the ancient and modern condition of any one country that has appeared in recent times. To judge of its merit, we must keep in view the comprehensiveness of its plan. It embraces history, antiquities, topography, literature, art, laws, religion, politics, morals, biographical sketches of illustrious men, &c.; and each of these topics has a triple treatment—first for the ancient epoch, next for the middle ages, and, thirdly, for modern times. The amount of erudition, the wide range of reading, the knowledge of art required to carry out such a plan, is not easily estimated. And no subject is handled superficially; no statements or opinions are taken on trust; and his remarks on subjects the most diverse—on scenery, architecture, painting, national character, manners, literary works, —all bear the impress of an original and richly-stored mind. Indeed, the only fault of the book arises from the compression forced upon him by the wide variety and superabundance of good matter it contains, a compression which sometimes deprives his best ideas of their due relief. The book went through five editions in a few years. Of his contributions to the *Edinburgh Review* we have not a very accurate record. The first of which we can speak with certainty was an article on Darley's edition of Beaumont and Fletcher's works, which appeared in the number for April 1841. It is a masterly sketch of the history of the English drama from Marlowe to Fletcher, and bespeaks an extent of reading in these old authors, and an appreciation of their spirit and their distinctive merits, which could only have been gained by a minute and patient study of their works individually. Perhaps his partiality for the Greek dramatists led him to this as a kindred subject; and no doubt he was also attracted by the rich mine of poetical thought these works afford and the copious light they throw on the manners of the period. It must be remembered, that about the end of the 15th century the drama absorbed the activity of the first minds in England, and its history was to no small extent the history of English literature. "It was the favourite vehicle," as he observes, "of public sentiment, and every other walk of the poetic art was deserted in favour of it. All men wrote plays who could write at all, and many wrote indifferent plays who might have attained eminent success in other departments of poetry." In 1845 he contributed to the same journal an elaborate review of the two

Spalding. valuable editions of Shakspeare's works published by Mr Charles Knight and Mr Payne Collier. It is a very able disquisition on the many difficult questions that have been mooted respecting the text of the plays; the varieties in the different editions, and the sources of those varieties; how far they were alterations made by the poet himself, how far suppressions or interpolations introduced by others; how far the blunders of careless transcribers, or the worse blunders supposed to be committed by piratical reporters, who took down the plays from the mouths of the actors in Shakspeare's own theatre. These and many other points are discussed with a sagacity and a range of information which inspire full confidence in the conclusions come to. Such investigations are not idle exercises of ingenuity. The poet's reputation is national property; and it is satisfactory to know that we have the plays almost exactly as he left them; that the corruptions due to would-be improvers of the text are neither numerous nor important; that "for almost everything that is grossly faulty, no less than for all in them that is superlatively excellent, the poet himself must stand solely accountable;"—further, that he was not the hasty and careless writer some have supposed; that "several of his dramas were subjected by himself to a process of alteration, which is not adequately described unless we call it re-writing; and that several others, though not changed so materially, received from his hand verbal corrections so numerous, so careful, and so characteristic, as to be even a more unequivocal proof than re-writing would have been, of modest, thoughtful, patient industry." We know only of two other articles from his pen in the *Edinburgh Review;* on Glassford's *Translations from the Italian Lyric Poets*, and on Sir E. Bulwer Lytton's poem of *King Arthur*. They are less elaborate than his reviews of the dramatists, but spirited and graceful.

To *Blackwood's Magazine* he contributed, in November 1835, a picturesque and amusing narrative of his journey across the Apennines, entitled *Eight Days in the Abruzzi*. In *Tait's Magazine* he was the author of a review of *Burke's Correspondence; Maitland on the Dark Ages; Thiers' History of France under Napoleon; La Motte Fouqué's Theodolf; Life of Aretino; Michelet's Priests, Women, and Families;* two tales from the German of Tschokke, and probably some others. In 1853 he published *The History of English Literature*, a concise outline of the origin and growth of the English language, which has had a very extensive sale. Mr Spalding supplied above fifty biographical notices to the supplement of the *Penny Cyclopædia*, including the names of Arminius, Gauden, Greene, Galt, Gillies, Mitford, &c., and a number to this *Encyclopædia*, including Addison, Bacon, Demosthenes, Sir Walter Scott, &c. He likewise wrote the articles Logic and Rhetoric for this work. In the composition of the former, Mr Spalding adopted hints from the German authorities, from the excellent treatise of Mr Mill and from Sir William Hamilton; but the work as a whole is highly original, and far in advance of any manual hitherto published in this country. Its merit was acknowledged in complimentary letters from high authorities in England and Germany. The article Rhetoric is in substance a theory of literature, and contains much that is new both in form and matter. The first part is psychological, and deals with the faculties exercised in the action of mind on mind. The second consists of an analysis of the processes which constitute the art of eloquence. Both treatises are profound, and severely scientific in form. Mr Spalding seemed eminently fitted for the labours of the bar by his careful study of the law, his singular acuteness and readiness, and great powers of application. But his success did not correspond to his expectations, and perhaps his proud and fastidious spirit saw something in the means by which unpatronised men like himself often rise into extensive practice to which he was averse. Probably from some such motives, when Mr Moir resigned the chair of rhetoric in the University of Edinburgh in 1838, he became a candidate for it and was successful. He resigned it in 1845, when he was appointed professor of logic in the University of St Andrews, and in this situation he remained till his death on the 16th November 1859. His natural abilities, which were of a high order, were improved by an excellent education in his youth, and by unwearied study in after life. His apprehension was quick, his memory tenacious, and in the pursuits to which he gave his mind no amount of labour deterred him. Hence the wide range and the solidity of his acquisitions. What he knew he knew accurately, and could avail himself of readily. His style is distinguished by clearness, precision, and purity; it is rarely ornate, never ambitious or florid. As a teacher he devoted himself to his duties with an amount of zeal and industry rarely exemplified, sparing neither himself nor his pupils; or as one of them expressed it, "No Scotch professor ever did so much work for his students, or obtained so much work from them." With the quick feeling of honour which belongs to a gentleman, he united a deep sense of religion; and in all the private relations of life, as a husband, a father, and a friend, he was an exemplary man. He fell a victim to disease of the heart in his fifty-first year, and with all his faculties in full vigour, leaving a widow and four children. (C. M.)

Spallanzani. SPALLANZANI, Lazaro, a celebrated naturalist, was born at Scandiano, in the duchy of Modena, on the 12th January 1729. He began his studies in his native country, and at the age of fifteen went to Reggio de Modena, where he was instructed in rhetoric and philosophy by the Jesuits, who contended with the Dominicans in order to secure his attachment. His thirst for knowledge determined him to go to Bologna, where his relative Laura Bassi, a woman highly celebrated for her genius, eloquence, and skill in natural philosophy and mathematics, was one of the most distinguished professors of Italy. Under this enlightened guide, he was taught to prefer the study of nature to that of her commentators, judging of the real value of the commentary by its resemblance to the original. He availed himself of the wisdom of that lady's counsels, the happy effects of which he very soon experienced. Spallanzani's taste for philosophy was not exclusive, for he carefully studied his own language, became a proficient in the Latin tongue, and attached himself above every other to the Greek and French. By the advice of a father whom he ardently loved, he applied himself to jurisprudence; but being urged by Antonio Vallisnieri to renounce his vocation, by procuring the consent of his father, he gave himself up to the study of mathematics with more zeal than ever, at the same time devoting himself to the study of languages, both living and dead.

It was not long before he was known all over Italy, and, what is seldom the case, his own country first made that estimate of his talents which they justly merited. In the year 1745, he was chosen professor of logic, metaphysics, and Greek, in the University of Reggio, where he taught during ten years, devoting every moment of his leisure to the study and contemplation of the works of nature. The attention of Haller and Bonnet was fixed by his observations on the animalculæ of infusions, the latter assisting him in his laudable career, and ever after distinguishing him as one of the learned interpreters of nature. He was invited to the University of Modena in 1760; and some years after he declined to accept of the advantageous offers made to him by the Academy of St Petersburg, as well as similar ones from Coimbra, Parma, and Cesene. He preferred his native spot, and therefore continued at Modena till the year 1768, and saw raised up by his care a generation of

men constituting at that time the glory of Italy, among whom we find Venturi, Belloni, Luchesini, and Angelo Mazzo. In 1765, while he resided at Modena, he published his *Saggio di Osservazioni Microscopiche concernenti il Sistema di Needham e di Buffon;* in which he establishes by a number of the most ingenious and solid experiments, the *animality of microscopic animalculæ.* This work was sent by the author to Bonnet, who drew from it a prediction respecting the future celebrity of Spallanzani, which he lived to see accomplished. This circumstance gave birth to the most intimate friendship, which lasted till the close of life, and constituted their chief happiness. During the same year he published a truly original work, entitled *De Lapidibus ab Aqua resilientibus;* in which he proves, by the most satisfactory experiments, and in opposition to the commonly received opinion, that what are called *ducks and drakes,* are not produced by the elasticity of the water, but by the effect naturally resulting from the change of direction experienced by the stone in its movement, after it has struck the water, and has been carried over the hollow of the cup formed by the concussion.

When the University of Padua was re-established upon a larger scale, the Count de Firmian was directed by the Empress Maria Theresa to invite Spallanzani to be professor of Natural History, although the chair was solicited by many celebrated characters. His reputation justified this preference, and immense crowds of students thronged to his lectures. He possessed much ingenuity, and his knowledge was of vast extent: his method was simple, but rigorous in its nature, and what he knew he connected with principles firmly established.

In the year 1776 he published, in two volumes quarto, his work entitled, *Opuscoli di Fisica Animale e Vegetabile,* containing the explanation of part of the microscopic observations which were previously given to the world. It must be admitted, that the art of accurate observation is one of the most difficult, and it cannot be denied that it is at the same time the most necessary, and requires a rare combination of talents. These were possessed by Spallanzani in a remarkable degree, as is fully evinced by the researches which his admirable writings have recorded. The polite manner in which he conducted his dispute with Needham respecting the phenomena of generation, secured for him a high degree of applause. On this occasion, he treated of the influence of cold upon animals, and proved that the torpidity of some during winter does not depend on the impression which the blood may receive from it, since a frog deprived of blood becomes torpid when reduced to the same cold state, by being immersed in ice, and swims, as formerly, when restored to a proper degree of warmth. Spallanzani travelled through Switzerland and the Grisons, in the year 1779, after which he went to Geneva, spending a month with his friends, by whom his conversation was not less admired than his masterly writings. In the year 1780, he published, in two volumes quarto, his *Dissertazioni di Fisica Animale e Vegetabile,* in which he unfolded the secrets of the interpretation of two very intricate phenomena concerning the economy of animals and vegetables. To this study he was led from some experiments made by him upon digestion; and he repeated the experiments of Reaumur on gallinacious birds, remarking, that the trituration, which, in this case, is favourable to digestion, could not be a very powerful means. He perceived that the gizzard of those birds, by which the stones of fruit are pulverized, did not digest the powder thus formed; it being necessary that it should undergo a new operation in the stomach, previous to its becoming chyle, for the production of the blood and other humours. This subject may be regarded as one of the most difficult in physiology, because the observer is always under the necessity of finding his way in the midst of darkness: the animal must be managed with care, that the derangement of the operations may be avoided; and when the experiments are completed with great labour it is requisite that the consequences be well distinguished. In this work Spallanzani analyses facts with scrupulosity, in order to ascertain their causes with certainty; comparing nature with his experiments, in order to form a correct judgment respecting them; laying hold of everything essential to them in his observations, and measuring their solidity by the increase or diminution of supposed causes. John Hunter appears to have been greatly hurt by this work; and in the year 1785 he was induced to publish *Some Observations upon Digestion,* in which he throws out some bitter sarcasms against the Italian naturalist. Spallanzani took ample revenge by publishing this work in the Italian language, and addressing to Caldani, in 1788, *Una Lettera Apologetica in Risposta alle Osservazioni del Signor Giovanni Hunter.* Here he exposed with great moderation, but at the same time with logic which nothing could resist, the mistakes and errors of the British physiologist.

The generation of animals and plants is discussed in the second volume of his *Dissertazioni;* where, by experiments as satisfactory as surprising, he proves the pre-existence of germs to fecundation, showing also the existence of tadpoles in the females of five different species of frogs, in salamanders and toads, before their fecundation. He likewise recounts the success of some artificial fecundations upon the tadpoles of those five species, and even upon a quadruped.

In the year 1781, he took the advantage of the academical vacation for the purpose of making a journey, in order to add to the cabinet of Pavia. In the month of July he set out for Marseilles, where he began a new history of the sea, which presented him with many new and curious facts on numerous genera of the natives of the ocean. He went also to Finale, Genoa, Massa, and Carrara, to make observations on the quarries of marble, held by statuaries in such estimation. He then returned to Spezzia, and brought from thence to Pavia a vast number of fishes, which he deposited in the cabinet of that city, wholly collected by himself. With the same view and success he visited the coasts of Istria in 1782, and the Apennine mountains the subsequent year, taking notice of the dreadful hurricanes and the astonishing vapours by which that year became so noted in meteorology. The Emperor Joseph, on examining this cabinet, presented Spallanzani with a gold medal. In 1785, he was offered the chair of natural history by the University of Padua, vacant by the death of Antonio Vallisnieri; but in order to prevent his acceptance of it, his salary was doubled by the Archduke; and he went to Constantinople with Zuliani, who had been appointed ambassador from the Venetian Republic. He set out on the 21st of August, and on the 11th of October reached the Turkish metropolis, where he remained during eleven months. His attention was fixed by the physical and moral phenomena of this country, which were new even to Spallanzani. He wandered along the borders of the two seas, and ascended the mountains in the vicinity; he paid a visit to the island of Chalki, discovering to the Turks a copper-mine, the existence of which they had never once conjectured. In the island of Principi, not far from Constantinople, he discovered an iron-mine, of which the Turks were equally ignorant.

A voyage by sea was undoubtedly the safest, but the dangers to which he would be exposed by land were regarded as nothing when contrasted with the idea of being beneficial to science and to man. Having reached Bucharest, Mauroceni, the friend of science, received Spallanzani with marks of distinction, presented him with many rarities which the country produced, and supplied him with horses for travelling, with an escort of thirty troopers, to the confines of

stances are narrated under Attica. We come now to the events which led to the Persian war. When applied to for
B.C. 501. assistance by the Ionian Greeks in their revolt against Darius, the Spartans refused to aid them; but afterwards, when the Persian monarch sent to demand the submission of Greece to his authority, they joined with their countrymen in rejecting the demand with contempt, and thus became involved equally with the Athenians in hostility against Persia. When the confederacy was first formed against the Persians, the supremacy was admitted even by Athens to belong to Sparta; for when the Aeginetans gave into the demands of Darius, the Athenians sent to Sparta to accuse them of betraying the common cause. A jealousy, however, soon grew up between Sparta and Athens, and the narrow and often selfish policy of the former tended to widen the breach. In the first Persian invasion, they permitted the
B.C. 490. Athenians single handed to meet and conquer the enemy at Marathon, being prevented, as they said, from sending aid in time by having to wait for the time of full moon. As a similar delay afterwards occurred on another critical occasion, one may be permitted to suspect that it was not in either case due wholly to superstition. In the invasion of
B.C. 480. Xerxes, Sparta played a much more conspicuous part in defence of Grecian liberty; though even then the only engagement whose glory belongs exclusively to them was that of Thermopylæ; and this celebrated battle, with all the courage which it displayed, was productive of no good results. The Persians were advancing with an immense host through Macedonia and Thessaly against Greece. The only spot where it could be hoped to make any effectual resistance to their advance was the pass of Thermopylæ, between the eastern extremity of Mount Oeta and the Malian Gulf. To the north-east, the pass expanded into a small plain in which stood the town of Trachis, where Xerxes was encamped during the battle. The force with which Leonidas undertook to defend this pass consisted only of 300 Spartans, 400 Thebans, and from 8000 to 11,000 allies from the other states.

Xerxes advancing near the pass, was surprised to find that the Greeks were resolved to dispute his passage; for he had always flattered himself, that on his approach they would betake themselves to flight, and not attempt to oppose his innumerable forces. He waited four days without undertaking anything, on purpose to give them time to retreat. He then ordered them by a herald to deliever up their arms. Leonidas, in a style truly laconical, answered, "Come and take them." Xerxes, transported with rage at this reply, commanded the Medes and Cissians to march against them, seize them alive, and bring them to him in fetters. These troops, unable to break the ranks of the Greeks, soon betook themselves to flight. In their room, Hydarnes was ordered to advance with that body which was called *Immortal*, and consisted of 10,000 chosen men; but when these assailed the Greeks, they succeeded no better than the Medes and Cissians, being obliged to retire with great loss. The next day the Persians made another attack; but with all their efforts they could not make the Greeks give way, and, on the contrary, were themselves put to a shameful flight. Having lost all hope of forcing his way through troops that were determined to conquer or die, Xerxes was extremely perplexed and doubtful what measures he should adopt, when one Ephialtes, in expectation of a great reward, came to him, and pointed out a circuitous path which led to the rear of the Spartan forces. The king immediately ordered Hydarnes, with a select body of Persians, to follow this path by night, and attack the Greeks from behind. The Phocians who had been set to guard this important route were taken by surprise, and retired with precipitation to the very top of the mountain. But Hydarnes, neglecting to pursue them, marched down the mountain with all possible expedition, in order to attack in the rear those who defended the straits. Leonidas, being apprised of the treachery of Ephialtes, and perceiving that there was no longer any hope of success, advised his allies to retire, though he conceived that he himself and the Spartans could not with honour retreat. With this advice they all complied except the Thebans, who were detained by Leonidas as hostages, for they were suspected to favour the Persians, and the Thespians, who could not be prevailed upon to abandon Leonidas. Xerxes, after pouring out a libation at the rising of the sun, began to move with the whole body of his army, as he had been advised by Ephialtes. Upon their approach, Leonidas advanced to the broadest part of the pass, and fell upon them with undaunted courage and resolution. Great numbers of the enemy falling into the sea, were drowned; others were trampled under foot by their companions, and very many killed by the Greeks; who, knowing they could not avoid death upon the arrival of those who were advancing to fall upon their rear, made prodigious efforts of valour. In this action fell the brave Leonidas; on which Abrocomes and Hyperanthes, two brothers of Xerxes, advanced to seize his body, and carry it in triumph to Xerxes. But the Lacedæmonians, more eager to defend it than their own lives, repulsed the enemy four times, killed both the princes, with many other commanders of distinction, and rescued the body of their beloved general out of the enemy's hands. But in the meantime, as the troops, guided by Ephialtes, were advancing to attack their rear, the surviving Greeks retired to the narrowest part of the pass, and all drawing together, except the Thebans, who laid down their arms, posted themselves on a rising ground. In this place they made head against the Persians, who assaulted them on all sides, till at length, overwhelmed by numbers, they all fell, except one, who escaped to Sparta. Some time after, a monument was erected at Thermopylæ in honour of those brave defenders of Greece, with two inscriptions; the one general, and relating to all those who died on this occasion, importing that the Greeks of Peloponnesus, only 4000 in number, fought against the Persian army, consisting of 3,000,000. The other related to the Spartans in particular, and was composed by the poet Simonides, in these words:—"Go, traveller, and tell the Spartans that we lie here in obedience to their laws."

The Persian host now advanced, without further opposition, into the heart of Greece, ravaging Phocis, Bœotia, and Attica. The fate of Athens is narrated in the article Attica. The Spartans at this time declined to send any forces to resist the enemy in Northern Greece, and confined their efforts to the defence of the Peloponnese. Meanwhile, however, the combined fleet, under Eurybiades, a Spartan, encountered the Persian armada near Artemisium, in the strait between Eubœa and the mainland. This engagement proved indecisive; but soon afterwards the great naval victory of Salamis was gained, chiefly by the conduct of Themistocles and the services of the Athenian ships, which formed the greater part of the fleet. This was the first decisive check which the Persians received. Xerxes, with the fleet, was obliged to take to flight, leaving only his army under Mardonius to effect the conquest of Greece. The Spartans were at length roused by the remonstrances of the Athenians to make an effort for the expulsion of the Persian army from Northern Greece; and in 479 despatched a force of 40,000 men under Pausanias for that purpose. B.C. 479.
No sooner did Mardonius hear of this movement than he withdrew from Attica, where he had previously been encamped, and pitched his camp on the Asopus in Bœotia. Pausanias continued his advance, and was joined at Corinth by the forces of the other Peloponnesian states, and at Eleusis by those of Athens under Aristides. He then took up a strong position on the Asopus, near Platæa, opposite the Persian camp. For some days the two armies

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remained in sight of each other, engaged in manœuvres and skirmishes, marching and countermarching, but without coming to a general engagement. The decisive battle of Platæa was at length brought on more by accident than design on either side. Its issue remained doubtful, till the Persian general fell in heading a charge of cavalry. On this the whole army took to flight, and were pursued by the Greeks, who, after a tremendous carnage, seized upon the camp, with all its stores and treasures. This victory for ever delivered Greece from the danger of Persian invasion. The broken remains of the great army immediately began to retreat; and their return to Asia forms one of the most disastrous episodes in the whole course of ancient history. Not content with self-defence, the Greeks, emboldened by their success, prosecuted the war with Persia on the coasts of Asia Minor, with a view to the emancipation of the Ionian cities in that country. The victory of Mycale was gained by the combined fleets on the same day as that of Platæa. Pausanias was soon after appointed to the command of the naval forces of the confederacy; and in this capacity he first conquered Cyprus, and afterwards took Byzantium from the Persians. But as he became elated with his success, his proud and overbearing conduct excited the jealousy of the allies, and they all, with the exception of the Peloponnesian states, called upon the Athenians to accept the supremacy in the confederacy instead of the Spartans. The latter thereupon withdrew altogether from the war, and their ascendency was thenceforth confined to the Peloponnese, which still remained firm in its adherence to Sparta. B.C. 477.

From this period the growing jealousy and opposition between Sparta and Athens began more openly to break out, until at length the two states were engaged in deadly war with one another. In 465, the Spartans were on the point of invading Attica, at the solicitation of the Thasians, when their design was cut short by an alarming and dangerous event, which led to the outbreak of the third Messenian war. B.C. 464. A most dreadful earthquake happened at Sparta, in which, according to Diodorus, 20,000 persons lost their lives; and Plutarch avers that only five houses were left standing in the whole city. On this occasion the Helots, descended from the ancient Messenians, attempted to regain their liberty, by making an assault on the city, in hopes of gaining the upper hand in the confusion, and cutting off all who had escaped from the earthquake. But their attempt was defeated by the prudence of the Spartan king Archidamus, who, aware of the impending danger, and observing that the citizens were exposing themselves to an attack in their anxiety to preserve their property, caused the alarm of war to be sounded. On this the citizens armed themselves in haste with such weapons as they could lay hold of; and meeting the insurgents a little way from the city, by their superior discipline compelled them to retire. The latter, however, knowing that they had now no mercy to expect from those who had already treated them with such cruelty, resolved to defend themselves to the last. Having therefore seized upon their old stronghold Ithome, they from thence made such incursions into the Spartan territories that they compelled their imperious masters to ask assistance from the Athenians. This was immediately granted; but the consciousness of their own bad faith led them to suspect that of the Athenians, whom they in consequence dismissed, while retaining the services of all their other allies. On this the Athenians left them in disgust, and allied themselves with the Argives against Sparta. In 457 they attempted to intercept a Spartan army returning from an expedition to Doris, but were totally defeated at Tanagra. Meanwhile, as the Messenians did not venture to come to an engagement with a Spartan army in the field, but took shelter in their fortified places, the war was protracted for nearly ten years. In 455 the Athenian fleet, under Tolmides, sailing round the Peloponnese, burned the Spartan arsenal at Gythium, and received the fugitive Messenians, who had at last been compelled to surrender Ithome. These were then settled at Naupactus, which the Athenians had recently gained, and there they proved steadfast allies of Athens, and constant foes to Sparta. B.C. 455. Thus ended the third and last of the Messenian wars. The war with Athens, however, still continued, until, by the influence of Cimon, the leader of the aristocracy in that city, who had been recalled from banishment about this time, a truce for five years was concluded in 450. B.C. 450. On the expiration of this truce, the Spartans invaded Attica, and had penetrated as far as Eleusis, when they suddenly retired, induced, it is said, by bribes from Pericles. B.C. 445. After this a peace was concluded for thirty years, in terms more favourable to Sparta than those of the former. But this peace did not last unbroken for half the time contemplated; for, in 431, the Peloponnesian war broke out, B.C. 431. and during the twenty-seven years of its continuance, Greece was almost without intermission torn by a deadly struggle between her most powerful states. The allies and dependants of Sparta in this war comprised the whole of the Peloponnese, except Argos and Achaia; and in Northern Greece, Thebes, with the greater part of Bœotia; the Opuntian Locrians, Phocians, Dorians, Ætolians, and the Corinthian colonies in the north-west. For an account of the origin and course of the war see ATTICA. Towards the close of this war Sparta had received much assistance from the younger Cyrus, son of Darius, the Persian monarch, and satrap of Lydia, Phrygia, and Cappadocia. In return for this, when Cyrus meditated an expedition to dethrone his brother Artaxerxes, he obtained the aid of 10,000 Spartan soldiers. The expedition failed by the B.C. 401. defeat of Cunaxa, in which Cyrus fell, and the Greek generals were soon after treacherously slain; but Xenophon, an Athenian, conducted safely the celebrated retreat of the Greeks, of which he has left a narrative. The Ionian cities which had supported Cyrus, refusing to submit to his successor Tissaphernes, applied for assistance to Sparta, and thus led to a new Persian war. Under the command of B.C. 399. Thimbron, and afterwards of Dercyllidas, the Spartan forces gained great successes; and after Agesilaus took the command, B.C. 396. they very nearly overthrew the Persian Empire. But the career of this victorious general was cut short by the intrigues of the Persian satrap Tithraustes, who succeeded in raising a confederacy between the Thebans, Athenians, Corinthians, and Argives, against Sparta, and thus causing what has been called the Corinthian war. The Spartans, B.C. 395 under Lysander, invaded Bœotia, but suffered a total defeat at Haliartus, where their general fell. Agesilaus was then recalled from Asia; and returning, completely turned the fortune of the war by his victory at Corinth in 394, and soon after by that of Coronea. But the naval power of Athens was re-established by the victory of Conon at Cnidus; and in the subsequent course of the war the prestige of the Spartan arms was much weakened by the defeat of her troops by Iphicrates. Both parties were at length desirous of peace, which was concluded in 387, through the B.C. 387. intervention of Persia. This, which is known as the peace of Antalcidas, was on the whole favourable to Sparta; and about this time that nation had attained the highest pitch of power which it ever reached.

By the peace of Antalcidas the Thebans were deprived of the government of Bœotia, which they had for a long time enjoyed, and they were so much provoked that at first they absolutely refused to accede to the treaty; but as Agesilaus made great preparations to attack them, they at last thought proper to comply. It was not, however, long before a new war commenced, which threatened the total subversion of the Spartan state. As, by the peace of Antalcidas, the King of Persia had in a manner guaranteed the sovereignty of Greece to Sparta, this republic very soon

B.C. 385. began to exercise its power to the utmost extent. The Mantineans were the first who felt the weight of their resentment, although they had been their allies and confederates. In order to find a pretext for making war against them, they commanded them to quit their city, and to retire into five old villages, which, they said, had served their forefathers, and where they would live in peace themselves, and give no umbrage to their neighbours. As they refused to obey, an army was sent against them to besiege their city. The siege was continued through the summer with very little success on the part of the Spartans; but having, during the winter season, dammed up the river on which the city stood, the water rose to such a height as either to overflow or throw down the houses; and the Mantineans were thus compelled to submit to the terms prescribed to them, and to retire into the villages. The Spartan vengeance next fell on the Phliasians and Olynthians, whom (B.C. 379.) they forced to agree to such measures as they thought proper. After this they assailed the Thebans, and, by attempting to seize on the Piræus, drew the Athenians also into the quarrel. But here their career was arrested: the Thebans had been taught the art of war by Chabrias the Athenian; so that even Agesilaus himself took the command of the Spartan army in vain. At sea they were defeated by Timotheus the son of Conon (B.C. 376.); and by land the battle of Leuctra (B.C. 371.) put an end to the superiority which Sparta had so long retained over Greece. After this dreadful defeat, the Spartans had occasion to exert all their courage and resolution. Agesilaus, by his prudent conduct, kept up the spirits of the people, at the same time that by his skill in military affairs he checked the progress of the enemy. Yet, during the lifetime of Epaminondas, the Theban general, the progress of the war was greatly to the disadvantage of the Spartans; but after his death at the battle of Mantinea (B.C. 362.), all parties soon became desirous of peace. In the peace concluded in the following year, the independence of Messenia was recognised; and though Sparta at first refused to acknowledge it, she never regained her ancient dominion. Agesilaus did not long survive; and with him, we may affirm, perished the glory of Sparta. Soon after this all the states of Greece fell under the power of Philip of Macedon, who invaded Laconia after his victory at Chæronea in 338. (B.C. 268.) The Spartans, however, maintained their ground with great resolution against the celebrated Pyrrhus king of Epirus, whom they repulsed for three days successively, though not without assistance from one of the captains of Antigonus. Soon after this one of the kings of Sparta, named Agis, perceiving the universal degeneracy that had taken place, made an attempt to restore (B.C. 240.) the laws and discipline of Lycurgus, by which he hoped the state would be restored to its former glory. But though at first he met with some appearance of success, he was in a short time tried and condemned by the ephors as a traitor to his country. Cleomenes, however, who ascended the throne in 216 B.C., accomplished the reformation which Agis had in vain attempted. He suppressed the ephoralty; cancelled all debts; divided the lands equally, as they had been in the time of Lycurgus; and put an end to the luxury which prevailed among the citizens. Cleomenes also gained several victories over the Achæan league, and conquered a large part of the Peloponnese; but Antigonus Doson, king of Macedonia, who had been summoned to the aid of the Achæans, totally (B.C. 221.) defeated him in the battle of Sellasia. The Spartan king then fled to Egypt, where he put an end to his own life. With him perished every hope of retrieving the affairs of Sparta; the city fell into the hands of Antigonus, after which a succession of tyrants gained and lost the ascendency, till at last all disturbances were ended by the Romans, (B.C. 146.) who reduced Greece to the condition of a province.

It only remains to make some observations on the national character, manners, and customs of the Spartans, which, as they were at once the cause and the result of the peculiar constitution of the country, may best be learned from a view of that constitution. It might seem, on first sight, a singular circumstance that the government of Sparta, which was constantly at the head of the aristocratic party in Greece, should exhibit what appears to be a very popular character. But this apparent anomaly disappears when we remember that the population of Laconia consisted of three very different classes—the Spartans, or governing class; the Periœci, or subjects; and the Helots, or slaves. The fundamental principles of the constitution were two—the superiority of the Spartans over both the other classes, and their equality among themselves. Thus the government, instead of being at all popular, was a very narrow oligarchy; for none of the inferior orders had any political privileges whatever, and, in ordinary circumstances, none could ever rise from a lower to a higher class. The Spartans themselves were divided into three clans or families, and these again were subdivided into thirty lesser divisions called *obes;* but these distinctions, though founded on descent, did not imply any difference in rank or privileges; the only inequality among the ruling class being the hereditary right to the crown, which belonged to the two families of the Heraclidæ. And though in Sparta, alone of the Greek states, the kingly form of government was permanently retained, it was very much limited by the other parts of the state. The sovereign power ultimately resided in the assembly of the people, held periodically in a field near the city; and in it every Spartan, without respect to birth or wealth, had an equal voice. This assembly had the right of filling all the elective offices in the state, of electing the Gerusia or senate, and of accepting or rejecting the proposals made to it by the magistrates. They had the ultimate decision of all questions about peace and war, treaties, taxes, changes in the constitution, and disputes about the succession to the throne. The Gerusia, or council of elders, consisted of thirty members, two of which were the kings, while the others were elected by the popular assembly in a singularly primitive fashion. The candidates, whose only qualification was to be above sixty, came forward successively to the assembly, and were chosen according to the amount of applause they received, as judged by persons shut up in a neighbouring room. The duties of the senators, who held office for life, were to prepare measures for the popular assembly, and to exercise criminal jurisdiction. In this body the kings had no greater authority than their colleagues; but they presided in a tribunal for civil affairs, they were the high-priests of the nation, and shad the command of the armies. Of the inferior magistrates little is known, with the exception of the ephors, who at one time rose to the highest power in the state. Their number was five, and they seem to have first come into prominence at a period subsequent to that of Lycurgus. It is not improbable that their power was either conferred or greatly increased at the time of the conquest of Messenia, when a new body of citizens seems to have been admitted, and, like the Roman tribunes, whom they resembled in many respects, they may have been representatives of the newly admitted and at first inferior citizens. They engrossed the greater part of the civil jurisdiction, which had before belonged to the kings; and they had the power even to control the royal proceedings.

The great prevailing principle of the Spartan institutions was the subordination of the interests of the individual to those of the community: the citizen was to live only for the state; all his wealth, powers, time, and if need be his life itself, were to be given up to its service. This state of things was the necessary result of the position of the Spartans in the country they had conquered; a mere handful of men compared with the numbers of their subjects

Sidenotes (right margin): Spartan constitution. — Divisions of the people. — The popular assembly. — The gerusia. — The kings. — The ephors. — Manners and institutions.

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and slaves, who were of a wholly distinct and even hostile race. To this cause must be ascribed the martial character of the training to which every Spartan was subjected. From their very birth all the children were considered to be the property of the state, and though left to the care of their parents till their seventh year, they were from that time onwards put under a course of public discipline, gradually increasing in severity, and having for its one object to make them perfect soldiers. This training continued till the age of thirty; and even after that time they were liable to military service until they were sixty. The public meals (*syssitia*) and hard fare of the Spartans are well known, and may be traced back to the same general principle as their other institutions. Industry and commerce were very far from being encouraged at Sparta; all agriculture, manufactures, and trade being considered unworthy the attention of the free-born citizen, and left to the inferior classes. The only legal currency was of iron, a restriction which, if it was intended to discourage the love of money, most signally defeated its own end, for there were no vices to which the Spartans were more prone than those of venality and avarice. A remarkable feature of Spartan society was the much greater freedom allowed and respect paid to women, than in any other of the Greek states. In this matter they probably retained very much of the old manners of the heroic age.

Spartan character.

The national character of the Spartans exhibited many shining virtues, such as unwavering patriotism and public spirit, dauntless courage and endurance, a primitive simplicity of life and tastes, indefatigable perseverance, and a temper submissive to the laws of the state; but these were balanced by equally glaring faults, overbearing pride and narrow-minded exclusiveness, avarice, duplicity, and a total disregard of honour and uprightness in their dealings with foreign states. The uniformity of training to which they were all subjected naturally discouraged any great or original genius, and hardly any Spartan was ever celebrated in arts or literature, science or philosophy. All the great names of which she can boast, as those of Leonidas, Pausanias, Brasidas, Lysander, and Agesilaus, were distinguished solely for military genius, and even in their own sphere were equalled by many of the citizens of her more illustrious rival Athens. But although in reading the history of Greece our sympathies are irresistibly drawn to the side of Athens, it should be remembered that one important phase of the Grecian character is most fully exhibited in the Spartan institutions and history.

City of Sparta.

With regard to the city of Sparta, the remark of Thucydides, that if it were destroyed, posterity would have some difficulty in inferring the power of the nation from the extent of the remains that would be left, has proved prophetical; for of Sparta it might be said at the present day, with almost as much truth as of Troy long ago, "*etiam periere ruinæ.*" The city, like that of Rome, was built on a series of small hills, connected with the chain of Taygetus, and on the plain to the south-east, between these hills and the Eurotas. It was originally formed by the union of four earlier hamlets, Pitane, Limnae, Mesoa, and Cynosura, and it was never a very compactly built place, but always retained its original gardens, plantations, and other characteristics of village life. Pitane, which was the most fashionable quarter of the town, lay farthest north; Limnae lay along the bank of the Eurotas; Mesoa probably occupied the extreme south-east, and Cynosura the extreme south-west. In the midst of these different quarters stood the acropolis and market-place of Sparta. In the former the principal building was the temple of Athena Chalciœcus, or of the Brazen House, so called because it was covered with plates of bronze; also a temple of the muses, and several others of smaller size. The spacious agora or market-place was surrounded by colonnades, and from it the principal streets in the city diverged. In it stood the senate-house, with the offices of the ephors and other magistrates; but its chief ornament was the splendid marble portico erected from the spoils of the Persian war, and embellished with numerous sculptures. The principal streets were the *Aphetais* running southwards from the agora, and the *Scias* running to the south-east, both of which were lined with many temples and public buildings. Another street led westward from the agora to the theatre, a building used in the good old days of Sparta, not for dramatic, but for athletic sports. The private dwellings of the Spartans, like those of the Romans in early days, were poor and mean, as they reserved all sumptuous and expensive decorations for the temples of the gods and the halls of the nation. The city was, in its flourishing days, never fortified, being defended, not by walls, but by the arms of its citizens; and until the invasion of Epaminondas, no enemy ever approached near the capital. At a later period hasty defences were thrown up, but Sparta was not regularly fortified till it came under the power of the Romans. A modern town has been built since the Greek revolution on one of the hills of Sparta, and the village of Mistra lies not far off.

Spartacus || Spelman.

SPARTACUS. See Roman History.

SPASK, a town of European Russia, in the government and 30 miles E.S.E. of Riazan, on a lake of the same name, which communicates with the Oka. Here are several churches, a school, and many public and private gardens. Many of the inhabitants are employed in cotton factories, and also in the navigation of barges on the Oka. Pop. 4433.

Spask, another town of Russia, on the Studenetz, in the government and 110 miles N.N.E. of Tambov. It contains churches and schools, and has some manufactures of iron-ware. Pop. 4447.

SPECIES. See Logic.

SPECIFIC GRAVITY. See Hydrodynamics.

SPECTACLES. See Optics.

SPECTRA, images presented to the eye after removing them from a bright object, or closing them. These ocular spectra are of four kinds: 1st, Such as are owing to a less sensibility of a defined part of the retina, or spectra from defect of sensibility. 2d, Such as are owing to a greater sensibility of a defined part of the retina, or spectra from excess of sensibility. 3d, Such as resemble their object in its colour as well as form; which may be termed direct ocular spectra. 4th, Such as are of a colour contrary to that of their object, which may be termed reverse ocular spectra.

SPECULUM. See Optics and Telescope.

SPEED, John, an English historian, was born at Farrington in Cheshire, in the year 1542. He was by trade a tailor, and a freeman of the company of merchant-tailors in the city of London. In 1606 he published his *Theatre of Great Britain*, which was afterwards reprinted in folio, under the title of *The Theatre of the Empire of Great Britain.* In 1614 appeared his *History of Great Britain;* and in 1616 he published in octavo, *The Cloud of Witnesses, or the Genealogies of Scripture.* These genealogies were prefixed to many editions of the English translation of the Bible; and King James gave him a patent for securing the property to him and his heirs. His works were really of but little merit, and owed their chief excellences to other writers. He had twelve sons and six daughters, and died in 1629. He was interred in the church of St Giles's, Cripplegate, London, where a monument was erected to his memory.

SPELMAN, Sir Henry, an eminent antiquary, was descended from an ancient family, and born at Congham, near Lynn in Norfolk, in 1562. He studied at Trinity College, Cambridge, and afterwards took to the profession of law. He was appointed sheriff of his county, and afterwards

was knighted by King James I., who had a particular esteem for him on account of his known capacity for business, and he employed him several times in Ireland in public affairs. When he was about fifty years of age, he retired to London, whither his genius had always inclined him. He collected all such books and MSS. as concerned the subject of antiquities, either foreign or domestic, and published in 1626 the first part of his well-known *Glossarium Archaiologicum*, which he never carried beyond the letter L. The next work which he undertook was an edition of the *English Councils;* of which he published the first volume in 1639, leaving the second volume, as well of this as of his *Glossary*, to be published by Dugdale. The second volume appeared in 1664. Spelman wrote several other works relating to ancient laws and customs, and died in 1641. Upon his death, all his papers came into the hands of his son, Sir John Spelman, a gentleman who had abilities to have completed his father's design, if death had not prevented him. The second part was afterwards published by Sir William Dugdale, but with all the marks of a scanty unfinished performance. His *Treatise concerning Tithes*, and his *History of Sacrilege*, deserve a passing notice. His posthumous works were published at Oxford, in folio, in the year 1698, under the inspection of Gibson, afterwards Bishop of London.

SPENCE, JOSEPH, an amiable English writer, was born in the year 1699, but his family history remains in obscurity. He was educated at Eton, Winchester, and New College, Oxford, where he took his degree of A.M. in 1727. The previous year he published a small volume entitled, *An Essay on Pope's Odyssey, in which some particular beauties and blemishes of that work are considered.* This essay was greatly admired by his contemporaries, and it procured him the friendship of Pope. Spence was elected professor of poetry in 1728, and held that office ten years, which is as long as the statutes will allow. His account of Stephen Duck was first published in 1731; but it was afterwards much altered, and prefixed to an edition of Duck's *Poems.*

Towards the close of the year 1730 he travelled into Italy as companion to Charles, earl of Middlesex. He likewise visited the continent in 1737 and in 1739. In 1736 he republished *Gorboduc*, at Pope's desire, with a preface giving an account of its author, the Earl of Dorset. He quitted his fellowship in 1742, upon being presented by his college to the rectory of Great Horwood in Buckinghamshire. He never resided on his living; but paid it an annual visit, distributing large sums of money among the poor, and providing for many of their children. The same year he was appointed professor of modern history at Oxford. In 1747 he published a large folio volume entitled, *Polymetis; or, an Inquiry concerning the Agreement between the Works of the Roman Poets and the Remains of Ancient Artists; being an attempt to illustrate them mutually from each other.* By the publication of this work, Spence is said to have cleared L.1500. He was installed prebendary of the seventh stall at Durham on the 24th May 1754. Besides editing Blacklock's *Poems*, he wrote a number of tracts on various subjects, which will be found in Dodsley's *Fugitive Pieces.* On the 20th of August of the same year, he was unfortunately drowned in a canal at Byfleet in Surrey.

More than half a century after his death, appeared his gossiping *Anecdotes, Observations, and Characters of Books and Men, collected from the Conversation of Mr Pope, and others, with Notes and a Life of the Author* by S. W. Singer, London, 1820, 8vo, 2d edition, 1858. This is the only work by which Spence is now known. Dr Johnson, in his *Life of Pope*, says of Spence, that he "was a man whose learning was not very great, and whose mind was not very powerful. His criticism, however, was commonly just; what he thought he thought rightly, and his remarks were recommended by his coolness and candour."

SPENCE, *William*, an eminent entomologist, was born in 1783. In early life he was engaged in business at Hull, and it was here he contracted the taste for the study of insect life which led to his introduction to the Rev. William Kirby, and with whom he engaged in the production of one of the most popular works in the English language on the study of natural history. This work was *An Introduction to Entomology, or Elements of the Natural History of Insects.* The work was suggested originally by Spence in 1808, and the first volume of it appeared in 1815. The work was completed in 4 vols. in 1826, and has already gone through seven editions. The two entomologists exchanged specimens in 1805, and this gradually led to the warmest friendship between them. (See KIRBY, *William.*) Spence, besides contributing his share to this great work on natural history, wrote besides various papers illustrative of insect life, for the *Linnean Transactions*, and for the *Magazine of Natural History.* He was for many years Fellow of the Royal, Linnean, and Entomological Societies. He sat in parliament at the beginning of the present century, and wrote a political pamphlet, which attracted a considerable degree of attention, on the independency of Great Britain on foreign nations. He died at his residence in London, where he had lived during the latter part of his life, on the 10th of January 1860.

SPENCER, JOHN, a learned theologian, was born at Bocton-under-Blean, in Kent, in the year 1630. From the grammar-school of Canterbury he was removed to Corpus Christi College at Cambridge, where he was entered on the 25th of March 1645. Having taken the degree of A.B. in 1648, and of A.M. in 1652, he was chosen a fellow in 1655. In 1660 he preached a sermon before the university, and during the same year it was published under the title of *The Righteous Ruler.* He afterwards published a learned and curious work, entitled *A Discourse concerning Prodigies.* To the second edition, corrected and enlarged, he added *A Discourse concerning vulgar Prophecies*, Lond., 1665, 8vo. During the same year, he took his degree of D.D. In 1667, he was presented by his college to the rectory of Landbeach, and on the 3d of August elected master of the college. About a month after his election, he was preferred by the king to the archdeaconry of Sudbury, in 1672 to a prebend of Ely, and in 1677 to the deanery of that church. In 1669 he had published a Latin dissertation concerning Urim and Thummim. But his most elaborate work is *De Legibus Hebræorum Ritualibus, et earum Rationibus, libri tres.*, Cantab., 1685, 2 tom. fol. An edition, with the author's additions and improvements, was published at Cambridge in 1727; and several editions, one by Pfaff, was printed on the continent. Dr Spencer died on the 27th of May 1695, in the 63d year of his age. He was a great benefactor to his college, to which he bequeathed an estate that had cost him L.3600. He married Hannah, the daughter of Isaac Pullen of Hertford, and had a son and a daughter, who both died before their father.

SPENCER, *John Charles*, third *Earl*, better known by the title of *Lord Althorp*, which he bore throughout the greater part of his life, was the eldest son of the second Earl Spencer, and of Lavinia, daughter of the Earl of Lucan, and was born on the 30th of May 1782. He was educated at Harrow and Cambridge, where he received the honorary degree of M.A. in 1802. At the age of 22 he became member for Oakhampton, and in 1806 he was an unsuccessful candidate for the University of Cambridge. He was returned during the same year for Northamptonshire, which he continued to represent until the passing of the Reform Bill. He was vigilant, active, unostentatious, and honest in his political conduct during the long reign of the Tories. On Lord Grey coming to power in November 1830, Althorp was appointed Chancellor of

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the Exchequer. While he held this responsible office, he was distinguished for his industry and candour, and "the honest Lord Althorp" was a name by which he was long known to the House of Commons and the public. In his public appearances he was shy and undecided, and had a thick and painful utterance. Much more capable of gathering the juice of details than of extracting the riches from a large generalization, he was incapable, rather than otherwise, of grasping with iron hand the intelligence and the sympathies of the House. Yet it was astonishing the patience with which they waited on his sluggish utterance and his general clumsiness. This was doubtless owing to the high character which he bore. His mind was naturally vigorous, his memory was good, his affections were warm, and he was wholly free from malice in his public conduct. Lord Jeffrey expresses once and again his admiration of his "calm, clumsy, courageous, immutable probity, and well meaning." The good sense and the unflinching honesty of the man carried him over many a quagmire in which many a cleverer man would have unquestionably sunk. The most conspicuous measures which he supported were the Reform Bill and the Poor Law Amendment Act.

On the 10th of November 1834 Lord Althorp was elevated to the Upper House by his father's death, and his majesty at once availed himself of the opportunity of declaring the Melbourne ministry dissolved. Henceforward Earl Spencer confined his energies for the most part to the improvement of agriculture and to the growth of cattle. It was at his suggestion the Royal Agricultural Society was formed in 1837; and he was not only chosen president of this society, but likewise of the Yorkshire Agricultural Society in 1843. Lord Spencer was likewise an original member of the Roxburghe Club, and was vice-chairman of the council of the Society for the Diffusion of Useful Knowledge. Lord Brougham dedicates to him his *Discourse on the Study of Natural Theology*, 1835; and it is understood that it is Lord Althorp with whom he conducts his *Dialogues on Instinct*, 1839. Lord Spencer died at his seat, Wiseton Hall, in Nottinghamshire, on the 1st of October 1845. He was succeeded in the peerage by his next surviving brother.

SPENER, Philip Jakob, founder of the Pietists in Germany, and an exceedingly active reformer of the Protestant Church, was born, on the 13th of January 1635, at Rappoltsweiler in Alsace, now Ribeauvillé, in the department of Haut-Rhin in France. His father was a councillor of his native town, and he received much of his early education from the Countess of Rappoltstein and her chaplain, who seem to have taken great interest in the lad. He displayed early a strong leaning to theology and mysticism. At 15 years of age he was sent to the gymnasium of Colmar, and subsequently went to Strasburg to study theology under Schmidt and Dannhauer, who were hot Lutherans. His mind was active and open, and he stored it with all manner of solid learning, from Grotius and his philosophy down to Hebrew and Arabic. Having taken his degree in philosophy in 1654, he became for a time tutor to the sons of the Prince of Birkenfeld, and delivered lectures on philosophy and history. From 1659 to 1662 he visited, in pursuit of knowledge, the universities of Bâsle, Tübingen, Freiburg, Geneva, and Lyons. In the latter town, his contact with Père Menestrier determined him to heraldry, and he published a number of works of no great interest, and chiefly of a genealogico-historical character. On his return to Strasburg, he was appointed public preacher in 1662, and he at once rose into notice by the fervid piety of his discourses and the purity of his life. He was soon invited to Frankfort-on-the-Main, where his earnestness and zeal soon gained him followers, and his intemperate denunciations of the Calvinists drew from him many of the powerful and wealthy citizens of the town. The Calvinists remonstrated with Spener, and, to the scandal of his own party, he listened to their complaints, and resolved henceforward to confine his denunciations to the vicious and the immoral.

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In 1670 he set on foot his "Collegia Pietatis," which consisted of a meeting of any of his hearers who found any difficulties in his weekly discourses, or who required further explanation of anything that had been advanced in his sermons. In 1675 appeared his *Pia Desideria*, pointing out the need of a reform in the preaching of Germany, and inveighing against all who held up mere doctrine to their people, to the neglect of common Christian charity and humility. In 1686 he removed to Dresden, at the request of the Elector of Saxony, where he was made court preacher and member of the consistory. The resistance of some clergymen to the doctrines of mysticism called forth, in 1691, his work on *the Independence of Christians from all Human Authority in Matters of Faith*, which materially extended the principles of tolerance throughout Germany. At the University of Leipsic the nickname of Pietists was first bestowed on the followers of Spener; and one of his disciples, a theological teacher, had been persecuted by the other professors. An appeal was made to the elector, but in vain, and Spener found it for his advantage to remove to Berlin, where the office of provost, of inspector of the church of St Nicholai, and assessor of the consistory, awaited him. Here he enjoyed great respect. Being charged with heresy in 1692 by the theologians of Halle, Spener wrote in his own defence the *True Agreement with the Confession of Augsburg*. Friedrich August I., on his accession to the throne of Saxony in 1694, urgently solicited his return to Dresden, but he declined. The good and pious Spener died at Berlin on the 5th of February 1705. In 1700–9 appeared his *Theolog. Bedenken*, in 4 vols.; and in 1711 there were added to those theological replies, *Letzte Theolog. Bedenken*. Besides his *Kleinere Schriften*, published by Steinmetz, there likewise appeared the posthumous work, *Consilia Theologica*, in 1709. His life was written by Canstein in 1740, and by Hossbach in 1828.

SPENSER, Edmund, one of the greatest of English poets, was born probably in East Smithfield, London, about the year 1553.[1] There is no record in which the admirers of his genius may trace the incidents of his early years; but there is reason to suppose that they were clouded by poverty and dependence. On the 20th of May 1569, he entered Pembroke Hall, Cambridge, in the humble character of a sizer; a circumstance which is alone sufficient to rescue those luckless scholars from despondency, and to render them respectable in the eyes of their more fortunate companions. Some poems, in a collection of fugitive pieces entitled, *The Theatre for Worldlings*, which appeared during this year, are ascribed to Spenser, upon internal evidence. On the 10th of January 1572–3 he took the degree of A.B., and on the 26th of June 1576 that of A.M. From a letter of his friend Gabriel Harvey, himself a poet of some reputation in his time, it appears that, in consequence of having made enemies, who had both the will and power to injure him, he quitted Cambridge in despair of academical preferment. He had luckily some friends in the north of England, among whom he now found a temporary asylum. Whether he was received as an honoured guest, or compelled to turn his learning to account in the way of tuition, is unknown; but the latter supposition is the more probable of the two.

During his retirement in the north, Spenser wrote *The*

[1] Thomas Keightley, in a late number of *Fraser's Magazine* (October 1859), ingeniously argues that Spenser's birth must have taken place as early as 1551.

 Shepherd's Calender. Nothing is more common than for poets to deprecate the barbarity of a phantom, and to be reduced to despair, because some angelic nonenity turns a deaf ear to their entreaties; but it is said that "Rosalind" was a real mistress, at whose feet Spenser sighed in vain. The successful rival of the needy sonneteer was, in all likelihood, some substantial yeoman. At this period of his history, Harvey advised him to try his fortune in London; and it is probable that he abandoned without reluctance the scene of his unrequitted passion. Upon his arrival in the metropolis, he was fortunate enough to obtain an introduction to Sir Philip Sidney, who invited him to become his guest at Penshurst, the seat of the family in Kent. As a token of gratitude for this hospitality, the *Shepherd's Calender*, published in 1579, by E. R., was "entituled to the noble and vertuous gentleman, most worthy of all titles, Maister Philip Sidney."

Till long after the time of Spenser, the poet depended upon the casual gratuities of distinguished persons, who sometimes exerted their influence in procuring for a favourite bard some less precarious means of subsistence. Recommended, as it is conjectured, by the Earl of Leicester, uncle to Sir Philip Sidney, the poet went to the continent, as Keightley conjectures, in 1579–80, and subsequently proceeded to Ireland with Arthur, Lord Grey of Wilton, who was appointed deputy of that kingdom in 1580. During this year he had begun his *Faerie Queen*, for he writes to Harvey, April 10, 1580, asking him to return it. Spenser was the secretary of the viceroy, and discharged the duties of his office with greater promptitude and exactness than poets usually display in the ordinary business of life. His *View of the State of Ireland*, a treatise written in the form of a dialogue, probably between 1593 and 1596, displays no inconsiderable portion of political sagacity. By the interest of Lord Grey, Leicester, and Sidney, Spenser obtained, in 1586, a grant of 3028 acres of the forfeited estates of the Earl of Desmond. This piece of good fortune was imbittered by the death of his patron, the gallant Sidney, who fell in the same year at the battle of Zutphen. The pastoral elegy of "Astrophel," sacred to the memory of the departed hero, although not published until 1595, was probably written when the grief of the poet was at its height. It was provided by the royal patent, that those who profited by the forfeiture should reside upon the lands that were allotted to them. According to this arrangement, Spenser proceeded to a place named Kilcolman, in the county of Cork. This exile, to what was then little better than a region of barbarians, was cheered by a visit from the renowned Sir Walter Raleigh in 1589. At the suggestion, it may be presumed, of his distinguished guest, whom perhaps he accompanied to England, the poet soon exchanged his Hibernian solitude for the splendours of a court. In 1590 were published the first three books of the *Fairy Queen;* and the poet was afterwards presented by Raleigh to Queen Elizabeth, who conferred upon him a pension of fifty pounds a-year, then no despicable sum. The grant of this pension was discovered in the chapel of the Rolls by Malone, who has thus been enabled to clear the reputation of Lord Burleigh from the stigma of having intercepted the bounty of his sovereign to the author of the *Fairy Queen.* Malone has also made it appear that Queen Elizabeth had no poet-laureate, an appointment which was supposed to have been held by Spenser. In the sonnets annexed to the poem is one to his new patron, "the right noble and valorous knight, Sir Walter Raleigh;" but Spenser does not forget to shed a grateful tear to the memory of Sidney. There is a sonnet addressed to the Countess of Pembroke, the darling sister of that accomplished person, for whose amusement he wrote his *Arcadia.* With mournful dignity, the poet acknowledges to the countess his many obligations to

——that most heroicke spirit,
The heauens pride, the glory of our daies.

During his absence in Ireland, to which kingdom he returned after the publication of the *Fairy Queen*, was printed a collection of Spenser's minor pieces, entitled *Complaints: containing sundrie small Poems of the World's Vanitie. Whereof the next page maketh mention*, by Ed. Sp., Lond., 1591, 4to. This production was followed by *Daphnoida*, an elegy on the death of Douglas Howard, daughter of Henry Lord Howard. It is dated January 1, 1591–2. About this period he is supposed to have paid a visit to his native country; after which a considerable space intervenes unmarked by incidents.

Being no longer a pennyless rhymster, Spenser now wooed a kinder mistress than "Rosalind." This lady, whose name is unknown (Keightley conjectures it was Elizabeth), became his wife in 1593 or 1594. This progress of this successful courtship is traced in his *Amoretti, or Sonnets.* In 1595 appeared the pastoral of *Colin Clout's come home again.* It is dedicated to Sir Walter Raleigh, who is introduced as the Shepherd of the Ocean. In 1596, he published four *Hymns.* He informs the Countess of Cumberland and the Countess of Warwick, to whom they are inscribed, that the two latter, composed in his riper years, and treating of heavenly love and beauty, were designed to atone for the two former, which were written in the heyday of his blood, and of which the subjects are sensual desire and earthly grace. In the same year, or more probably three years earlier (Sonnet 18), were produced the fourth, fifth, and sixth books of the *Fairy Queen.* Of that magnificent poem, two additional imperfect cantos are all that can be found. Our limits prohibit the discussion of the question, whether the remaining six books, which would have completed the design, were destroyed by fire during the Irish rebellion, or left unfinished. Nor is there much utility in transcribing a long list of poems no longer extant, which are supposed to have shared their fate. In the course of this year, Spenser presented his *View of the State of Ireland* to the queen; but, for reasons not very clearly explained, that performance was not printed until thirty-five years after the author's death. It was published by Sir James Ware in Dublin in 1633.

In a letter from Queen Elizabeth to the Irish government, dated September 30, 1598, which was discovered by Malone, Spenser is recommended to be sheriff of Cork. A royal recommendation is generally equivalent to a command, but the rebellion of Tyrone put a period to all the poet's hopes of dignity and emolument. To escape the fury of the insurgents, he abandoned his house in Kilcolman, leaving behind him one of his children, who had been forgotten in the terror of the moment. Having removed every thing else that it contained, the miscreants set fire to the building, and left the infant to perish in the flames. The burning of his house and the spoiling of his goods are attributed to his own cupidity by some writers, but the fact of his having been nominated sheriff of Cork is sufficient to account for it. Spenser did not long survive these multiplied calamities. On the 16th of January 1598–9, soon after his arrival in England, he died at an inn in King Street, Westminster, London. The authority for this assertion, it must be confessed, is somewhat slender. It rests on the implied truthfulness of a statement in a manuscript notice in a copy of the *Faerie Queen* that had originally belonged to Henry Capell, "Qui obiit," says this notice, "apud diversorium in platea Regia apud Westmonasterium juxta London, 16° die Januarii 1598." The expenses of his funeral were defrayed by the unfortunate Earl of Essex, who buried him in Westminster Abbey, near the remains of Chaucer; a spot on which he had always desired to take his last repose. Ben Jonson, in his Conversations with Drummond, stated, with what truth it is difficult to say,

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"that the Irish having rob'd Spenser's goods and burnt his house and a little child new born, he and his wyf escaped; and after, he died for lake of bread in King Street, and refused twenty pieces sent to him by my Lord of Essex, and said, 'He was sorrie he had no time to spend them.'"

Spenser left two sons, Sylvanus and Peregrine. Hugolin, the son of the latter, was restored to his grandfather's estate by Charles II.; but, adhering to the infatuated successor of that monarch, he was outlawed, after the Revolution, for high treason. The lands of the outlaw, however, were bestowed upon his cousin William, the son of Sylvanus, through the interest of Montague, afterwards Earl of Halifax. William Spenser was presented to the notice of Montague by Congreve. "The family of the Spensers," says Gibbon, "has been illustrated and enriched by the trophies of Marlborough, but I exhort them to consider the *Fairy Queen* as the most precious jewel in their coronet."

Of Spenser's personal character we are in a great measure left to form our opinion from his works. Both the tendency and details of these are highly favourable to virtue; and the many chaplets he threw upon the hearse of Sidney prove that he cherished the memory of his benefactor with pious care. It is easy to imagine gratitude allied to every other noble quality, and it is mere misanthropy to question the sincerity of tears that fall to those who can give no more.

Dr G. L. Craik, in his admirable volumes on *Spenser and his Poetry*, has the following remarks:—The *Fairy Queen* "is not a poem like the *Iliad*, fiery, passionate, dramatic as life itself; it is all more like to a dream than to waking life. Its descriptions and pictures, it must be confessed, more resemble visions in the clouds than anything to be seen on earth. And this, we apprehend, is what Coleridge must be understood to mean when he says that Spenser's descriptions are not, in the true sense of the word, picturesque; but then no more are Claude's landscapes picturesque. Both want a peculiar piquancy which is one of the characteristics and constituents of the picturesque as commonly limited. It is essentially a thing of earth rather than of heaven, tending always towards the human, almost towards the domestic, offering nestling places for the affections; delighting, therefore, more in houses and fields than in mountains and forests, and more in mountains and forests than in sea and sky. Spenser's descriptions are not picturesque in this sense, because his poetry has so little flesh and blood throughout. Yet he is surely one of the very greatest of painters in words, diffuse and florid, no doubt, rather than energetic and expressive; but of what affluence and prodigality of power and resources in his own style, of what inexhaustible ingenuity and invention, of what flowing freedom of movement, of how deep and exquisite a sense of beauty! He is, indeed, distinctly and pre-eminently the poet of the beautiful. Of the purely beautiful, as consisting simply in form and colour, his poetry is the richest storehouse in the literature of the world; and what it contains of this pure essential beauty is not more matchless for its quantity than for the quality of much of it. Nor let it be supposed that this is a narrow realm in which he reigns supreme. The region of form is of boundless extent, comprehending whatever gratifies the sense of sight and sound, or the imagination and fancy as excited through them. But Spenser's poetry is full also of the spirit of moral beauty. It is not a passionate song, but yet it is both earnest and high-toned, and it is pervaded by a quiet tenderness that is always soothing, often touching: a heart of gentleness and nobleness ever lives and beats in it. With all its unworldliness, too, it breathes throughout a thoughtful wisdom, which looks deep even into human things; and oftenest sad and pitying, is yet also sometimes stern. Thus, although the music is in the air, and invisible spirits seem to make it, it wants not many a note betraying its mortal origin.

"Spenser's verse is the most abundantly musical in English poetry. Even Milton's, more scientific and elaborate, and also rising at times to more volume and grandeur of tone, has not so rich a natural sweetness and variety, or so deep a pathos. His poetry swims in music; he winds his way through stanza after stanza of his spacious song, more like one actually singing than writing, borne along, it might seem, almost without effort or thought.

"His treatment of words upon such occasions is like nothing that ever was seen, unless it might be Hercules breaking the back of the Nemean lion. He gives them any sense and any shape that the case may demand. Sometimes he merely alters a letter or two, sometimes he twists off the head or the tail of the unfortunate vocable altogether. In short, it is evident that he considers his prerogative in such matters to be unlimited. But this fearless, lordly, truly royal style in which he proceeds makes one only fear the more how easily, if he chose, he could avoid the necessity of having recourse to such outrages. After all, they do not occur so frequently as much to mar the beauty of his verse: the more brilliant passages of the poem are for the most part free from them.

"Distinct and dissimilar in many respects, opposed in some, as are the genius of Spenser and that of Homer, we have yet always felt that there is something in the poetry of the one that recalls that of the other. The fire, the passion, the dramatic life, the narrative rapidity of Homer, Spenser wants; the Homeric is of all poetry that in which there is most flesh and blood, the Spenserian that in which there is the least. Homer is both soul and body, Spenser is only soul, or soul with the body laid asleep as it is in dreams; the Homeric poetry is essentially and intensely of this world, that of Spenser as essentially and intensely not of this world; the one is full of the spirit of sunshine and the open air, the other of that of moonlight and torchlight. Yet, spite of these great differences, is there any other English poetry that is so like the Homeric as that of Spenser? any other through which an English reader, properly warned in regard to the wide disagreement between them in many respects, could get so near to a just and lively conception of that of Homer? We should say there certainly is not.

"One of Spenser's inventions in the *Fairy Queen* is his magnificent stanza, which may be said to be the last new form of verse that has fairly established itself in the language."

There are in all some forty editions of Spenser's works. The most prominent of these are, an edition with a glossary and a life of the author, and an essay on allegorical poetry, by John Hughes, London, 1715, 6 vols. 12mo. The *Fairy Queen*, with an exact collation of the two original editions, a life of the author by Dr Birch, and a glossary, together with 32 plates from designs by Kent. Lond., 1751, 3 vols. 4to. Another edition of this poem, with notes critical and explanatory, was soon afterwards published by Ralph Church, A.M., Lond., 1758, 4 vols. 8vo. And about the same time appeared a new edition, with a glossary and notes explanatory and critical, by John Upton, A.M., Lond., 1758, 2 vols. 4to. An elaborate and complete edition of Spenser's works was at length published by Todd, Lond., 1805, 8 vols. 8vo; also, Dr Craik's *Spenser and his Poetry*, 3 vols., 1845, already referred to.

Speusippus.

SPEUSIPPUS, an Athenian philosopher, and the nephew and successor of Plato. He assumed the direction of the Platonic school in 349 B.C. Contrary to the practice of his master, Speusippus required from his pupils a stated gratuity. He placed statues of the Graces in the school which Plato had built. On account of his infirm state of health, he was commonly carried to and from the academy in a vehicle. On his way thither he one day met Diogenes, and saluted him; the surly philosopher refused

to return the salute, and told him that such a feeble wretch ought to be ashamed to live; Speusippus replied, that he lived not in his limbs, but in his mind. At length being wholly incapacitated, by a paralytic stroke, for the duties of the chair, he resigned it to Xenocrates. He is said to have been of a violent temper, fond of pleasure, and exceedingly avaricious. Speusippus wrote many philosophical works, which are now lost, but which Aristotle thought sufficiently valuable to refute, and to purchase at the expense of three talents. From a few fragments which remain of his philosophy, it appears that he adhered very strictly to the doctrines of his master. (See *Speusippi de Primis Rerum Principiis Placita*, Ravaisson, 8vo, Paris, 1838.)

SPEY, a river of Scotland, rises in a small loch of the same name, in Inverness-shire, between Lochs Laggan and Lochy, and flows in a N.E. direction through the valley called from it Strathspey. Its upper course is in the county of Inverness; it then traverses that of Moray for a short distance, and finally separates Moray from Banff. After a course of about 96 miles it falls into the Moray Firth, a little to the east of Lossiemouth. It receives many small streams, but none of any size or importance. Though at first it is a sluggish stream, in the lower part of its course it is one of the most rapid in Scotland, and this renders it difficult of navigation. Large quantities of timber, however, are floated down the Spey. The river abounds in salmon, and the fisheries in it are very valuable.

SPEZIA, a seaport-town of the Sardinian dominions, on an inlet of the Gulf of Genoa, in the division and 50 miles E.S.E. of Genoa. It has a fine situation, and is generally well built, defended by a castle, and enclosed by walls. There is here a spacious and handsome public square, numerous churches, a town-hall, convent, hospital, and schools. The Gulf of Spezia forms a very fine harbour; it is the same that was called by the ancients *Portus Lunæ*. Pop. 9796.

SPHERE is a solid, formed by the revolution of a semicircle about its diameter.

SPHEROID, a solid approaching to the figure of a sphere. It is generated by the entire revolution of a semi-ellipsis about its axis. When the revolution is made round the largest axis, the spheroid is called *prolate;* and when round the shortest, *oblate*. This last is the figure of the earth, and probably of all the planets.

SPHINX, in fabulous history, a monster which had the head and breasts of a woman, the body of a dog, the tail of a serpent, the wings of a bird, the paws of a lion, and a human voice. This creature is variously represented in Greek mythology. It sprang from the union of Orthos with the Chimæra, or of Typhon with Echidna, or of Typhon with the Chimæra. The Sphinx had been sent into the neighbourhood of Thebes by Juno, who wished to punish the family of Cadmus, which she persecuted with immortal hatred; and it laid this part of Bœotia under continual alarms, by proposing enigmas, and devouring the inhabitants, if unable to explain them. In the midst of their consternation, the Thebans were told by the oracle that the sphinx would destroy herself as soon as one of the enigmas which she proposed was explained. In this enigma she wished to know what animal walked on four legs in the morning, two at noon, and three in the evening. Creon, king of Thebes, promised his crown and his sister Jocasta in marriage to him who could deliver his country from the monster by a successful explanation of the enigma. It was at last happily explained by Œdipus, who observed, that man walked on his hands and feet when young, or in the morning of life; at the noon of life he walked erect; and, in the evening of his days, he supported himself by leaning on a staff. The sphinx no sooner heard this explanation than she dashed her head against a rock, and immediately expired. Some mythologists wish to unriddle the fabulous traditions about the sphinx by the supposition, that one of the daughters of Cadmus, or Laius, infested the country of Thebes by her continual depredations, because she had been refused a part of her father's possessions. The lion's paw expressed, as they observe, her cruelty, the body of the dog her lasciviousness, her enigmas the snares which she laid for strangers and travellers, and her wings the despatch which she used in her expeditions. The legend of the sphinx is supposed to have been introduced from Egypt or Ethiopia. Among the Egyptians the sphinx was the symbol of religion, by reason of the obscurity of its mysteries; and on the same account the Romans placed a sphinx in the *pronaos* or porch of their temples.

SPILSBY, a market-town of England, in the county and 31 miles east of Lincoln. It consists of four streets, diverging from a central market-place, in which stands an octagonal cross. The principal buildings are a court-house, raised on pillars, and the old parish church, which contains many interesting monuments. There are also places of worship for Independents and Methodists, a grammar-school, two national schools, and various charitable institutions. Pop. 1461.

SPINAGE, or SPINACH. See HORTICULTURE.

SPINAZZOLA, a town of the kingdom of Naples, in the province and 23 miles W.S.W. of Bari, near the source of the river Locone. It contains several churches, convents, an hospital, and an almshouse. Pop. 5300.

SPINET, or SPINNET (Ital., *Spinetta*), an old-fashioned musical instrument, of which the brass and steel wires were struck by quills fixed to the tongues of the jacks that were moved by finger-keys. It was the predecessor of the harpsichord and the pianoforte.

SPINNING is the art of forming continuous threads by drawing out and twisting together filamentous materials. This was at first a manual art, and was practised in the earliest ages. The simple tool first made use of consisted of a piece of wood, with its lower extremity of a conical form like a boy's top, and its upper portion long and tapering to a point, to which the fibres to be spun were fixed; this was termed a spindle, and in using was spun like a top to twist the threads. To the spindle an addition was soon made of the distaff, consisting of a piece of wood, round which the material to be spun was lapped. The distaff was held in the one hand of the spinner, while the other hand was engaged in drawing the fibres from the mass, and ever and anon giving fresh impetus to the motion of the spindle. This simple apparatus must have been early used, as among the sculptures of the early Egyptian tombs we find representations of females forming threads with the spindle; and singular though it be, the same apparatus may yet be found in a few places in Scotland, affording, in its toilsome progress, a striking contrast to the whirling wonders of the cotton-mill.

A great improvement in the use of the distaff and spindle, by which the spinner's hands were in a great measure left free to regulate the formation of the thread, was made by mounting the spindle in a frame, and using a larger wheel to drive it by a belt; and this again was further improved by using a treadle to effect the movement of the wheel by the foot of the spinner. No attempt, however, to introduce mechanism to supply the place of the skill and dexterity in manipulation, which the spinner could acquire only by assiduous practice, appears to have been made before the beginning of the eighteenth century. At that time there were in common use two kinds of spinning implements. The one, called the *large wheel*, was used in the spinning of wool and cotton, consisting of a large wheel or rim mounted in a frame, and having a belt to drive the spindle which projected from the side of the frame, and had the material to be spun affixed to its end. In spinning, the operator, usually a female, laid hold of the wool or cotton with the finger and thumb of her left hand, at a few inches distant from the spindle, and

drew it towards her, while she turned the wheel with her right hand; she thus extended and twisted repeated portions, and as they were twisted, she, by guiding with her hand the thread she had formed, allowed it to be wound upon the spindle. Thus, from the carded cotton or wool, a loose flabby thread or *rove* was formed, which was again subjected to a similar drawing or extension, and twisted until reduced to a fine and compact thread. The other implement, called the *small* or *Saxon wheel*, was a more perfect apparatus, and was used for the spinning of flax; it had on its spindle a bobbin, on which the thread was wound, and a flyer revolving with greater rapidity than the bobbin, to give the thread twist; a fixed distaff, on which the prepared flax was loosely rolled; and a treadle by which a rotatory motion was given to the wheel by the foot of the operator, whose hands were thus left at liberty to draw out the fibres of the flax in the requisite number to form the thread; in doing this, the fibres were, from time to time, moistened with saliva, to make them more readily combine.

Such were the spinning implements used in Britain and elsewhere, fit companions for the rude looms by which their produce was woven into cloth. But improvements had begun to be made in the apparatus for weaving. The shuttle, which had to be thrown by both hands alternately, and in cloths above thirty-six inches wide, by two men, one at each side, was in 1733 superseded by the fly-shuttle, the invention of John Kay of Bury in Lancashire. By this improvement, the weaver could throw the shuttle from side to side with his right hand; one man could weave the widest fabrics, and could produce nearly twice as much work as by the old method. The spinners could not now supply weft for the weavers, and hence arose the necessity for some machine that would increase the production of yarn.

In 1738, Lewis Paul, the son of a Dr Paul, and who had been left in the guardianship of Lord Shaftesbury and his brother, appears to have been the first who made an attempt to substitute mechanism for the hands and skill of the spinner. To him is due the honour of discovering the principle of roller-spinning, a principle, forty years afterwards, fully developed by the genius of Arkwright. In that year Paul obtained a patent for a machine "for the spinning of wool and cotton in a manner entirely new." Paul had originally some little property acquired by marriage, but while working at his invention he appears to have fallen into poverty, to have become involved in debt, and to have skulked about under assumed names, to avoid his creditors. He had gone to Birmingham to avail himself of the better skill of the workmen there in the construction of his machine, and had borrowed money from Mr Warren, a bookseller, and Mr Wyatt, one of those who worked at the construction of the machine. He was unable to repay this money, but Warren accepted as payment of his L.100, a license to erect fifty spindles; and Wyatt agreed to take the machine which he had helped to set up in payment of his claim of L.800. On his return to London, Paul sold several machines. He confined his attention chiefly, however, to the sale of his licences, in which he was so successful that he was soon enabled to pay off his debts. He lived in comfortable circumstances to the time of his death in 1759.

Although Wyatt does not appear to have set up any claim to the invention of the machine which thus fell into his hands, yet in the following account by his son, Mr Charles Wyatt, the whole merit of the invention is claimed for him.

"In the year 1730, or thereabouts, living then at a village near Litchfield, our respected father first conceived the project, and carried it into effect; and in the year 1733, by a model of about two feet square, in a small building near Sutton Coldfield, without a single witness to the performance, was spun the first thread of cotton ever produced without the intervention of the human fingers, he, the inventor, to use his own words, '*being all the time in a pleasing, but trembling, suspense.*' The wool had been carded in the common way, and was *passed between two cylinders, from whence the bobbin drew it by means of the twist.*

"This successful experiment induced him to seek for a pecuniary connexion equal to the views that the project excited, and one appeared to present itself with a Mr Lewis Paul, which terminated unhappily for the projector; for Paul, a foreigner, poor and enterprising, made offers and bargains which he never fulfilled, and contrived, in the year 1738, to have a patent taken out in his own name for some additional apparatus, a copy of which I send you; and in 1741, or 1742, a mill turned by two asses walking round an axis was erected in Birmingham, and ten girls were employed in attending the work. Two hanks of the cotton then and there spun are now in my possession, accompanied with the inventor's testimony of the performance. Drawings of the machinery were sent, or appear to have been sent, to Mr Cave, for insertion in the *Gentleman's Magazine*.

"This establishment, unsupported by sufficient property, languished a short time, and then expired; the supplies were exhausted, and the inventor much injured by the experiment, but his confidence in the scheme was unimpaired. The machinery was sold in 1743. A work upon a larger scale, on a stream of water, was established at Northampton, under the direction of Mr Yeoman, but with the property of Mr Cave. The work contained 250 spindles, and employed fifty pair of hands.

"The work at Northampton did not prosper. It passed, I believe, into the possession of a Mr Yeo, a gentleman of the law, in London, about the year 1764; and, from a strange coincidence of circumstances, there is the highest probability that the machinery got into the hands of a person who, with the assistance of others, knowing how to apply it with skill and judgment, and to supply what might be deficient, raised upon it, by a gradual accession of profit, an immense establishment, and a princely fortune."

Mr Robert Cole, F.S.A., is in possession of documents which, notwithstanding this circumstantial account, clearly prove Paul's title to be considered sole inventor of roller-spinning. The principles of his invention are contained in the following extract from the specification of his patent:—"The wool or cotton being thus prepared (by carding into slivers), one end of the mass, rope, thread, or sliver, is put betwixt a pair of rowlers, cillinders, or cones, or some such movements, which being twined round by their motion, draws in the raw mass of wool or cotton to be spun in proportion to the velocity given so such rowlers, cillinders, or cones. As the prepared mass passes regularly through or betwixt these rowlers, cillinders, or cones, a *succession* of other rowlers, cillinders, or cones, moving proportionably faster than the first, draw the rope, thread, or sliver, into any degree of fineness which may be required. Sometimes these successive rowlers, cillinders, or cones (but not the first) have another rotation besides that which diminishes the thread, yarn, or worsted, viz., that they give it a small degree of twist betwixt each pair, by means of the thread itself passing through the axis and centre of that rotation. In some other cases only the first pair of rowlers, cillinders, or cones, are used, and then the bobbyn, spole, or quill, upon which the thread, yarn, or worsted is spun, is so contrived as to draw faster than the first rowlers, cillinders, or cones give, and in such proportion as the first mass, rope, or sliver is proposed to be diminished."

To appreciate rightly Paul's invention, we must take into consideration the state of the art at his day. No machine, except the household wheels, already described, then existed, and their useful effect depended on the skill and dexterity of the spinner. Paul's invention contained the germ of a self-acting and self-regulating principle; and the means which he used were so unlike any operation perform-

ed by the hands, that although unfortunately his success was only partial, he is yet entitled to our admiration for the originality of his genius. He did much for the art, if what he did prepared a foundation for Arkwright's superstructure.

The next invention was one in which an effort was made directly to imitate the action of the spinster, as exemplified in the wool-wheel, in drawing away the roving of wool, until extended to the proper length, and, after having twisted it, winding it on the cope or spindle. This was the "Jenny," the invention of which is claimed by Mr Guest for Thomas Highs, a reed-maker in Leigh near Bolton, but is more generally accorded to James Hargreaves, a weaver, residing at Stanhill village near Blackburn. These ingenious men were doubtless independent inventors, working out their ideas without the knowledge of each other's proceedings, and the difference in their respective machines countenances this view. Mr Guest gives Hargreaves the name of the improver of the jenny.

If we imagine many spindles to be set in motion by one wheel, and the ends of the rovings connected with these to be inserted between two pieces of wood, which, like the jaws of a vice, would hold them firmly, and by which they could all be drawn back at one time by the left hand of the spinner, while with his right hand he could drive the wheel which gives the spindles their motion, we shall have a good idea of the first spinning-jenny, which was, indeed, no more than this. In process of time, however, the machine was rendered very different from the one first constructed. The spindles were increased from eight (the number in Hargreaves's original machine) to eighty, and upwards; the clove or clasp by which the slivers or rovings were held was improved in form, and mounted on a carriage, and made to run on a railway in the framing, the effect of which was more perfect equality of the thread, and a greater degree of precision in the process. The yarn when spun was built up in a conical form on the cope or spindle by a proper apparatus, and altogether the machine was very much improved. Still, with all its improvements, it was only a hand-wheel of many spindles. But as a hand-wheel it probably effected more good than it would have done had it been more complete. It still remained a domestic implement of small cost, and its use rapidly extended. The jenny was imperfect in so far that it could only be brought to act upon rovings, which required to be formed on the hand-wheel already described. This defect was soon remedied by the introduction of the *slubbing billy*, in which the parts of the jenny were reversed, the place of the clove or clasp being supplied by rollers, and the spindles being mounted in a frame running on a railroad. The card rolls or slivers were in this machine placed continuously on an inclined plane, formed by a travelling canvass, which conducted them up to the feeding-rollers, placed at its highest point; and on passing through the feeding-rollers the slivers were attached to the spindles, which, receding from the rollers, twisted the slivers and formed rovings for the jenny. This machine is still used for forming the rove in wool-spinning.

The problem of automatic spinning, however, remained yet to be practically solved, and this solution was reserved for the genius of another man in poor circumstances—Richard Arkwright.

The bad success of roller-spinning in the hands of Wyatt, an ingenious man, and of those other speculators who purchased either machines or licenses from Paul, would have deterred most men from again attempting it; but partial failure appears to have ever stimulated the persevering Arkwright to fresh exertion. He, a poor man, a barber by trade, unaided, almost uneducated, and totally unacquainted with mechanics, perfected a system of machine-spinning which ultimately raised the manufactures of his country to a height unexampled, and obtained for him honour and wealth.

Arkwright's principle of roller-spinning need not here be particularly described, as we shall have occasion to illustrate it more fully afterwards. It is only necessary generally to observe, that in this mode of spinning the material is extended to the requisite degree by rollers, and twisted and wound up by a flyer and bobbin, as in the small flax-wheel, the drawing, the twisting, and the winding up being simultaneously carried on. Important as the invention of roller-spinning is, it is not on it alone that the fame of Arkwright rests, but also on the power of mind displayed in remodelling the habits of people accustomed to desultory working, and, in short, in establishing the factory system.

The next great invention was also produced by a man in humble circumstances—Samuel Crompton, a weaver at Hall-in-the-Wood, near Bolton. This ingenious individual, combining the drawing roller of Arkwright with the jenny of Hargreaves, produced a beautiful, though somewhat complex machine, to which he gave the appropriate name of the *mule-jenny*. In the mule-jenny the drawing rollers are mounted in a stationary frame, and the twisting spindles in a moveable carriage; the rovings are passed through the rollers and attached to the spindles; the rollers and spindles are then made to revolve, and the carriage to recede from the rollers, carrying away and twisting the attenuated rove. When a sufficient quantity of rove has been given out, the motion of the rollers is suddenly stopped, and that of the spindles of the carriage increased to nearly double its former velocity, the carriage itself still receding from the rollers, but at about one-half its former speed; thus the greatest extension only takes place as the rove receives twist to enable it to bear it.

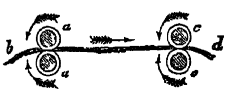
These machines were all the offspring of the cotton manufacture; but it may be well supposed that the principle on which they act would soon be adopted in the spinning of wool, flax, and silk. It is not here necessary to trace the different steps through which, by slow degrees, the parts of these machines were brought to suit the peculiarities of other manufactures. We shall, therefore, proceed to the elucidation of the principles of spinning the various textile materials by machinery, observing first, that, to fit these materials for spinning, they are made to undergo several preparatory processes; the effect of which, when well performed, is to separate the fibres, to unravel those which are entangled, and, except in the case of flax, to present the whole mass in a continuous sliver or ribbon of an equal width and density throughout its whole extent. On this sliver the operation of spinning is performed.

If we take hold of a portion of such a sliver with the hands rather farther apart from each other than the average length of the fibres of which it is composed, we shall find that, by the sliding of the fibres on each other, we can extend it a little without breaking it. Suppose, then, that we thus extend a few successive portions, and lay them together, and combine them by slightly twisting them, so that the tortion shall generate a certain compression among the co-fibres, we shall now find that we are able to extend the mass considerably farther without breaking, and so by continued drawing and twisting we may attenuate the sliver until it become a fine thread. There are two circumstances which limit its extensibility. The first is that state of it when many of the fibres which compose it end together at the same place, and which it is one of the objects of carding, and the purpose of some of the after-processes, to prevent. The second is when the friction produced by the twisting becomes so great that the fibres will sooner break than slide on each other.

The operations, then, to be performed by the spinning machinery are—to extend the mass of sliver as it comes from the preparatory machines, by repeated operations, or *drawings*, as they are termed, into a narrower and narrower ribbon; to twist this ribbon into a loose thread or

rove, to enable it to bear greater extension; and further, to extend this rove to the last degree of attenuation required, twisting it, at the same time, so *hard*, that, when the operation is finished, and the thread perfectly formed, the fibres will sooner break through than separate, by sliding on each other. All these operations are, however, more or less mixed up with each other in practice. Thus, the carding-engines, besides disentangling the fibres, draw the broad sheet of loose filaments into a narrower and more compact sliver; the drawing-frames extend this into a still narrower ribbon; in the roving-frames the drawing still proceeds, and by an additional apparatus the sliver is twisted; and this drawing and twisting are carried on together in the spinning-frame and in the mule-jenny until the completion of the thread.

The manner in which the drawing is effected may be conveniently represented by a figure. Let *a a* in the figure represent a pair of rollers, which are called retaining-rollers; let these revolve in the direction of the arrows with a given velocity, and receive between them the sliver *b d;* they will thus impart to it the rate of motion of their own surfaces; let *c c* be another pair of rollers, which are called drawing-rollers, revolving with twice the speed of *a a*, and receiving between them the sliver. Imparting to it now their own motion, they will cause it to move forward twice as fast as it is yielded by *a a*, which it can only do by the fibres sliding asunder. If, therefore, a given length of sliver be passed through the roller, it will be drawn out to twice its original length, and its sectional area will be but half of what it was. The drawing-rollers have here been supposed to move twice as fast as the retaining-rollers; but their relative speed may be in other proportions. Thus the drawing-rollers may move three, four, or five times faster than the other pair, and extend the sliver to three, four, or five times its original length. This difference of speed is termed the draught of the machine, and a machine is said to have a draught of two, three, four, five, or six, as the speed of the surface of the drawing-rollers is so many times greater than that of the retaining-rollers. It is obvious that, to effect the lengthening of the sliver, the distance between the drawing and retaining-rollers must be somewhat greater than the average length of the fibres which compose the sliver. For were the distance less than this, the consequence would be disruption of the fibres themselves, from both rollers having hold of the opposite ends of the same fibres at the same time. But the distance may be too great, which would tend to make the fibres separate entirely at the middle point between the rollers, or at least to make the greatest attenuation take place there.



It is obvious, too, that the amount of extension which a single sliver can endure must be small, from the danger of the ends of many fibres occurring at the same place. Hence there exists a necessity for laying many slivers of the first drawing together for the second drawing, and many of these again for the third drawing. This laying together of the drawings, which is termed doubling, possesses the advantage of ensuring greater equality in the thread, from the inequalities of the separate drawings contemperating each other. The oftener this doubling is repeated, the more compact and equal, or *level*, the thread will be, and the more capable of enduring attenuation from the interspersion of the endings of the fibres.

As an example, in figures, of the effect of the drawing and doubling processes, suppose the velocity of the drawing-rollers to that of the retaining-rollers, or, in other words, the draught of the machine to be as 5 to 1, let the length of the sliver, before drawing, be 1, and its density 1; after the drawing we shall have the length increased to 5, and the density diminished to ·2. Suppose a doubling consisting of 8 of those new drawings to be put through the rollers, we shall have a new sliver formed, length 25, density ·32; and the result of the doubling being repeated four times, the ratios being the same, that is in figures, $\frac{8}{5} \times \frac{8}{5} \times \frac{8}{5} \times \frac{8}{5} = \frac{4096}{625} = 6{\cdot}5$, will be a length of 625, and a density 6·5; that is to say, there will be 6·5 times as many fibres in the same space as there were originally, and the length will be increased to 625, this length of 625 being made up of 4096 separate slivers, or ends, as they are termed.

Such is the process of drawing without twist, in its simplest form, and as it is applied to cotton, wool, and silk waste. In flax-spinning the nature of the material renders a more complicated apparatus necessary. Each fibre of flax, on minute examination, will be found to be made up of a number of smaller parallel filaments bound together. The separation of these bundled filaments is partially effected by the hackling process; but it is evident, that the thread is not capable of its greatest degree of attenuation until the total separation of the filaments be completed. For this reason, a hackle, which shall separate the filaments, is an essential part of the drawing apparatus for flax; and, in the repeated doublings of the slivers, a succession of machines is used, in which the hackles are gradually finer.

From the length of the fibres of the flax, the rollers require to be at a considerable distance from each other, and the hackles are placed in the interval between them. They are fixed to an endless chain, working over rollers, and their points are made to move through the sliver, with a speed a little greater than that of the retaining-rollers. They thus have a double action. Entering the sliver immediately on its emission from the retaining-rollers, and moving faster than it does, they split down the bundles of the fibres, and allow the sliver to be extended by the rollers. As they proceed onwards, the action of the drawing-rollers makes the extending sliver move many times faster than the hackles, and, by this means, straightens and lays parallel those fibres which may happen to be doubled, or to lie obliquely in the sliver. This ingenious apparatus is called the Gill, from the name of its inventor.

The process which succeeds these repeated drawings, whether made by the simple rollers or by the gill, is twisting the sliver into a rove. For this purpose, an addition of a bobbin and flyer is made to the drawing machine. The bobbin is made to revolve with such speed as to wind up the rove as fast as it is yielded by the last pair of rollers, and the flyer with so much additional speed as to give to the sliver the desired twist while moving between the roller and the bobbin. As the diameter of the bobbin is continually increasing by the accumulation of the rove, and as the speed of the rollers remains constant, it is necessary to vary the speed of the bobbin, so that, as it increases in diameter, it may diminish in speed, and wind up the rove at the same rate throughout. The mechanism for effecting this is, in some machines, very complicated.

The next operation is forming the thread from the rove. For this there are two kinds of machines used—one, the throstle, which is a simplification of Arkwright's spinning-frame, and consists of a set of drawing-rollers, with bobbins and flyers, as in the roving frame; the other is that combination of the drawing-rollers with the jenny which is termed the *mule*. In the roving and throstle frames the twisting apparatus is stationary, and merely twists, and the twisting succeeds the drawing. In the mule the twisting apparatus recedes from the rollers faster than they yield the sliver, and consequently has a drawing as well as a twisting power. In the throstle, the rove being pulled by

Spinola.

the bobbin through the flyer, is, while yet tender, subjected to a continual strain. In the mule the rove is only subjected to strain, as it receives twist enough to enable it to bear the strain without injury. The mule, too, by the peculiarity of its mode of action, destroys those inequalities of the rove which result from defects in the drawing, or injury sustained in the roving. To understand how it does so, it is necessary to observe, that, when a thread of unequal thickness is twisted, the fibres which compose the thick parts, forming larger and more oblique spirals than those which compose the small parts of the thread, require a greater force to twist them, and consequently remain soft, while the small parts become comparatively hard twisted. If a considerable length of such a thread were pulled, the fibres of the thick parts would slide upon each other; while those of the smaller parts, being mutually compressed, by their greater degree of torsion, would resist the drawing asunder. The drawing would thus take place only in the thick parts; and as they diminished in size, the twist would gradually become equally diffused. The mule, acting in this manner, with a drawing and twisting power, upon a considerable length of unequally sized, and consequently unequally twisted rove, reduces its inequalities, and renders it level and uniformly twisted throughout.

Arkwright's first machine was called the water-twist frame, from having originally been driven by water-power. It consisted of a pair of retaining-rollers and a pair of drawing-rollers, such as those we have used for the sake of illustration, which effected the extension of the sliver. From the drawing-rollers the sliver passed to another pair of rollers, called the delivering-rollers, which, moving with the same velocity as the drawing-rollers, had no extending power, but merely compressed the sliver and delivered it to the twisting apparatus. This consisted of the bobbin and flyer of the Saxon or flax wheel, improved in respect of the flyer being rendered automatic in spreading the thread on the bobbin; and this automatic action was shortly afterwards, with good effect, transferred from Arkwright's machine to the hand-wheel by a Mr Antis. Each system of rollers and twisting apparatus in Arkwright's machine was separate, and was driven by a separate system of gearing, and pulleys and bands, rendering the machine, when of great extent, exceedingly complicated. One of the greatest improvements of modern days is the simplification of the moving parts, by making each roller continuous along the whole length of the machine, and using only one set of driving apparatus at the one or other extremity, and by making the shaft for driving the twisting machinery also continuous.

We have seen that the parts of the machine which per form the operations of drawing and twisting, viz., the rollers, and the bobbin and flyer apparatus, are very simple. The complexity arises, therefore, from the number of parts required to communicate motion to these parts, and to regulate their movements; and the arbitrary nature of the form and arrangements of the parts for communicating motion, causes the great differences which exist in the various spinning machines. In a brief sketch like the present, it is obviously impossible to notice the many beautiful arrangements which, from time to time, have been introduced; and we must refer the reader to the articles COTTON, FLAX, ROPEMAKING, SILK, WOOL, &c., for detailed information as to the peculiar modifications in spinning machinery, rendered necessary by the quality of the article operated upon. (J. N.)

SPINOLA, AMBROSIO, MARQUIS DE, one of the greatest generals of his time, was born at Genoa in 1569. His family had originally come from Spinola, a small town in the north of Italy; and one of his ancestors, on coming to Genoa, had amassed a considerable fortune by mercantile speculations. His brother Frederic, who had entered the naval service of Spain, and had attained the rank of admiral in a year or two, came to Genoa, and induced Ambrosio, then a quiet citizen, to undertake the command of the land forces, while he should scour the sea with his ships. Ambrosio left Milan in May 1602, and by steady discipline and regular pay, avoided the disorder and mutiny which prevailed among the majority of the Spanish troops. Entering the low countries under Mendoza, he was defeated at the siege of Grave, which he had gone to relieve, by the renowned general, Prince Maurice, on the 20th September 1602. Shortly after Spinola was appointed general-in-chief of the forces of Spain, and he gained great distinction by the taking of Ostend from the Dutch, which the Spaniards had besieged for three years and two months. Having repaired to Madrid, he was received by King Philip III. with every mark of distinction, and was appointed commander-in-chief of all the Spanish and Italian forces in the Netherlands. In an interview with Henry IV. of France, to which he was admitted on his way to resume his command in the Netherlands, that monarch took the opportunity of inquiring at the Spanish commander his plans for the ensuing campaign. Spinola caught his drift, and detailed them literally as he intended to execute them. The cunning monarch taking it for granted that Spinola's intentions were directly the opposite of what he had narrated to him, wrote off forthwith to Prince Maurice the very contrary of what he had been told. "Others," said Henry IV. afterwards, "have deceived me by falsehood, but Spinola by speaking the truth." An armistice was shortly afterwards proposed by the Court of Madrid, and Spinola and Maurice were at peace for twelve years. Spain again renewed her claims upon Holland in 1621, on occasion of the disputed succession to the Duchy of Cleves. This roused again the old foes, Spinola and Maurice, but Spinola had the good fortune to have all the luck on his side. Juliers was taken, and Breda was besieged by the Spaniards. The Prince of Nassau (Maurice) died of a fever caught in the low marshes which surround the town of Breda. Spinola's health was likewise shaken, and after the opening of the gates of Breda, he retired from the command of the Spanish forces. He died in 1630, it is said of vexation and disappointment at having his pecuniary claims disregarded by the court of Spain.

Spinoza.

SPINOZA, BENEDICT DE, the greatest pantheist the world has yet seen, was the son of a Jewish merchant of Portugal, who had migrated into Holland some time before the date of the philosopher's birth, which occurred at Amsterdam on the 24th November 1632, the same year in which John Locke was born. For the Hebrew name Baruch, which he received at his baptism, he afterwards substituted the Latin equivalent Benedictus. His family, which was poor, committed his education to the hands of the rabbis, and his instructors discovered very early what a treasure they had received in Baruch Spinoza. His mind was exceedingly quick and penetrating; he read and re-read the sacred Scriptures, which were prescribed to him for study, and used to perplex the chief rabbin, Moses Morteira, with the frequency of his puzzling questions, which no one had deigned to put since the days of the oldest patriarch. With the same industry and intelligence he perused the Talmud, and with a similar result. The rabbis shook their heads gravely, and knew not how it might turn out. Their pupil was so earnest and simple, so honest and truthful, in all his inquiries, that they were quite at their wits-end what to make of him. Had he been an immoral boy, they could readily have found a convenient source for his interrogatories in the father of lies. But the lad's goodness rendered such a supposition absurd. The quiet and decided manner in which he went about the tasks assigned to him by the rabbis, and the unconscious daring which he had manifested

in his inquiries into the Holy Scriptures and the Talmud, required of his instructors a larger measure of intelligence than they had been blessed with, and a greater degree of patient watchfulness than they had ever been accustomed to employ. His friends now induced him to commence the study of the Latin language, and he accordingly received his first lessons from a German doctor. This last act presented a fresh source of alarm to the minds of the faithful rabbis. They tax all their vigilance, and by the aid of two young spies, try to entrap their gentle pupil. Spinoza is now in danger, for the frantic rage of a Dutch mob is no slight matter. On investigation it is found that he has had the audacity occasionally to absent himself from the Jewish synagogue. It further appears that he cannot be brought to make a promise of greater regularity even at the expense of bribery. One thousand florins, a large sum for a Jew, have been privately tendered to him to acknowledge the authority of these bearded prophets, but Spinoza, who, in the depths of his confused wanderings, has discovered some gleams of honesty flickering through the dim vaults of his own soul, replies with great calmness and decision that he is not a hypocrite. "Not," says he, "if the pension were tenfold." The engines of the ancient faith are now summoned, and Baruch Spinoza is excommunicated from the fellowship of the faithful, by the dark and horrible appliances known only to the Jewish Church. Spinoza is told of what has happened at the synagogue. His answer he concludes in these words: "I know no better than they what is to become of me, but I have taken nothing which is not mine, and I have done no one any wrong, whatever I may suffer." Father and mother and sisters (for Spinoza had two of them, who were subsequently distinguished by all the grovelling avarice of their race) are now positively forbidden his society, and the quiet lad must seek his occupation and companionship wheresoever he may. Still eager for knowledge, he attached himself to a learned physician, Francis Van den Ende, who was reported not to be so strict as his neighbours in matters of religion, and who kept a school for the better class of young Dutchmen, or others who chose to avail themselves of his instructions. In this school Spinoza became a tutor in mathematics and modern languages, and received in return a knowledge of the Latin language, and some say also of the Greek. His tutor in Latin was the clever daughter of his superior, who, in spite of a tendency to corpulency and other personal defects, gained quite a hold on the affections of the excommunicated Jew. The honest usher would have married the girl, had not a more attractive object to female vanity been found in a certain Herr Kerkering, a rich young merchant from Hamburg, who had likewise taken lessons from the same teacher. The pearl necklaces, and other finery adapted to the female taste, had their due effect, and the blushing Van den Ende, though greatly against her will, was induced to follow to the altar the gay merchant of Hamburg, and to leave Spinoza to heal the wound his heart had received as best he might. The young philosopher took his jilting as quietly as became one of his profession, and applied himself with increased assiduity to his physical and metaphysical studies.

But Spinoza had not yet done with the Jews. Passing by the old Jewish synagogue one night, he received the thrust of a dagger, which just grazed his side, and which was aimed at him by a fanatic of the religion he had just renounced. The cunning rabbis now resolved secretly to destroy the school where he had lately found an asylum. They circulated rumours of the atheism of the superior, and Van den Ende was banished out of Holland. This unfortunate man afterwards sealed his patriotism with his life at Paris in 1674.

Meanwhile Spinoza had to provide for his necessities as he could, and he took to the fashioning of glass lenses, which he came to grind with singular accuracy. With the exception of some time spent in learning the rudiments of drawing, he devoted his whole life to his lenses; that is to say, all the time which he found it necessary to expend upon labour for which he could fairly expect remuneration. As for the rest of his time, what one might misname his leisure hours, he devoted exclusively to speculation. Truth was the loadstar to which he constantly turned, and provided people would only let him alone, he was content to pursue undisturbed his scientific researches, careless alike of what is called fame, or of the noisy reputation which the crowd bestows upon the objects of its admiration. Spinoza was not an ascetic. He dressed himself plainly and neatly; but affected no gaieties such as did not become his position. His fare was exceedingly simple, formed for the most part of alternations of gruel and mutton-broth. His health, certainly, was not robust, and hence, there was an additional reason for the simplicity of his fare. The only luxury he indulged in was a pipe of tobacco. He was of middle stature, of a pleasant countenance, with piercing eyes, a slightly dusky skin and black hair; a good specimen, in short, of a Spanish Jew. Thus did this outcast Hebrew live and work, always gentle and good-humoured, with a kind word and a kind smile for every one.

Spinoza dwelt for some time in 1660 with a familiar acquaintance, who lived between Amsterdam and Auwerkerke. In 1661 he withdrew to the village of Rhynsburg, where he remained for the next four years. It was during his residence here that his friends prevailed upon him to give to the world his first publication, *Cartesii Principia Philosophiæ more geometrico demonstrata*, and added, by way of appendix, *Cogitata Metaphysica*. This work appeared in 1663, with a preface from Louis Meyer, a physician of Amsterdam, who was kind enough to introduce this shy youth to the public. Spinoza had brought a more logical intellect to the study of this subject than its great author could pretend to, and hence his representation of Descartes' philosophy was the clearest and the most concise in existence. This small treatise by the obscure Jew flew over all Europe, and speculators, great and small, were anxious to make his acquaintance. The most notable of the correspondents of this year which have been preserved were Henry Oldenburg, Simon de Vries, and Louis Meyer. In 1664, he accepted an invitation from Jan de Witt, the greatest statesman in Holland, to go to the Hague. He subsequently received from this courtier a pension of L.35 a year. Accordingly, in the month of June we find him removed to Voorburg, some miles from the Hague, which he exchanged, for greater convenience, for a boarding-house, kept by a widow, Van Velden, who lived on the quay. It was in this house that honest old Pastor Colerus, some time before 1698, hired the room once occupied by the philosopher, as bed-room, eating-room, and study, and from which this Protestant clergyman strove to realize to himself something of the man who had once lived and worked there. It was during his residence here he published his *Tractatus Theologico-Politicus*, 1670. The whole of Christendom almost rose in arms against Spinoza, but this did not disturb the philosopher, nor does it seem to have troubled his cogitations. Curious to say, some of the most eminent divines of the present day have held principles exactly similar to those promulgated in this *Tractatus;* but three centuries do much to clear the human vision. Finding this place too expensive (for he must now save time for his books), Spinoza, in 1671, crossed the street to the house of a painter named Van der Spyck, where he spent the remainder of his life. Good, fussy old Colerus gives many a pleasant picture of Spinoza's residence in this household, which cannot here be dwelt upon. Suffice it to say, that the philosopher lost nothing of his honesty and simplicity of character. Sometimes, when wearied with

his meditations, he would draw the children of the family around him, and amuse them by showing them insects in the microscope. He betrayed an interest in all manner of creatures, and a spider-fight would make him laugh immoderately. He usually joined the family in hearing the preaching of Dr Cordes, a good Protestant pastor, and when the day was over, the great philosopher would permit the children of Van der Spyck to scramble all over him. Getting them adjusted he would tell them pleasant stories, and breath over them an atmosphere of gentle solemnity. He would speak to them of their Father in heaven, and one day, he tells them, if they be good children, they may go there to him. And admonishing them to love their earthly parents, and to be kind to one another, he lets his young charge go for the night. This does not look like irreligion, let Pierre Bayle and others croak as they please about atheism.

The year of his removal to Voorburg was the date of his letters to William de Blyenburg, a clever, vain sort of man, who tried, by a rather fulsome letter, to induce Spinoza to write to him. The correspondence soon broke off, however, as Spinoza saw it would be fruitless. The year 1672 was a gloomy one for Spinoza, and for the state of Holland. He lost his best friend, the statesman, Jan de Witt, who was murdered by a frantic mob in the prison of the Hague. This was the only occasion on which the philosopher is said to have displayed violent emotion. He wept like a child, and is said ever afterwards to have avoided the recollection of the scene. Simon de Vries, a wealthy young student of Amsterdam, had for some time been a correspondent of Spinoza's on his darling subject. Coming to the Hague one day, De Vries called on Spinoza, and would have him accept a present of 2000 florins. He had to go sorrowfully away, however, for his simple master had no relish for florins. Shortly after the poor youth died. Spinoza hearing he had been mentioned in his will, hastened to the spot, and could only be prevailed upon by the brother of the deceased to accept of 300 florins. In 1673 Dr Fabritius wrote to Spinoza from the University of Heidelberg, by the Elector Palatine's orders, inviting him to remove thither, and fill the chair of philosophy, *cum amplissimâ philosophandi libertate*. This would not have been an unpleasant invitation to Spinoza, now that his pension and his friend were gone; but as one of the conditions was the elector's hope that the philosopher would contrive to avoid collision with existing beliefs, Spinoza did not see clearly "within what limits his philosophy *could* be restrained," and so he modestly declined. Still the same directness and unconsciousness; still the old simplicity of genius. A professor, he said in addition, was an exalted person, and he had lived all his life as a poor workman; so he resolved to stay with Van der Spyck.

The *Ethica* was now finished, which had cost Spinoza ten of the best years of his life. But when a man does a thing really well, no questions are asked as to the time he expended on it. Spinoza tried to publish this work in the city of Amsterdam, but the troubled state of the theological atmosphere withheld him. The remaining years of his life were employed on a political treatise on the theory of human society, which he did not live to finish; a Hebrew Grammar, also unfinished; and a translation of the Pentateuch, which he destroyed a day or two before his death. Leibnitz had heard of his matchless skill in constructing optical glasses, and he wrote Spinoza one or two letters regarding it, which may be seen, with the optician's answer, in *Epistolæ* 51, 52 of his *Opera*. Spinoza, as has been already mentioned, was a man of very delicate health, and so assiduously had he kept at his duties that he was frequently not seen for many days at a time. A strong frame would have bent under such constant application to the most abstruse studies, and Spinoza had to pay the penalty of his devotion to truth by being prematurely removed from the working world. He had given symptoms of consumption at a very early period, and that insatiable vampire gradually sucked out his life-blood. Here is Colerus's account of his last hours, leaving Bayle's and the rest of them for those who have a relish for such things. On the 21st of February 1677, being the communion Sabbath with the Hague Protestants, the Van der Spyck family were at church. Spinoza, who had been a good deal worse than usual, sent the day previously for Louis Meyer, the physician of Amsterdam. With this friend he had talked about the publication of his *Ethica*, and other matters relating to his effects when he was gone, when the summons came upon him quite suddenly. Van der Spyck returned from church to gaze upon the glassy eyes of what, a short while before, had been his dear friend Benedict Spinoza. He died at the comparatively early age of forty-four years.

There were published after the death of Spinoza, in 1677, his *Ethica Ordine Geometrico Demonstrata et in quinque partes distincta;* his *Tractatus de Intellectus Emendatione;* his *Tractatus Politicus;* his *Epistolæ;* and his *Compendium Grammatices Linguæ Hebrææ*. The edition used in preparing this article is the *Benedicti de Spinoza Opera quæ supersunt omnia*, by C. H. Bruder, 3 vols., Leipsic, 1843.

Numerous biographies, of more or less merit, have been written of Spinoza, of which we may mention the one published at Utrecht, in 1698, by the Lutheran pastor, Johann Colerus, as, with all its faults, unquestionably the best. This book was published in French, at the Hague in 1706. There was issued from the Brussels press, in 1731, *Refutation des Erreurs de Bénoit de Spinoza*, par M. de Fenelon, archeveque de Cambray, par P. Lamy, et par M. le Comte de Boullainvilliers, avec la *Vie de Spinoza*, ecrite par M. Jean Colerus, augmented by a number of particulars drawn from a manuscript of the philosopher's life, made by one of his friends. There is likewise the unfortunate life, or rather caricature, of Spinoza in Bayle's *Dictionnaire*, Amsterdam, 1740. Francis Halma published at Utrecht, in 1698, *Het Leven Van Ben. de Spinoza*, with some notice of his writings. There is likewise *La Vie de Spinoza par un de ses Disciples*, Amsterdam, 1719; and another *Vie*, by another of his disciples, Hamburg, 1735; and a *Leben B. Von Spinoza*, by J. M. Philipson, Braunschw., 1790. He is taken up besides in the collections of N. Barnabite, of Kortholt, and of Saverien. Biographies of Spinoza have likewise been written by the various editors of his works. Among the more recent are Paulus, Gfrörer, Auerbach, Orelli, Bruder, Saintes, and Damiron. Notices of his life have likewise appeared in English in the *Oxford and Cambridge Review* for 1847, and in the *Westminster Review* for 1843. These articles have been attributed respectively to Froude the historian, and to Lewes, author of the *Life of Goethe*. Some fifty authors, of all shades of ability, have written against Spinoza in Latin, Dutch, German, French, and English.

For an analysis of the *Ethica*, and for a critical estimate of its principles, the reader is referred to the article PANTHEISM.

We shall close this biography with a remark or two on the method and spirit of Spinoza's great work. The *Ethica* is logically considered the most perfect book in existence; psychologically, it is one of the most fallacious. Any one who chooses to employ a method of rigorous deduction upon which to construct the universe, must hail the *Ethica* as the paragon of all books that have ever emanated from the human brain. But the man who, while very anxious to get his knowledge into a strictly deducible order, finds, nevertheless, at every step of his preliminary inquiries, that his attention is constantly deflected into the multitudinous and conflicting channel of details that surrounds him, must imperiously feel the utter futility of all logical

Spinoza. attempts at harmonising the sum of knowledge. He at once feels that he must content himself with a much more imperfect comprehension than is held out to him in books like the *Ethica*, that are built up upon the sole principle of order and subordination. All honour to formal logic when employed about its legitimate work, that of analysis and orderly arrangement; but there is perhaps no single faculty of the human mind whose proper function has been so much misunderstood, and so frequently misapplied, both in ancient and modern times. It is really astonishing how many facts of the living world escape one who is perpetually engaged on grinding out of his logical machine the orderly sounds that enliven his fancy or please his taste. The great world-hymn is by much too grand and solemn a thing to be beaten out by patient industry from a paltry music-box of man's construction. No ear ever hears a full diapason of that great world-instrument whose strings stretch to and fro through all time, and are smitten by invisible fingers into the loftiest and deepest music, tremulously shaking the hearts of poets into song, falling in dewy silence on the hearts of thoughtful men, impelling them on in the race of glorious discovery. It is only in fragments that we catch in any case the music of the spheres, and it certainly is never by "discourse of reason" that airy ladder is erected on which the angels of God ascend and descend to the homes of men "on errands of supernal grace." It is only by a rift in the splendid garment in which the universe is enshrined, that one catches the fading glory of a summer's day; it is only a glimpse into the distant regal spirit-world which one exiled on this barren promontory receives, when he rises to the height of the exalted belief that there, the just has died for the unjust, and men are brought near unto God. But neither in the case of the perfectly beautiful, nor in that of the absolutely good, has logic, or any of its laws, aught to do with the matter; and to the being who is caged in behind the iron bars of ratiocination, on all beyond the narrow circle by which he is enclosed, no light shines, and the voice of man is not heard at all. Our hearts are closed by it to tender pity, our ears are shut by it to divine music, and by it we must judge that there is nothing really beautiful in all the world. Spinoza, in pursuing this deductive method as never man has yet pursued it, has left to the world an invaluable legacy of a quite negative kind. The value of his *Ethica* lies entirely in this, that he has determined, once and for all, what the human mind can accomplish in the *à priori* region in which he chose to move. He has left a memorial to all future thinkers of what the discursive reason, by its sole unaided power, can achieve. This merit is Spinoza's by right, that he has put together a book that may fairly challenge the world to produce its equal in strict ratiocinative rigour; but the higher question, of whether he has taken an accurate account of the varied, the ever-changing and even contradictory elements of man's life, is what he cannot answer in the affirmative, and which for ever must stand in his way when claiming our approval of what he has so elaborately designed. Spinoza, and all men both before and since his day, who have absolutely adopted his method, must be content with being designated by the name of *Pantheist.*

No one but the morbidly sentimental can complain of this as harsh treatment of this illustrious thinker. All men who choose to labour in the high field of science are usually known by the complexion of their thoughts, or by the matter to which those thoughts are applied. Designations have been invented, of more or less accuracy, to mark off those workers from their fellow-labourers in the same field, and we have done no more than assign to Spinoza, as has been often done before, the place and the title by which he may be known.

The character of Spinoza is naturally one of the most devout on record, for his life was, in a manner, one unbroken hymn. He was not a pious man, as that word is now usually understood, for he was not a Christian, at least in profession. He had much conversation with the sect of the Mennonites, but it does not appear that he ever subscribed to their faith. Some of the greatest minds which the world has known have owned his superiority, and have loudly proclaimed his fame. Among these not the least illustrious are Novalis, Schleiermacher, Lessing, and Goethe. All these men have bowed down before their intellectual superior in the sphere of reasoning, and have looked up worshipfully to Spinoza, as to their human master, in much that pertained to the nature and the character of Deity. Novalis calls him a "god-intoxicated man," and Schleiermacher calls upon all thinkers to offer up with him "a lock of hair to the manes of the holy but persecuted Spinoza." The thought of these men, all gifted more or less with the highest forms of genius, and widely different in all that can constitute character, finding a common bond of brotherhood in the speculations of this obscure Jew, is suggestive of much curious thought. There is one thing which must have struck the more patient readers of the *Ethica*, and which is likely, more or less, to have been the source of attraction, whether consciously or unconsciously, to all the higher minds who have felt themselves drawn towards the book. It is the deep religious[1] feeling with which it is written. One cannot term it ethical, the word is much too cold to express the thought. The book is in a manner saturated with religiousness. Not that it is so observable in the particular language of any portion of it. It lurks in the hidden depths, from which both thought and language flowed. It floods over, as it were, all the dry propositional details in which the book abounds. It permeates them. It flows round them, over them, beneath them, and through them, with its mysterious motion, covering all that it touches with a kind of sacredness. It is this, much more than the matter of which the book is constituted, which has gained for it so wide a sympathy among all the finer minds who have been brought into contact with it. But it is precisely on this account that the book is calculated not to benefit clever readers, who are not constitutionally thoughtful, who do not see the open secret of this world. It is because the dry skeleton holds so well together, that readers of a certain type are almost sure to wrench it from the deep basis of feeling on which it naturally rests, and drag it out vauntingly before the world. To such persons the work is like the sphinx of old, it devours those who cannot solve its mysteries. It is perhaps as much what men, drawn to the *Ethica*, think into it, that constitutes its main excellence to them, as what they are capable of extracting from its stubborn propositions. (J. D—S.)

Spires. SPIRES (Germ. *Speyer*), a town of Bavaria, capital of the Palatinate, on the left bank of the Rhine, at its confluence with the Speyerbach, 10 miles S.S.W. of Manheim. It is entered by five gates, and surrounded by walls, which enclose a large extent of ground, formerly covered with buildings, but now either entirely vacant or occupied only with gardens. The most remarkable edifice is the cathedral, which is one of the largest structures existing in the Romanesque style of architecture. The east end, which has two high pointed towers and a semicircular termination, is part of the original building founded by the Emperor Conrad in 1027. The rest of the building is all later than 1165; and a great part of it has been built since 1689, when it was partially destroyed by the French. Since 1816, when Spires came into the possession of Bavaria, much has been done to repair and restore the cathedral,

[1] It is hardly necessary to observe, that *religion* is here employed in its purely natural signification, as expressive of that attitude of mind and heart in which one has permanently before his contemplation the things that pertain to a higher state of existence.

and in 1856 the three western towers were rebuilt. In the kings-choir, between the nave and choir of this church, is the burial-place of many of the German emperors. Of the house of Hohenstaufen, Conrad II., Henry III., IV., and V., and Philip, were interred here; also Rudolph of Hapsburg, Adolph of Nassau, and Albert I., the son of Rudolph. These graves were broken into, and their contents scattered by the French in 1689; but the bones were collected again by order of Charles VI., and monuments have been erected to Adolph of Nassau by his descendant the duke William, and to Rudolph by King Louis of Bavaria. The interior of the cathedral is also decorated with frescoes by German artists, some of which are the finest modern works in the country. In a hall of antiquities, to the north-east of the cathedral, are preserved many interesting Roman and mediæval remains found in the Palatinate. Of the old *Ritscher*, or imperial palace, only a single round wall is now preserved. It was in this building that the Diet was held in 1529, at which the Reformed princes gave in the Protest, from whence they obtained the name of Protestants. Spires contains, besides the cathedral, numerous Roman Catholic and Protestant churches, schools, hospitals, public offices, &c. Wax-candles and tobacco are manufactured here, and some trade is carried on. Spires is built on the site of the ancient Noviomagus; and it is one of the most ancient, as it long was one of the chief cities of Germany. At first it was a Roman military station, as a defence against the assaults of the Allemanni, afterwards it was strongly fortified; and, from the time of Charlemagne onwards, it was for a long time the ordinary residence of the emperors of Germany, and the seat of the Diet. During this period its population amounted to 27,000, and its trade was very extensive; but in the seventeenth century it began to decline, and in 1689 was laid in ruins by the French. For many years it lay in ruins, and even when rebuilt it never recovered its former prosperity. A second time it was destroyed by the French in 1794; and it was not till after 1816 that it was restored. Pop. 9500.

SPITALFIELDS, a port of London, in the county of Middlesex, immediately to the N.E. of the city. It is included in the borough of Tower Hamlets, and covers an area of 53 acres, with a population of 15,336. It is chiefly occupied by silk-weavers; and is celebrated for its silk manufactures, which were first established here by French refugees after the revocation of the Edict of Nantes. (See London.)

SPITHEAD. See Portsmouth.

SPITZBERGEN, a group of islands in the Arctic Ocean, lying between N. Lat. 76. 30. and 80. 40., E. Long. 9. and 22., separated from the coast of Greenland on the west by the Greenland Sea, and from Nova Zembla on the east by the Sea of Spitzbergen. There are four large, and a great number of smaller islands. Spitzbergen proper, the largest of the group, is of a very irregular shape. It consists of two parts, West Spitzbergen and New Fresland, or East Spitzbergen, which are connected only by a narrow isthmus. South of the latter of these parts lies Edges Island, separated from the other by Tymens Fiord, a strait about 50 miles long and 10 broad. To the east of New Fresland, and separated from it by Henloopen or Waygatz Strait, is North-East Land; and about 12 miles to the west of Spitzbergen proper lies the long and narrow Charles' Island. A long narrow inlet, called Weide Jans Water, extends into the very heart of the group, separating West Spitzbergen, first from Edges Island, and then from East Spitzbergen, and washing, at its northern extremity, the isthmus that joins the two parts of the main island. The other side of this isthmus is formed by Weide Bay, an inlet running in from the N.E. The other islands of the group are very insignificant; most of them skirt the shores of the larger ones at a short distance. The Thousand Isles to the south of Edges Island, and the Seven Islands to the north of North-East Land, are the principal groups. The entire area of the islands is estimated at 29,460 square miles. The west coast of the largest island is irregular, being penetrated by many small bays and creeks; and it is skirted by lofty mountains, which in some places come quite down to the edge of the sea. The mountains rise to the height of 3000 or 4000 feet; and the valleys between them are either covered with snow, or else, where they are narrow, entirely occupied with glaciers, which in many places reach down to the sea, and form a perpendicular wall of ice several hundred feet in height. South Cape, or Point Lookout, the most southerly headland in Spitzbergen, is a low promontory; but immediately behind it the mountain-chain begins to rise. The greater part of Charles Island is occupied with steep mountains, some of whose peaks attain the height of 4500 feet. The northern shores of the group are not so lofty and rugged as the western. In some places the ground is comparatively level, and not totally destitute of vegetation. The eastern coast of North-East Land is lined almost throughout with glaciers. Of the interior of the islands very little is known. The climate is intensely cold; the mean temperature of the three warmest months on the west coast is not three degrees above the freezing point. For four months the sun never rises above the horizon; and were it not for the brilliancy of the aurora borealis, and the light of the moon when full, the land would be enveloped in total darkness. The vegetation of the islands is very scanty and stunted, as there are not more than forty species of plants found here; but the most of them are very rapid in their growth, springing up, flowering, and bearing seed all within a month or six weeks. The country does not afford sustenance for a single human being; and yet, not only is Spitzbergen frequently visited by whalers, but there have been at several times colonies residing for a length of time on the islands, and one Russian gentleman spent there fifteen years without once leaving the country. Reindeer, polar foxes, and polar bears, are the animals found in Spitzbergen. Whales, walruses, seals, &c., abound in the surrounding sea; and there are large numbers of sea-fowl of different kinds. Spitzbergen was discovered by Barentz, a Dutch navigator, in 1596; though the English afterwards asserted it to have been the land seen by Sir Hugh Willoughby in his unfortunate expedition in 1553. The latter, however, was probably not Spitzbergen, but part of Nova Zembla. The country derived its name from the sharp peaks of its mountains. In the seventeenth century the settlement of Smeerenburg, on the north coast of Spitzbergen, was founded by the Dutch; and this was for a long time a flourishing whaling station. At a later period, Russian adventurers were in the habit of spending a part of the year in hunting and fishing here.

SPOHR, Ludwig, one of the greatest violinists of the German school, and also a distinguished composer, was, according to his own authority, born at Brunswick, on the 5th of April 1784, and not at Seesen in 1783, as has been stated by several writers. His father, a physician, and a skilful amateur flute-player, had the good sense to allow his son every means of cultivating that talent for music manifested in his early boyhood. One writer has asserted that Spohr "showed no early talent for music;" but that seems not only highly improbable, but it is contradicted by the testimony of German and other authors. The violin is an instrument peculiarly requiring a true and delicate musical organization for the attainment of excellence in its handling. Placed under Maucourt, a violinist at the court of the Duke of Brunswick, the boy Spohr made such progress as to be able, when only twelve years old, to play at court a violin concerto of his own composition. At thirteen he was appointed one of the musicians of the duke's chapel. At

sixteen he became a pupil of the celebrated violinist, Franz Eck, with whom he visited St Petersburg and Moscow, remaining in Russia for eighteen months. After his return to Brunswick he made a musical tour through Saxony and Prussia, and, with the consent of his patron, the Duke of Brunswick, accepted the office of music-director at the court of Saxe-Gotha. Soon afterwards he married Dorothea Schindler, one of the best harpists in Germany, and went with her to Vienna, where he was appointed music-director of the theatre An der Wien, an office which he held for several years. He composed for that theatre his *Faust*, his *Jessonda*, his *Zemire und Azor*, and some other operatic works, besides writing several stringed-quartets, &c. In 1817 he visited Italy, and was heard with great applause in the chief towns. Returning from Italy he went to Frankfort-on-the-Maine, to take the place of music-director of the theatre there. In 1819 he visited Paris, where his violin-playing was but coldly received. He went to London in 1820, by invitation of the Philharmonic Society, and performed some of his compositions at the concerts of that society, where also two symphonies and an overture of his were produced. He was much praised by some of the London critics for his purity of tone and high finish, although others found fault with his want of energy and animation. In 1823 he was appointed chapel-master at the court of Hesse-Cassel, which office he resigned in November 1857. In England three of his oratorios were performed and enthusiastically received, especially his *Last Judgment*, but their popularity did not endure. Most of his instrumental music has met with the same treatment in Great Britain; although many of his compositions for the violin are still, and must always be, highly esteemed. Spohr was a great master of the violin, and composed much excellent music for his instrument, in his own peculiar style. He is recorded as one of the best quartet-leaders in Europe, as he always endeavoured to render justice to the author's music, making no inopportune display of his own powers of execution. He was the founder of a new German violin-school, and some of his pupils are now the best violinists in Germany. His method of teaching the violin is shown in his *Violinschule*, a large folio volume, published at Vienna in 1831. It is an excellent work, and should be studied by every aspiring violinist. As a composer of vocal music, Spohr can hold no high place. For voices he writes too instrumentally; and yet it is said of him that his style of violin-playing was really vocal—that "he *sang* upon his instrument!" Many years ago, and in the height of the *furore* regarding Spohr's music in England, we had occasion to publish our opinion of his style of composition. While considering him, in some respects as a great artist, we objected to his want of broad and decided *melody*, and to his perpetual and wearisome use of chromatic intervals in his modulations and harmonies, which gave a character of vagueness and affectation to his compositions. There is a dandyism in musical composition, as well as in bodily dress and bearing. We never thought him a good melodist, nor a solid contrapuntist; and our opinion seems now to be gaining ground in England. Few eminent composers have more widely mistaken the true powers of their art, as well as their own powers, than Spohr. Attempts to express physical or moral phenomena by means of music must, in the nature of things, be always unsuccessful, except in a very limited degree. (See MUSIC, § *Imitative Music.*) Can any thing more absurd be conceived than an attempt, in music, to describe *silence* by means of *sound?* It appears that Spohr was twice married, his first wife, Dorothea Schindler, having died on the 20th of November 1834. At Cassel, he retired from professional life in November 1857. He was indefatigable in composing, notwithstanding his various avocations as a violinist, director, chapel-master, and teacher. A very tall, stalwart, handsome man, his manners appear to have been far from attractive. In society he was discourteous, self-sufficient, and overbearing. He affected to know nothing about the works of great contemporary composers, seeming to consider himself as all in all. If not beloved for modesty and affability, he was through life respected for honest and independent conduct. Dr Ludwig Spohr died at Cassel on the 22d of October 1859. Dr Spohr's chief compositions are—three oratorios, viz., *Die Letzten Dinge; Des Heilands letzte Stunden;* and *Das Jüngste Gericht*, besides a scenic oratorio, *Das befreite Deutschland.* A Mass for two choirs and five voices unaccompanied; three Psalms for two choirs of four voices each; *Vater Unser*, for four voices; Hymn for four choirs, four solo voices, and grand orchestra. Seven dramatic operas—viz., *Der Zweikampf der Geliebten; Der Berggeist; Faust; Jessonda; Zemire und Azor; Peter von Albano; Der Alchymist.* Songs for four male voices; Scene and air (Italian words), with orchestra; Songs for a voice and piano, seven sets. Six grand Symphonies; four Overtures; Nonetto, for nine stringed and wind instruments; Ottetto, for five stringed and three wind instruments; three Double Quartets, for four violins, two altos, and two violoncellos; four stringed Quintets; fourteen sets of stringed Quartets; five sets of violin Duets; two concerted Symphonies for two violins; thirteen violin Concertos; two clarinet Concertos; four *Pot-pourris* for violin and orchestra; Quintet for piano, flute, clarinet, horn, and bassoon; Sonatas, Rondeauxs, and Fantaisies. Spohr's *Autobiography* is at present (April 1860) passing through the press in Germany. (G. F. G.)

SPOILS, whatever is taken from the enemy in time of war. Among the ancient Greeks, the spoils were divided among the whole army, only the general's share was the largest; but among the Romans the spoils belonged to the republic.

SPOLETO, a delegation of the Papal States, bounded on the N. by those of Perugia and Camerino, E. by that of Ascoli and the kingdom of Naples, S. by the delegation of Rieti, and W. by that of Viterbo; area, 1130 square miles. The eastern part of the country is occupied by the central chain of the Apennines, including the two loftiest peaks within the Papal dominions; Monte della Sibilla (7300 feet), and Monte Vittore (8130 feet). Various branches of this main ridge extend towards the west, and the delegation is thus, as a whole, mountainous. The greater part of the country is watered by affluents of the Tiber; but a small portion, east of the water-sheds of the Apennines, sends its waters into the Adriatic by the Tronto. On the west, the Maroggia flows northwards and joins the Topino, an affluent of the Tiber; and the Nera, a little to the east of the former river, flows southwards and falls into the Tiber. Between these two rivers rises a ridge called the Mountains of Somma. The valley of the Maroggia is the most fertile part of the whole country; it produces in abundance maize, wheat, pulse, wine, oil, and various fruits. The forests afford much valuable timber. Large numbers of cattle are reared, and much cheese is made. Among the minerals of the country are limestone, marble, gypsum, and potter's clay. Hardly any manufactures or trade are carried on here. Pop. (1853) 134,939.

SPOLETO, the capital of the above delegation, on the side of a steep hill above the Maroggia, 61 miles N.N.E. of Rome. It consists of narrow, crooked streets, lined with houses, not very well built. In a commanding position stands the cathedral, an edifice erected in the time of the Lombard dukes of Spoleto, and still retaining some traces of its original Gothic architecture in five pointed arches, which are now supported by Grecian pillars, introduced by Bramante. In the interior are many interesting monuments and works of art. There are in the town several other churches, a citadel, originally built by Theodoric, king of the Goths,

a town-hall, and a fine palace, belonging to the Ancajani family. Spoleto is the seat of a bishop, and has a college, manufactories of hats and woollen cloth, and some trade in corn, wine, and oil. It occupies the site of the ancient Spoletium, which does not seem to have existed before the Romans established a colony here in 240 B.C. In the second Punic War, after the battle of Lake Trasimenus, Hannibal made an assault on the town, but was repulsed with vigour, and the colony remained faithful to the Roman cause throughout the whole of the war. While the Western Empire continued, Spoletium remained a large and flourishing town. It was partly destroyed by the Goths; but under the Lombards it became the capital of a duchy, which continued to exist independently till the 12th century. There are some interesting Roman remains at Spoleto. Pop. 8500.

SPONDEE. See Foot.

SPONGES. See Zoophytes, § *Polypes*.

SPORADES, the ancient name of a group of islands in the Ægean Sea, which were so called because they were irregularly scattered, in opposition to the Cyclades, which lay in a circle round Delos. Their names, as enumerated by Strabo, are—Pholegandros, Sicinos, Ios, Thera, Therasia, Anaphe, Lagusa, Amorgos, Astypalæa, Icaria, the Corassiæ, Patmos, Leria, Lebinthos, the Calydnæ, Nisyros, Telos, Chalcia, and Casos. Pliny gives a much longer list of the Sporades, and some geographers include this group among that of the Cyclades. The most important of the islands are described under their several names.

SPOTSWOOD, or Spotiswood, John, Archbishop of St Andrews, was descended from the lairds of Spotswood in the county of Berwick, and was born in the year 1565, being the son of John Spotswood, minister of Calder, and one of the superintendents. He was educated in the University of Glasgow, and succeeded his father in the parsonage of Calder when but 18 years of age. In 1601 he attended Lodowick Duke of Lennox as his chaplain, in an embassy to the court of France for confirming the ancient amity between the two nations, and returned in the ambassador's retinue through England. When he entered upon the archbishopric of Glasgow, he found there was not L.100 sterling of yearly revenue left; yet such was his care for his successors that he greatly improved it, much to the satisfaction of his diocese. After having filled this see eleven years, he was raised to that of St Andrews in 1615, and thus became primate and metropolitan of all Scotland. He presided in several assemblies for bringing the Church of Scotland to some degree of uniformity with that of England. He continued in high esteem with King James VI., nor was he less valued by King Charles I., who was crowned by him in 1633, in the abbey-church of Holyrood House. In 1635, upon the death of the Earl of Kinnoul, chancellor of Scotland, the primate was advanced to that post; but he had scarcely held it four years, when the confusions beginning in Scotland, he was obliged to retire into England; and being wasted with age, grief, and sickness, died at London on the 26th December 1639, and was interred in Westminster Abbey. The only work which he is known to have published bears the title of *Refutatio Libelli de Regimine Ecclesiæ Scoticanæ*, Lond., 1620, 8vo. This was an answer to a tract of Calderwood, who replied in the *Vindiciæ* subjoined to his *Altare Damascenum*. A more considerable work was published several years after his death—*The History of the Church and State of Scotland, beginning the year of our Lord* 203, *and continued to the end of the reign of James VI. of ever blessed memory*, Lond., 1655, fol. An Appendix was afterwards added by Thomas Middleton. The character of Spotswood is thus delineated by Laing:—"In prosperity his behaviour was without moderation, in adversity without dignity; but the character of a leading, aspiring prelate has either been unduly extolled, or unjustly degraded. As a scholar and a historian he excelled his cotemporaries; and it was his peculiar felicity that his erudition was neither infected with the pedantry nor confined to the polemical disputes of the age. His abilities recommended him first to preferment; but his ambitious views were chiefly promoted by the supple, insinuative habits of craft and intrigue. His revenge was formidable to the nobility and officers of state, oppressive to the clergy, and, joined with an inordinate ambition, ultimately ruinous to his own order."—Laing's *History of Scotland*, vol. iii., p. 154.

SPRAT, Thomas, Bishop of Rochester, was born in 1636 at Tallaton in Devonshire. He received his education at Oxford, and after the Restoration entered into holy orders. In 1659 he published two indifferent poems, on the *Death of O. Cromwell*, and on the *Plague of Athens*. He became fellow of the Royal Society, chaplain to George Duke of Buckingham, and chaplain in ordinary to King Charles II. In 1677 he published the *History of the Royal Society*, and a *Life of Cowley*, who, by his last will, left to his care his printed works and MSS., which were accordingly published by him. In 1668 he was installed prebendary of Westminster; in 1680, he was appointed canon of Windsor; in 1683, dean of Westminster; and in 1684, consecrated to the bishopric of Rochester. He was clerk of the closet to King James II., and in 1685 was made dean of the chapel-royal; and the year following was appointed one of the commissioners for ecclesiastical affairs. In 1692 his lordship, with several other persons, was charged with treason by two men, who drew up an association, in which they whose names were inscribed declared their resolution to restore King James, to seize the Princess of Orange, dead or alive, and to be ready with 30,000 men to meet King James when he should land. To this they put the names of Sancroft, Sprat, Marlborough, Salisbury, and others. The bishop was arrested, and kept at a messenger's, under a strict guard, for eleven days. His house was searched, and his papers seized, among which nothing was found of treasonable appearance, except one memorandum, in the following words: "Thorough-paced doctrine." Being asked at his examination the meaning of the words, he said, that about twenty years before, curiosity had led him to hear Daniel Burgess preach; and that being struck with his account of a certain kind of doctrine, which he said "entered at one ear, and pacing through the head went out at the other," he had inserted the memoranda in his table-book, that he might not lose the substance of so strange a sermon. His innocence being proved, he was set at liberty, when he published an account of his examination and deliverance, which made such an impression upon him that he commemorated it through life by a yearly day of thanksgiving. He lived till the 77th year of his age, and died May 20, 1713. His other works are—*An Answer to Sorbiere; The History of the Rye-House Plot; The Relation of his own Examination*; and a volume of *Sermons*. The following favourable estimate of Sprat's abilities by the late Lord Macaulay deserves to be recorded. Thomas Sprat "was a man to whose talents posterity has scarcely done justice. Unhappily for his fame, it has been usual to print his verses in collections of the British poets; and those who judge of him by his verses must consider him as a servile imitator, who, without one spark of Cowley's admirable genius, mimicked whatever was least commendable in Cowley's manner; but those who are acquainted with Sprat's prose writings will form a very different estimate of his powers. He was indeed a very great master of our language, and possessed at once the eloquence of the orator, of the controversialist, and of the historian." (*Hist. of England*, vol. ii., p. 95, 1858.)

SPRENGEL, Kurt, a learned botanist of Germany,

was born on the 3d of August 1766, at Boldekow, in Pomerania. His father, who was a clergyman, superintended his early education, and succeeded in laying a broad and solid foundation of scholarship, on which Sprengel in after years reared so much. In addition to the ordinary classical authors, he united a knowledge of Hebrew and Arabic, and had already begun the study of botany, as his small work, *Anleitung Zur Botanik für Frauenzimmer*, 1780, still testifies. He began his studies in theology and medicine in Halle in 1784, and took his medical degree there three years afterwards. In 1789 he was appointed extraordinary professor of medicine in Halle; in 1795 he was advanced to be ordinary professor in the same department; and two years subsequently was made professor of botany. Since he began his studies at Halle he had published his *Beiträge zur Geschichte des Pulses*, 1787; *Galens Fieberlehre*, 1788; *Apologie des Hippokrates*, 1789; *Versuch einer pragmat. Gesch. der Arzneikunde*, 1792–99; and his *Handbuch der Pathologie*, 1795–97. The celebrity of these works brought Sprengel into notice, and he got numerous calls to fill various important chairs, both in and out of Germany. All such invitations he respectfully declined, and continued a close resident in his *Alma Mater* to the end of his life. Learned societies vied with each other in bestowing honours on the learned botanist of Halle. Upwards of seventy academies, learned and otherwise, presented him with their honorary diplomas. Kings also conferred on him their royal badges of distinction. Sprengel's head was not turned by such amazing success; he continued industriously to ply his favourite studies, by which he ultimately became one of the most learned men in Germany.

The record of Sprengel's works is the story of his life. He published his *Antiquitates Botanicæ* in 1798, which was followed by his *Geschichte der Medicin*, 1820, which had been begun in 1792. His *Historia Rei Herbariæ*, 1807; his *Institutiones Medicæ*, 1809–16; his *Flora Halensis*, 1806; and his *Von dem Bau und der Natur der Gewächse* 1811, form the most important of his works. Sprengel died of grief for the loss of his son, who had been professor of surgery at Greifwald, on the 15th of March 1833.

SPRINGFIELD, a town of the United States of North America, in Massachusetts, on the left bank of the Connecticut, 98 miles W. by S. of Boston, and 138 N.N.E. from New York. It occupies a fine situation, on a flat tract near the river and a rising ground beyond, and is for the most part well built of brick. The streets extend either parallel to the river, or at right angles to it, and in the centre of the town is an open space, containing fine trees and public walks. There are 12 or 13 churches, belonging to different sects, many schools, and two newspaper offices. Springfield contains the largest arsenal in the United States. It is in an elevated position, built of brick, and covers about 20 acres. There are about 20 water-wheels and 30 forges in connection with it; from 250 to 300 hands are employed; and about 15,000 muskets are annually manufactured. About 175,000 stand of arms are kept continually in store at this arsenal. Springfield has also manufactories of paper, iron, locomotives, and various kinds of machinery. The size and prosperity of the town are rapidly increasing. Pop. (1850) 11,766.

Springfield, the capital of the state of Illinois, one of the United States of North America, in the midst of wide, rich prairies, 96 miles N.N.E. of St Louis. It is regularly laid out, with a public square, and several wide, handsome streets. The chief buildings are the state-house, court-house, banks, churches, academies, &c. The town was founded in 1822, and had in 1853 about 6500 inhabitants.

Springfield, a town of the United States of North America, in Ohio, stands in a fertile and well-cultivated district, 84 miles N.N.E. of Cincinnati. It contains numerous churches, schools, public libraries, and newspaper offices. Cotton and woollen cloth, paper, and machinery, are manufactured in the vicinity. Pop. (1850) 5108.

SPRINGS. See Physical Geography, § 197, &c.

SPROTTAN, a town of the Prussian monarchy, province of Silesia, and government and 37 miles N.W. of Liegnitz, at the confluence of the Bober and the Sprottan. It is walled and entered by three gates, and it contains several Protestant and Roman Catholic churches, a court of law, public offices, an hospital, &c. Cotton cloth and hosiery are made here. Pop. 5049.

SPURZHEIM, Johann Gaspar, the pupil and colleague of Dr Gall in the elucidation of the structure and functions of the brain, was born near Treves, on the 31st of December 1776. His father, who cultivated a farm in that district, at first intended him for the church; but, after prosecuting his studies with this view, a change of purpose took place, and young Spurzheim went in 1799 to acquire a medical education at Vienna, where he soon became acquainted with Dr Gall. The views of that physician concerning the brain proved so interesting to him that, after bestowing attention upon them for several years, he at length, in 1804, became the associate of his master. In the following year, when Gall was forced by the Austrian government to leave Vienna (See Gall, F. J.), Spurzheim accompanied him in his travels through Germany, France, and Denmark. In 1807 they settled in Paris, and next year presented to the Institute a memoir of their anatomical discoveries. A committee, of which Cuvier was the leading member, was appointed to give an opinion of it: a translation of their unfavourable and, as the phrenologists say, uncandid report, will be found in the *Edinburgh Medical and Surgical Journal* for January 1809. This report being unsatisfactory to Gall and Spurzheim, they published their memoir, and a defence of it, under the title of *Recherches sur le Système Nerveux en général, et sur celui du Cerveau en particulier*, 4to, 1809. In 1810 was commenced the publication of the *Anatomie et Physiologie du Système Nerveux en général, et du Cerveau en particulier*, par F. J. Gall et G. Spurzheim, 4to, a work which was not completed till 1819. The third and fourth volumes were published after Spurzheim's separation from Gall in 1813, and bear the name of the latter alone. It is illustrated by a magnificent folio atlas, containing 100 plates. The physiological portion of this work was afterwards reprinted in 6 vols. 8vo, by Dr Gall, with his own name only, under the title, *Sur les Fonctions du Cerveau.*

Having left Dr Gall, Spurzheim, after taking his degree of doctor of physic at Vienna, came over to Britain in 1814, for the purpose of diffusing the new doctrines about the brain. His first step was the publication of *The Physiognomical System of Drs Gall and Spurzheim*, 8vo, London, 1815; followed by *Outlines of the Physiognomical System*, 12mo, 1815, and *Observations on the Deranged Manifestations of Mind, or Insanity*, 8vo, 1817. The anatomical and physiological views expounded in the first of these works having been violently assailed by the late Dr John Gordon in the 25th volume of the *Edinburgh Review*, Spurzheim suddenly made his appearance in the northern metropolis, and in the lecture-room of his opponent demonstrated by dissection the accuracy of his anatomical assertions. To the hostile article referred to he also replied at considerable length in his *Examination of the Objections made in Britain against the Doctrines of Gall and Spurzheim*, 8vo, Edinb., 1817. After lecturing in London, Dublin, Edinburgh, and other towns in the United Kingdom, he returned in 1817 to Paris, where he continued to lecture and publish till 1825. The works which he produced during this period are *Observations sur la Folie, ou sur les Dérangemens des Fonctions Morales et Intellectuelles de l'Homme*, 8vo, 1818; *Observations sur la Phré-*

nologie, ou la Connaissance de l'Homme Morale et Intellectuel, fondée sur les Fonctions du Système Nerveux, 8vo, 1818; and *Essai Philosophique sur la Nature Morale et Intellectuelle de l'Homme*, 8vo, 1820. His English work, entitled, *View of the Elementary Principles of Education, founded on the Study of the Nature of Man*, 12mo, appeared at Edinburgh in 1821, and was reprinted, with considerable additions, in 8vo, at London, in 1828. A French edition was published at Paris in 1822. A prohibition in 1824, by the French government, of the delivery of lectures without its special permission, obliged Spurzheim to confine himself to private conversations in his own house, and induced him in the following year to revisit Britain. While residing in London, where he gave several courses of lectures and dissections of the brain, he produced his *Phrenology, or the Doctrine of the Mind and of the Relations between its Manifestations and the body*, and *A View of the Philosophical Principles of Phrenology*, both 8vo, 1825: these are extended editions of some of the chapters of the *Physiognomical System.* He returned to Paris, but again visiting England in 1826, lectured to overflowing audiences in the London Institution, and in the same year published *Phrenology in Connection with the Study of Physiognomy*, 8vo, with 34 plates; also, *The Anatomy of the Brain, with a General View of the Nervous System*, 8vo, with 11 plates. Towards the end of this year, he lectured at Cambridge, and, after expounding his views in Bath and Bristol, delivered, in April 1827, a course of lectures to seven hundred auditors in the London Institution. His *Outlines of Phrenology* were published in the same year, at the close of which he visited Hull, whence he once more proceeded to Edinburgh, delivering in that city two courses of popular lectures, besides a professional course on the anatomy, physiology, and pathology of the brain. From Edinburgh he proceeded to Glasgow, and afterwards to London, where he had now fixed his residence. In 1828 appeared his *Sketch of the Natural Laws of Man*, 12mo, and on 14th May 1829 a paper of his on the brain was read before the Royal Society, into whose *Transactions*, however, it was refused admittance. It was published by Dr Spurzheim as an appendix to his *Anatomy of the Brain*, along with some pretty free *Remarks on Mr Charles Bell's Animadversions on Phrenology.* He this year lectured in many English towns, and in the following spring accepted of an invitation to Dublin, where he was created an honorary member of the Royal Irish Academy. After again lecturing there in 1831, he fixed his residence in Paris, and published in 1832 a small *Manuel de Phrénologie*, which is the last of his works. For the twofold purpose of diffusing phrenology and studying the American character and institutions, he sailed for the United States on 20th June 1832. Unfortunately, the climate proved detrimental to his constitution, which was injured still more by over-exertion and incautious exposure while lecturing at Boston; the consequence was a fever, which terminated in his death on the 10th of November 1832. His remains were honoured at Boston with a public funeral, at which an oration was delivered by Dr Follen, Professor of German in Harvard University.

As a phrenologist, Dr Spurzheim is generally regarded by his British disciples as having improved the philosophical aspect of phrenology, by classifying the facts better than Dr Gall, and also by pursuing them farther into their philosophical, moral, and practical results. At the same time, it appears to be the opinion of many that he sometimes proceeded to systematise prematurely, and that in his latter years he occasionally modified his views rather through caprice than from reason, or from the accumulation of new observations. It is justly objected to his writings, in comparison with those of Gall, that, in announcing his discoveries, he details neither the circumstances in which they were made, nor the cases by which they are supported. There has been much controversy on the relative merits of these two physicians, in extending the boundaries of phrenology and elucidating the anatomy of the brain. On this subject, the curious reader may consult the *Phrenological Journal*, ii. 185, vi. 307, and xi. 225; the preface to Spurzheim's *Anatomy of the Brain;* the *Memoir by Carmichael*, 1833; and the *Foreign Quarterly Review*, volume ii. (R. C—X.)

SQUARING, or QUADRATURE OF THE CIRCLE, signifies the finding a square exactly equal to the area of a given circle. This problem, however, has not been, and probably cannot be, strictly resolved by the commonly admitted principles of geometry, mathematicians having hitherto been unable to do more than to find a square that shall differ from the area of any proposed circle by as small a quantity as they please. The problem is of the same degree of difficulty, and indeed may be regarded as identical with another geometrical problem, namely, the *rectification of the circle*, or the finding a straight line equal to its circumference, for the area of a circle is equal to that of a rectangle contained by the radius and a straight line equal to half the circumference; therefore, if a straight line exactly equal to the circumference could be found, a rectilineal space precisely equal to the area might also be found, and the contrary. But although no perfectly accurate resolution of the problem has been obtained under either form, we can always find approximate values of the area and circumference, and it is now customary to apply the terms *quadrature* and *rectification* of the circle also to these.

The problem of the quadrature of the circle appears to have engaged the attention of geometers at a very early period, for we are told that Anaxagoras, who lived about five hundred years before Christ, attempted its solution while confined in prison on account of his philosophical opinions. We are ignorant of the result of his researches; but, although we cannot suppose they were attended with any success, we may reasonably conclude that we are indebted to them for the discovery of some of the properties of the figure, which are now known as elementary propositions in geometry.

Hippocrates of Chios was likewise engaged in trying to resolve the same problem, and it was no doubt in the course of his inquiries into this subject, that he discovered the quadrature of the curvilineal space, which is now known by the name of the *Lune* of Hippocrates. The nature of this discovery may be briefly explained as follows. Let ABCD be a circle, H its centre, AC its diameter, ADC a triangle inscribed in the semicircle, having its sides, AD, DC equal to one another. On D as a centre, with DA or DC as a radius, let the quadrantal arch AEC be described, then shall the curvilineal space bounded by the semicircle ABC and the quadrantal arch AEC (which is the *Lune* of Hippocrates), be equal to the rectilineal triangle ADC.

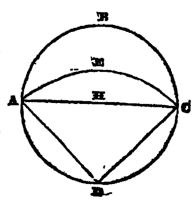


Fig. 1.

Although Hippocrates' discovery has led to no important conclusion either relating to the quadrature of the circle or that of any other curve, yet, at the time it was made, it might be regarded as of some consequence, chiefly because it showed the possibility of exhibiting a rectilineal figure equal to a space bounded by curve lines, a thing which we have reason to suppose was then done for the first time, and might have been fairly doubted, considering the insuperable difficulty that was found to attend the quadrature of the circle or its rectification.

Aristotle speaks of two persons, namely, Bryson and Antiphon, who, about his time, or a little earlier, were occu-

Squaring. pied with the quadrature of the circle. The former appears, according to the testimony of Alexander Aphrodiseus, to have erred most egregiously, he having concluded that the circumference was exactly $3\frac{3}{4}$ times the diameter. And the latter seems to have proceeded in the same manner as Archimedes afterwards did in squaring the parabola, that is, by first inscribing a square in the circle, then an isosceles triangle in each of the segments of the curve, having for its base a side of the square, and next again a series of triangles in the segments, having for their bases the sides of the former series, and so on. This mode of procedure, however, was not attended with success, as these spaces do not, as in the case of the parabola, admit of being absolutely summed.

It may be supposed that Archimedes exerted his utmost efforts to resolve this problem, and probably it was only after long meditation on the subject that he lost all hopes of success, and contented himself with that approximation to the ratio of the diameter to the circumference which is contained in his treatise *De Circuli Dimensione.* He found his approximation to the ratio, by supposing a regular polygon of ninety-six sides, to be described about the circle, and another of the same number to be inscribed in it, and by showing that the perimeter of the circumscribing polygon was less than $3\frac{10}{70}$ or $3\frac{1}{7}$ times the diameter, but that the perimeter of the inscribed figure was greater than $3\frac{10}{71}$ times the diameter; now, the circumference of the circle being less than the perimeter of the one polygon, but greater than that of the other, it follows that the circumference must be less than $3\frac{1}{7}$ times the diameter, but greater than $3\frac{10}{71}$ times, so that, taking the first of these limits, as being expressed by the smallest numbers, the circumference will be to the diameter as $3\frac{1}{7}$ to 1, or as 22 to 7 nearly.

Although the ratio found by Archimedes be the oldest known in the western world, yet one more accurate was known at a much earlier period in India. This we learn from the Institutes of Akbar (*Ayeen Akberry*), where it is said that the Hindoos suppose the diameter of a circle to be to its circumference as 1250 to 3927. Now, this ratio must have required the inscription of a polygon of 768 sides in the circle, and must have been attended with nine extractions of the square root, each carried as far as ten places of figures.

We learn from Simplicius that Nicomedes and Apollonius both attempted to square the circle, the former by means of a curve, which he called the *quadratrix;* the invention of which, however, is ascribed to Dinostratus, and the latter, by the help of a curve, denominated the sister to the tortuous line, or *spiral*, and which was probably the quadratrix of Dinostratus; the nature of which, and the manner of its application to the subject in question, we shall briefly explain.

Let AFB be a quadrant of a circle (fig. 2), and C its centre; and conceive the radius CF to revolve uniformly about C, from the position CA, until at last it coincide with CB; while at the same time a line DG is carried with a uniform motion from A towards CB; the former line continuing always parallel to the latter, until at last they coincide; both motions being supposed to begin and end at the same instant; the point E, in which the revolving radius CF, and the movable line DG intersect one another, will generate a certain curve line AEH, which is the *quadratrix* of Dinostratus.

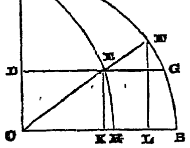


Fig. 2.

Draw EK, FL both perpendicular to CB; then because the radius AC and the quadrantal arch AFB, are uniformly generated in the same time by the points D and F, the contemporaneous spaces described will have to one another the same ratio as the whole spaces; that is, AD : AF : : AC : AB; hence we have AC : AB : : DC, or EK : FB. Now, as the moveable point F approaches to B, the ratio of the straight line EK to the arch FB will approach to, and will manifestly be ultimately the same as the ratio of the straight line EK to the straight line FL, which again is equal to the ratio of CE to CF; therefore the ratio of the radius AC to the quadrantal arch AFB is the limit of the ratio of CE to CF, and consequently equal to the ratio of CH to CB, H being the point in which the quadratrix meets CB. Since therefore CH : CB : : CA, or CB : quad. arch AFB, if by any means we could determine the point H, we might then find a straight line equal to the quadrantal arch (by finding a third proportional to CH and CB), and consequently a straight line equal to the circumference. The point H, however, cannot be determined by a geometrical construction, and therefore all the ingenuity evinced by the person who first thought of this method of rectifying the circle (which certainly is considerable), has been unavailing.

The Arabs, who succeeded the Greeks in the cultivation of the sciences, would no doubt have their pretended squares of the circle. We, however, know nothing more than that one of them believed he had discovered that the diameter being unity, the circumference was the square root of 10; a very gross mistake; for the square root of 10 exceeds 3·162; but Archimedes had demonstrated that the circumference was less than 3·143.

It appears that, during the dark ages, some attempts were made at the resolution of this famous problem, which, however, have always remained in manuscripts, buried in the dust of old libraries. But upon the revival of learning, the problem was again agitated by different writers, and particularly by the celebrated Cardinal De Cusa, who distinguished himself by his unfortunate attempt to resolve it. His mode of investigation, which had no solid foundation in geometry, led him to conclude, that if a line equal to the sum of the radius of a circle, and the side of its inscribed square were made the diameter of another circle, and an equilateral triangle were inscribed in this last, the perimeter of this triangle would be equal to the circumference of the other circle. This pretended quadrature was refuted by Regiomontanus.

It would be trespassing too much upon the patience of our readers were we to mention all the absurd and erroneous attempts which have been made during the last three centuries to square the circle. In a supplement to Montucla's *Histoire des Mathematiques*, we find upwards of forty pretenders to the honour of this discovery enumerated. They were almost all very ignorant of geometry; and many of them were wild visionaries, pretending to discover inexplicable relations between the plain truths of mathematics and the most mysterious doctrines of religion. From such persons as have generally pursued this inquiry, no improvement whatever of the science was to be expected; although, in some instances, it has derived advantage from the labours of such as have undertaken to expose the absurdity of their conclusions; as in the case of Metius, who in refuting the quadrature of one Simon à Quercu, found a much nearer approximation to the ratio of the diameter to the circumference than had been previously known in Europe, namely that of 113 to 355.

Among the most remarkable of those who have undertaken to resolve this problem, we cannot fail to enumerate Joseph Scaliger, a man of stupendous erudition. Full of confidence in his own powers, he believed that, entering upon the study of geometry, he could not fail to surmount by the force of his genius those obstacles which had completely stopped the progress of all preceding inquirers. He gave the result of his meditations to the world in 1592, under the title *Nova Cyclometria;* but he was refuted by Clavius, by Vieta, and others, who showed that the magnitude which he had

assigned to the circumference was a little *less* than the perimeter of the inscribed polygon of 192 sides, which proved beyond a doubt that he was wrong. Scaliger, however, was not to be convinced of the absurdity of his conclusion; and indeed, in almost every instance, pretenders to this discovery have not been more remarkable for their egregious errors, than for their obstinacy in maintaining that they were in the right, and all who held a contrary opinion in the wrong.

The famous Hobbes came also upon the field about the year 1650, with pretensions not only to the quadrature of the circle, but also to the trisection of an angle, the rectification of the parabola, &c.; but his pretended solutions were refuted by Dr Wallis. And this circumstance afforded him occasion to write not only against geometers, but even against the science of geometry itself.

We find it recorded by Montucla, as a sort of phenomenon, that one Richard White, an English Jesuit, having happened upon what he conceived to be a quadrature of the circle, which he published under the title, *Chrysæspis, seu Quadratura Circuli*, suffered himself at last to be convinced by some of his friends that he was wrong. But a solution of the same problem, found out by one Mathulen of Lyon, did not end in so much advantage to its author. This man in 1728 announced to the world that he had discovered both the quadrature of the circle and a perpetual motion; and he was so certain of the truth of these discoveries that he consigned 1000 *ecus* (about L.125) to be paid to any one who should demonstrate that he was deceived in either. The task was not difficult. Nicole of the Academy of Sciences demonstrated that he was wrong, and he himself allowed it; but he hesitated to pay the money, which Nicole had relinquished in favour of the Hotel Dieu of Lyon. The affair went before a court of justice, which adjudged the money to be paid, as Nicole had destined it, to the poor. At a later period, namely, in 1753, the Chevalier de Causans, a French officer, and a man who was never supposed to be a mathematician, suddenly found a quadrature of the circle in procuring a circular piece of turf to be cut; and rising from one truth to another, he explained by his quadrature the doctrine of original sin, and the Trinity! He engaged himself, by a public writing, to deposit with a notary the sum of 300,000 francs, to be wagered against such as should oppose him, and he actually lodged 10,000, which were to devolve to him who should demonstrate his error. This was easily done, as it resulted from his discovery that a circle was equal to its circumscribing square, that is, a part to the whole. Some persons came forward to answer his challenge, and in particular a young lady sued him at one of the courts of law; but the French king judged that the chevalier's fortune ought not to suffer on account of his whim; for, setting aside this piece of folly, in every other respect he was a worthy man. The procedure was therefore stopped, and the wager declared void.

We shall not enter further into the history of these vain and absurd attempts to resolve this important problem, but proceed to state what has actually been done by men of sound minds and real mathematical acquirements towards its solution. And in the first place, it may be observed that the problem admits of being proposed under two different forms; for it may be required to find either the area of the whole circle, or, which is the same thing, the length of the whole circumference; or else to find the area of any proposed sector or segment, or, which is equivalent, the length of the arch of the sector or segment. The former is termed the *definite*, and the latter the *indefinite* quadrature of the circle. The latter evidently is more general than the former, and includes it as a particular case. Now, if we could find by any means a finite algebraic equation that should express the relation between any proposed arch of a circle, and some known straight line, or lines, the magnitude of one or more of which depended on that arch, then we would have an absolute rectification of the arch, and consequently a rectification or quadrature of the whole circle. We here speak of an analytical solution; the ancients, who were almost entirely ignorant of this branch of mathematical science, must have endeavoured to treat it entirely upon geometrical principles. It is now well known, however, that all geometrical problems may be subjected to analysis; and that it is only by such a mode of proceeding they have in many cases been resolved.

With respect to the definite quadrature of the circle, no unexceptionable demonstration of its impossibility has hitherto been published. It is true, that James Gregory, in his *Vera Circuli et Hyperbolæ Quadratura*, has given what he considered as such a demonstration; but it was objected to by Huygens, one of the best geometers of his time. It is certain that the ratio of the diameter to the circumference, also, that the ratio of the square of the diameter to the square of a straight line equal to the circumference, cannot be expressed by rational numbers, for this has been strictly demonstrated by Lambert in the Berlin Memoirs for 1761. A demonstration is also given in Legendre's *Geometrie*. As to the indefinite quadrature, if Newton's demonstration of the twenty-eighth lemma of the first book of his *Principia* be correct, the thing ought to be absolutely impossible. For the object of that proposition is to prove, that in no oval figure whatever, that returns into itself, can the area cut off by straight lines at pleasure be universally found by an equation of a finite dimension, and composed of a finite number of terms. If this be true, then it will be impossible to express any sector of a circle taken at pleasure in finite terms. It is, however, to be remarked, that the accuracy of the reasoning by which Newton has attempted to establish the truth of the general proposition has been questioned by no less a geometer than D'Alembert: and indeed we know one oval curve, which returns into itself, and which according to Newton's proposition ought therefore not to admit of an indefinite quadrature; yet this is by no means the case, for it does really admit of such a quadrature. The curve we mean is the *lemniscata*, whose figure is nearly that of the numeral character 8. Upon the whole, then, we may infer that an unexceptionable demonstration of the impossibility of expressing either the whole circle, or any proposed sector of it, by a finite-equation, is still among the *desiderata* of mathematics.

Of the different methods which have been found for approximating to the area or to the circumference, that of Archimedes is the only one found by the ancients in the western world that has descended to modern times, and it appears to have been the most accurate known, until about the year 1585, when Metius, in refuting a pretended quadrature, found a more accurate ratio of 113 to 355, as we have already noticed. About the same time Vieta and Adrianus Romanus published their ratios, the former carrying the approximation to ten decimals instead of six (which was that of Metius's ratio), and the latter extending it to 17 figures. Vieta also gave a kind of series, which being continued to infinity, gave the value of the circle.

These approximations, however, were far exceeded by that of Ludolph Van Ceulen, who, in a work published in Dutch in 1610, carried it as far as 36 figures, showing that if the diameter were unity, the circumference would be greater than 3·14159,26535,89793,23846,26433,83279,50288, but less than the same number with the last figure increased by an unit. In finding this approximation, Van Ceulen followed the method of Archimedes, doubling continually the number of sides of the inscribed and circumscribed polygons, until at length he found two which differed only by an unit in the 36th place of decimals in the numbers expressing their perimeters. This was rather a work of patience than of genius; indeed the labour must have been

Squaring.

prodigious. He seems to have valued highly this singular effort; for, in imitation of Archimedes, whose tomb was adorned with a sphere and cylinder, he directed that the ratio he had found might be inscribed on his tomb.

Snellius abridged greatly the labour of calculation; and although he did not go beyond Van Ceulen, yet he verified his result. Descartes also found a geometrical construction, which being repeated continually, gave the circumference, and from which he might easily have deduced an expression in the form of a series. Gregory of St Vincent distinguished himself also on this subject; he however committed a great error in supposing he had discovered the quadrature of both the circle and hyperbola. Gregory's mistake was the cause of a sharp controversy carried on between his disciples on the one side, and by Huygens, Mersenne, and Lestaud, on the other; and it was this that gave Huygens occasion to consider particularly the quadrature of the circle, and to investigate various new and curious theorems relating to it, which are contained in his *Theoremata de Quadratura Hyperboles, Ellipsis, et Circuli*, 1651; and in his work *De Circuli Magnitudine inventa*, 1654. In particular, he showed, that if c denote the chord of an arch, and s its sine, then the arch itself will be greater than $c\times\frac{1}{3}(c-s)$, but less than $c+\frac{4c+s}{2c+3s}+\frac{1}{3}(c-s)$: he also showed that the arch is less than the sum of $\frac{2}{3}$ of its sine and $\frac{1}{3}$ of its tangent.

James Gregory, in his *Vera Circuli et Hyperbolæ Quadratura*, gave several curious theorems upon the relations of the circle to its inscribed and circumscribed polygons, and their ratios to one another; and by means of these he found with infinitely less trouble than by the ordinary methods, and even by those of Snellius, the measure of the circle as far as 20 places of figures. He gave also, after the example of Huygens, constructions for finding straight lines nearly equal to arches of a circle, and of which the degree of accuracy was greater. For example, he found that if A be put for the chord of an arch of a circle, and B for twice the chord of half the arch, and C be taken such that A + B : B : : B : C, then the arch itself is nearly equal to $\frac{8C+8B-A}{15}$, but a little less, the error in the case of a complete semicircle being less than its $\frac{1}{3500}$ part; and when the arch does not exceed 120°, it is less than its $\frac{1}{40000}$ part; and finally, for a quadrant the error is not greater than its $\frac{1}{300000}$ part. And farther, that if D be such that A : B : : B : D, then the arch is nearly equal to $\frac{12C+4B-D}{15}$, but a little greater, the error in the semicircle being less than its $\frac{1}{1000}$ part, and in a quadrant less than its $\frac{1}{80000}$ part.

Dr Wallis gave, in his *Arithmetica Infinitorum*, a singular expression for the ratio of the circle to the square of its diameter. He found that the former was to the latter as 1 to the product

$$\frac{3\times3\times5\times5\times7\times7\times9\times9\times11\times11, \&c.}{2\times4\times4\times6\times6\times8\times8\times10\times10\times12}$$

the fractions $\frac{3}{2}$, $\frac{3}{4}$, $\frac{5}{4}$, $\frac{5}{6}$, &c., being supposed infinite in number. The products being supposed continued to infinity, we have the ratio exactly; but if we stop at any finite number of terms, as must necessarily be the case in its application, the result will be alternately too great and too small, according as we take an odd or an even number of terms of the numerator and denominator.

An expression of another kind for the ratio of the circle to the square of the diameter was found by Lord Brounker. He showed that the circle being unity, the square of the diameter is expressed by the continued fraction

$$1+\cfrac{1}{2+\cfrac{9}{2+\cfrac{25}{2+\cfrac{49}{2+,\ \&c.}}}}$$

which is supposed to go on to infinity, the numerators 1, 9, 25, 49, &c., being the squares of the odd numbers 1, 3, 5, 7, &c. By taking two, three, four, &c., terms of this fraction, we shall have a series of approximate values, which are alternately greater and less than its accurate value.

Such were the chief discoveries relating to the quadrature of the circle made before the time of Newton; many others, however, were quickly added by that truly great man, as well as by his contemporaries. In particular, James Gregory found that t, being put for the tangent, the arch is expressed by the very simple series

$$t-\frac{t^3}{3}+\frac{t^5}{5}-\frac{t^7}{7}+\frac{t^9}{9}-\&c.$$

By supposing that $t=1$, in which case the arch is one-eighth of the circumference, we have the corresponding arch expressed by the series

$$4(1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}+\&c.)$$

which was also given by Leibnitz as a quadrature of the circle in the *Acta Eruditorum* in the year 1682, but was discovered by him in 1673. Gregory had, however, found the series under its general form several years before. This series is altogether inapplicable in its present form, on account of the slowness of its convergency; for Newton has observed, that to exhibit its value exact to twenty places of figures, there would be occasion for no less than five thousand millions of its terms, to compute which would take up above a thousand years.

The slowness of the convergency has arisen from our supposing $t=1$. If we had supposed t greater than 1, then the series would not have converged at all, but on the contrary diverged. But by giving to t a value less than 1, then the rate of convergency will be increased, and that so much the more as t is smaller.

If we suppose the arch of which t is the tangent to be 30°, then t will be $\sqrt{\frac{1}{3}}=\frac{1}{3}\sqrt{3}$, and therefore half the circumference to radius unity, or the circumference to the diameter unity, will be

$$\sqrt{12}(1-\frac{1}{3\cdot3}+\frac{1}{5\cdot3^2}-\frac{1}{7\cdot3^3}+\frac{1}{9\cdot3^4}-\&c.)$$

Machin, enticed by the easiness of the process, was induced, about the beginning of the last century, to continue the approximation as far as 100 places of figures, thus finding the diameter to be to the circumference as 1 to 3·14159,26535,89793,23846,26433,83279,50288,41971,69399,37510,58209,74944,59230,78164,06286,20899,86280,34825,34211,70680. After him, De Lagny continued it as far as 128 figures. But he has also been outdone; for in Radcliffe's library at Oxford, there is a manuscript in which it is carried as far as 150 figures, and Dr Rutherford has carried it to 208!

Although this last series, which was first proposed by Dr Halley, gives the ratio of the diameter to the circumference with wonderful facility when compared with the operose method employed by Van Ceulen, yet others have been since found which accomplish it with still greater ease.

We have given such a method in our treatise on ALGEBRA (see article 272). In the same treatise (article 273), we have given a very elementary method, which may be understood by the mere elements of geometry. For the analytical methods see FLUXIONS. (W. W.)

Stade.

STADE, a fortified town of Hanover, capital of a province of the same name, in a marshy district on the

Schwinge, about 3 miles above its confluence with the Elbe, 22 miles west of Hamburg. It is surrounded by walls, and has been recently partly fortified, although the plan once entertained of making it a complete fortress is now given up. The chief buildings are three churches; a normal seminary; a gymnasium, which occupies the site of an ancient Augustinian convent; a house of correction, and others. Flannel and hosiery are manufactured, and a considerable trade is carried on. Stade was in ancient times the seat of independent counts, of whom we read in history as far back as 931; but it afterwards became incorporated with the possessions of the archbishops of Bremen. Pop. 7950.

STADIUM, the chief Greek measure for itinerary distances, which was adopted by the Romans chiefly for nautical and astronomical measurements. It consisted of 600 Greek feet, or 625 Roman feet, or of 606¾ English feet. (See WEIGHTS AND MEASURES.)

STAËL, MADAME DE, ANNE MARIE LOUISE GERMAINE NECKER, was born at Paris in 1766; her father settled in that capital since 1749, and gradually by his industry and his integrity, raised himself to a very important position. He was at the head of one of the first banking-houses; his opinion on financial matters always commanded attention; his *salon* was the favourite resort of the *beaux esprits*, who inaugurated, during the eighteenth century, the reign of public opinion. Under such circumstances, M. Necker could not fail to be popular; from the same cause he soon began to think that the man whose name had become a household word—that the man whom Marmontel admired and Turgot listened to—that the friend of princes, economists, and academicians—in short, that M. Necker was the wonder of his age. It is quite certain that M. Necker's vanity acted as a drawback upon his otherwise estimable character; but some allowances should be made for the peculiar circumstances in which he was placed. We do not allude now to the species of worship which Madame de Staël cherished—the exaggeration of filial love; but the implicit reliance placed in all quarters upon the financier's *ipse dixit* was really ridiculous. Mademoiselle Susanne Curchod, before marrying M. Necker, had attracted the attention of Gibbon the historian, who was deterred, it is said, from any proposals by the threats of his father. The contrast between an extra-polished English gentleman and a simple unaffected Swiss country-girl, would have been most striking; Susanne Curchod's exchange of a village school-house for the crowded drawing-rooms of Paris was quite as *piquant*. She, however, soon gave evidence of a natural tact, which enabled her to do honour to the new position in which her lot was cast; and if it be true that real merit alone is exposed to the attacks of jealousy, no one ever deserved more praise than Madame Necker.

The education of the future Corinne was, if we may so say, begun, continued, and finished in her mother's *salon*. "We entered the drawing-room," writes Mdlle. Huber. "By the side of Madame Necker's arm-chair was a little wooden stool on which her daughter was expected to sit, and to keep herself very upright. Hardly had she taken her accustomed place, when three or four old people came round her, and spoke to her with the deepest interest. One of them, who wore a little round wig, took her hands in his, where he kept them a long time, talking to her all the while, as if she had been five-and-twenty years old. This was the Abbé Raynal; the others were MM. Thomas, Marmontel, the Marquis De Pesay, and Baron De Grimm. Mademoiselle Necker at that time was only eleven." Fortunately, from her strong feelings and her generous affectionate disposition, she could entertain no permanent sympathy for the heartless sneering and the analytical philosophy of the Voltairian school, and the perusal of her works amply evidences that she had nothing in common with that clever but dangerous coterie. Another writer, more powerful, perhaps, than the patriarch of Ferney—a writer whose doctrines, at all events, have contributed in a considerably large proportion to the intellectual and political education of the present generation—Rousseau, was the idol of Mademoiselle Necker's earliest literary worship. The author of *La Nouvelle Héloise* was a *chef d'école* in literature; he counteracted very decidedly the critical tendencies so prevalent towards the close of the eighteenth century, by powerful appeals to what M. Sainte-Beuve aptly calls the instinctive forces of the soul—melancholy, compassion, enthusiasm for genius, for nature, for virtue, for misfortune. Mademoiselle Necker was peculiarly qualified to appreciate Rousseau; full of passion as she was, and acting from impulse rather than principle, she espoused a code of tenets which had the merit of awakening the soul; and with the exception of a few literary trifles, which hardly deserve noticing, her first performance as an author was a work devoted to the apology of Jean Jacques. The *Letters on Rousseau* were published in the year 1788. Written in the pride of youth, they have the merits and faults peculiar to the production of an ardent imagination, which pours out its treasures without restraint. "An unreasonable admiration of her subject," says a critic, "has betrayed her into some extravagances, which would have been avoided had she treated the theme in after years; but the same cause has given birth to passages glowing with eloquence, and prophetic of the glories she was to achieve."

The very disposition which drew Mdlle. Necker's sympathies towards Rousseau, rendered her perfectly competent to judge and to censure some of the more prominent faults of that eloquent writer. She has noticed the sophisms contained in the *Nouvelle Héloise*, and the masterly critique she has given of that work will ever keep its place as a monument of skill and of discrimination. When the *Letters* were first published, the charge of affectation was brought against the authoress. She might have been accused, perhaps, of rashness, but certainly no person in the world was ever less affected. The reverse is in reality her case. She yields too much to what the French call *entrainement;* it is her soul that guides her pen.

But ere this, in 1786, Mdlle. Necker had married Baron De Staël, the King of Sweden's ambassador to the French court. It was a *mariage de convenance* in every sense of the word, and was attended with the usual unpleasant consequences which render unions of the kind so fatal to both parties concerned in them. Baron De Staël's principal fault seems to have been an utter disregard for the value of money—a curious failing for so near a connection of the greatest financier then living. The immense dowry which M. Necker gave with his daughter, speedily felt the influence of the baron's thoughtless liberality; and had not Madame De Staël subsequently placed herself and her children under the protection of M. Necker, it is likely that the improvident diplomatist would have seriously diminished, if not completely destroyed the fortunes of his young family.

The low ideas of morality which unhappily prevailed during the last century rendered matrimonial catastrophes such as Madame De Staël's matters of everyday occurrence; and if they did not always lead to an open rupture, it was because the husband and wife could quietly make up their minds to accept on both sides what society considered as an event of course. Madame De Staël never gave the slightest occasion for calumny, but she saw at once that marriage ought not to be made a question of *marketable* profit. Putting things in the most favourable position, the husband of a *femme célèbre* is speedily metamorphosed into a nonentity.[1] One day an *habitué* of Madame Geoffrin's dinner

[1] See on that subject a very curious passage in La Bruyère's *Caractères*, edit. Jannet, vol. i., pp. 221, 222. "Il y a telle femme," &c.

parties asked her what had become of that nice quiet old gentleman whom he used to meet every Wednesday evening at her house, and whose absence he had noticed for the last month. "That gentleman, sir," answered Madame, "was my husband; he is dead." Madame De Staël felt to its full extent the evil resulting from the immoral conventionalism adopted by the fashionable world, and she stigmatised it most energetically in *Delphine*, a novel which was published for the first time in 1802. This work produced the greatest sensation when it first came out; it was a revolution in the style of romance-writing. "Delphine," says Madame Necker de Saussure, "is Madame De Staël in her youth." Those fond of studying an author's character through the creations of his fancy, must have felt interested whilst perusing *Delphine;* but besides this, Madame De Staël there endeavoured to defend an idea, which is nothing else but a dangerous paradox. "Men ought to know how to set public opinion at defiance; woman must submit to it." Such is the text selected—a text so attractive, and at the same time so unsound, that it has, since 1802, been the favourite motto of a school in metaphysical literature. If Madame De Staël invented the *femme incomprise*, George Sand may be said to have vulgarised her. The principle which serves as a fundamental axiom to *Delphine* is essentially false. To quote Chénier, "Man ought not to defy public opinion; woman ought not blindly to bend before it. They should both sift it; accept it when it is legitimate; and reject it when it is erroneous. Right and wrong are invariable: the rules of propriety differ, it is true, according to the sexes; but nature does not condemn man to a life of scandal, and woman to a course of hypocrisy. Virtue and reason exist equally for both, and before those eternal limits all conventionalisms must stop. *Delphine*, as a novel, is more interesting from the sketches of character it contains than from the plot itself: M. de Talleyrand is painted to the life under the name of Madame de Vernon.

It is not our intention to give here a detailed account of Madame de Staël's numerous voyages during the revolution and the empire. We find her in 1793 at Coppet in Switzerland, where was her father's estate; she also visited England, and established herself at a house called Juniper Hall at Mickleham, near Richmond. There a colony of French refugees was speedily formed; the pressure of the times drove to foreign countries the most illustrious families of France, and several distinguished personages were the constant companions of Madame de Staël at Richmond. Count de Narbonne, Madame de la Châtre, M. de Talleyrand, General d'Arblay—such are a few names taken at random. Under the most distressing circumstances, the colony managed to keep up their spirits and to weather the storm. Occasionally they were reduced to very ludicrous shifts; we are told that this little party could afford to purchase only one small carriage, which took two persons, and that MM. de Narbonne and De Talleyrand alternately assumed the post of footman as they rode about to see the country, removing the glass from the back of the coach in order to join the conversation of those inside.

It was not without the greatest difficulty that Madame de Staël contrived to escape from Paris during the Reign of Terror. She had given dire offence by the independent way in which she acted, and by the sympathy she openly manifested for persons whom the "sovereign people" had visited with a sentence of proscription. Her letters on Jean Jacques Rousseau contain the following remarkable passage:—"N'éffacez point le sceau de raison et de paix que le destin veut apposer sur votre constitution; et quand l'acord unanime vous permet de compter sur le but que vous voulez atteindre, *prétendez à la gloire de l'obtenir sans l'avoir passé.*" The gifted writer had thus strikingly prophesied, six months before the convocation of the States General, the excesses into which the spirit of demagogueism was speedily to lead the revolution. The national convention, or rather the members of the famous *comité de salut public, did* go beyond the limits of legitimate reform; and they were not likely to deal mercifully with those, above all, who maintained the rights of liberty and protested against the tyranny of the mob. How to preserve her friends, how to harbour them, how to facilitate their escape, was the task Madame de Staël firmly and exclusively undertook, at a time when every attempt of the kind rendered her amenable to the guillotine. She thus saved the life of M. de Talleyrand, M. de Jaucourt, and M. de Lally-Tollendal. M. de Narbonne, ex-minister of war, was one of the persons on whose behalf she devoted herself most energetically. She watched the streets anxiously during one night when the police were hunting for him. His fate, if he were seized, would be instant death, and she knew that the search of her house must discover him. In this critical circumstance, the government agents called at the house of the Swedish embassy to make their dread domiciliary visit; one would think that only nerves of iron could maintain a calm appearance at such a moment. But she assures us that with her the case was otherwise. "We can always," she adds, "master our emotion, however violent it may be, when we feel that its indulgence would expose the life of another." Was there ever a nobler sentence penned?

Prior to the appearance of *Delphine*, Madame de Staël had published a work, which, together with the volumes on Germany to be presently noticed, contains the programme of her æsthetic system. It appeared in 1800, exactly one year previous to the literary *coup d'état* of M. de Châteaubriand. The title is, *On Literature considered in its relation to Social Institutions*."[1] Thus, nearly at the same time, from two opposite points of the horizon, rose two standards more intimately allied with one another than was thought at first; and round them were soon gathered those who had long felt the necessity of a literary revival. M. de Chateaubriand's fame has cast into the shade Madame de Staël's treatise, but the impression produced by the work we are now mentioning was strong and lasting. It was, in truth, a bold undertaking, both from the novelty of the opinions stated, and the frequent allusions to passing events; and Madame de Staël expected to meet with much bitter opposition.

Literature holds the closest and the most essential connection with the virtue, the glory, the liberty, and the happiness of a state; humanity is ruled by a law of perfectibility; and it is this law which, from time to time, has elevated the standard of public morality, together with the criteria of taste. The law of perfectibility is indefinite: guaranteed to the future as it was enjoyed by the past, it must follow the development of the social institutions; and its distinctive character in the present day will be the predominancy of the serious principles over wit, the triumph of the spirit of the north over the literary aspirations of the south. Such is, in a few words, the argument chosen by Madame de Staël for the subject-matter of her two volumes. They are composed of two parts quite distinct, and ought to be judged each by itself. The historical explanations are not generally very correct, nor the quotations apposite; this, of course, impairs more than once the strength of the best arguments. Madame de Staël may be said to have often guessed uncommonly well; but everything is not a matter of guess, and she has repeatedly adduced errors in support of truths. Imperfectly acquainted as she was with ancient literature, she might have been expected to stumble at the name of a Greek philosopher or a Roman poet, but the Paris Aristarchi could not forgive her a few gross mistakes in

[1] *De la Littérature considérée dans ses rapports avec les Institutions Sociales.*

modern lore: they insinuated that she had blundered purposely in order to make good a Utopian system; and when she gave the name of "father of modern poetry" to Ossian—that is, to the notorious Macpherson—no wonder that a hue-and-cry was immediately raised by the public press.

If we consider Madame de Staël's work as a development of the idea of perfectibility, it is open to the severest discussion. There is in it much to blame, much that is questionable; at the same time the author's faith and generous impulses are entitled, on our part, to respect and admiration. Nay, if we believe in Divine revelation, we also acknowledge the principle of perfectibility, although modified and corrected by the influence of the Gospel. Madame de Staël is too dogmatical, but we sincerely admire her fervent hope, her thirst for truth, her thorough contempt and hatred for everything that tends to sever us from immortality, and to bind us to the present moment.

In a literary point of view, the work we are now noticing is a complete manifesto of what the French term *romanticism.* It is not absolutely necessary, says the author, that we should do *better* than our forefathers, but we must do *otherwise;* we must not be *imitators*, we must be *ourselves.* Let us, as regards literature, yield to the inspirations which, after the downfall of the Roman Empire, came upon society; let us make room for the Christian element and the Germanic principle. Madame de Staël may not have suspected the extent of the literary revolution which she so strongly advocated; but her views were correct, and have only been explained and carried out by the Hugo school of French authors. At the time when she wrote, amidst all the anxieties of a revolutionary government, and the din of European warfare, it must have seemed extraordinary to many thinkers, that northern poetry should be considered as the necessary substratum for a new literary construction. Then, the idea of turning melancholy into an æsthetic axiom, appeared ridiculous beyond description. Critics laughed at that poetry which mingled its strains with the roaring of the waves and the moaning of the winds. The wits of the time of the Directoire shrugged up their shoulders when told that melancholy was the true source of inspiration, that authors ought to be gloomy, and that every genuine poet was, more or less, under the influence of despondency. In fact, Madame de Staël's axioms were so unexpectedly announced that they were rejected altogether as traits of sophistry. Chénier, Delille, Fontanes, and many others who enjoyed a large amount of well-deserved reputation for their poetical talent, were, besides, far from melancholy; and what was worse than all, Madame de Staël advocated her gloomy theory just at the moment when France, escaping from the Reign of Terror, was already half-intoxicated with glory and pleasure.

The asperity of the public press against both *Delphine* and the work *On Literature* went beyond the bounds of common politeness. Could the critics have become Dominicans for the nonce, they would assuredly have made an *auto-da-fe* of Madame de Staël and of her productions. Her exile towards the end of 1803, her travels, her long residence at Coppet, the friendship she formed with the most eminent German thinkers, directed her ideas into a new channel, and diverted her attention from the small talk of the Paris *feuilletons.* During the Directoire, when French society was endeavouring to reorganise itself, two *salons* served in Paris as centres where those persons met who had attained some taste for intellectual pleasures and for the amenities of elegant conversation. The celebrated Madame Tallien gathered together in her drawing-room the supporters of the new order of things, the real republicans, the men of Thermidor; around Madame de Staël might be found assembled, in a small but brilliant array, the thinkers, the enthusiasts who aimed at effecting a compromise between monarchy and the principles of 1789. Their ideal was derived from a deep acquaintance with England and English institutions; they thought that liberty could exist most harmoniously in connection with loyalty, a hereditary line of kings, and even a powerful aristocracy. These discussions, these meetings proved of very short duration; the eventful 18th of Brumaire occurred, and it became quite clear that, under the rule of the Consul Buonaparte, no room would be left for discussions of any kind. Compelled to quit France, Madame de Staël immediately went to Germany, studied the language of that country, visited Weimar and Berlin, and became acquainted with Goethe and the Princes of Prussia. At that time she was already collecting materials for the work which a second excursion (1807–8) enabled her to complete. The tidings of M. Necker's illness reached her in the midst of this new society, so suited to her taste, so calculated to draw out her brilliant conversational powers. Easily alarmed on account of one so fondly beloved, Madame de Staël felt a sad presentiment that she had seen her father alive for the last time. She instantly set out for Coppet, with her son and his tutor, August Wilhelm Von Schlegel. In a state of the greatest anxiety she arrived at Zurich, where she was met by Madame Necker de Saussure, who confirmed her worst fears. Her father was already at rest. Her grief was agonizing to witness, her whole perspective of the future seemed suddenly obliterated; life and death, earth and heaven, were equally at war against her; the one compelled her to wander desolate in strange countries, the other snatched from her her father—her first, most faithful, and dearest friend; her last support seemed gone, and hopeless of relief, she resigned herself to the most afflicting despair. Baron de Staël was dead since 1802. Thus severed from those whom she had a right to regard as her natural guardians, she sought in the delights of friendship both the protection she needed and a diversion to the sad thoughts which the state of her country could not fail to excite. Benjamin Constant, Mathieu de Montmorency, Madame Récamier, were then the favourite *habitués* of Coppet; and she watched with increased anxiety over the education of a son and daughter, whose amiable dispositions more than compensated for the bitter disappointments she had found in marriage. After a short stay in Italy, Madame de Staël passed a year in Switzerland. During this interval she was busy in the composition of *Corinne*, and needed little other employment. But as her work drew to a close, she felt an anxious desire of revisiting Paris, partly that she might correct the proof-sheets of the novel with greater care, partly to be near her son, who was then preparing for the polytechnic school under the direction of Wilhelm Schlegel. A police order prohibiting her from coming within 40 leagues of the metropolis, by dint of manœuvring, and thanks to the kindness of the minister Fouché, she obtained leave to reside at half that distance—at Acosta, a country-house belonging to Madame de Castellane. Poor Corinne! she could find nothing enjoyable far from the atmosphere of a *salon;* and that empassioned poetess whom we love to fancy, as Gerard's picture represents her, sitting on Cape Misenum, would have exchanged without a pang the Lake of Geneva for the muddy gutter which runs along the pavement of the Rue du Bac! Buonaparte was determined not to allow her the simple gratification she so ardently longed for. *Corinne ou l'Italie* appeared for the first time in 1807. Being quite foreign to political subjects, it might reasonably have been thought incapable of giving umbrage to the emperor. But its sudden popularity, and the vivid interest in awakened for Madame de Staël throughout Europe, awoke the detestable spirit of jealousy which characterised a sovereign for whose assaults nothing was too noble or too hopeless. On the 9th of April 1807, the very anniversary of her father's death, she received a new sentence of exile. It was now too evident that nothing but the giving up of her independence could satisfy her enemy.

Counting the bitter cost, and sighing to reflect that she disposed, perhaps, of the future of others as well as her own, she proudly resolved to maintain her consistency, and once more, at the bidding of her tyrant, said adieu to all that remained of her once brilliant connections in France. It was impossible, indeed, that she could please the emperor. Her last sentence breathed a spirit of generous enthusiasm which was distasteful to him. He is said to have remarked peevishly, "It is no matter what she writes, let it be politics, history, or romance; it comes to the same thing in the end: after reading her, people do not like me."

Corinne is a wonderful work; whether considered as a description of Italy, or as a work on the fine arts, or as a sort of autobiography, we are equally delighted and surprised. Her characters are drawn with the most consummate power, and the psychological analysis which it evinces is not surpassed by any book professing to lay before us the strife of the passions in the human heart. *Corinne* is the offspring of enthusiasm and of grief; it is no fiction. Madame de Staël was recording her own struggles when she described the hesitation of a woman who cannot decide in her choice between the happiness which springs from the affections, and the emotions to which talent and glory give rise.

We find by glancing at the innumerable memoirs written during the last century, interesting accounts of the coterie over which Voltaire presided at Ferney; a few particulars respecting Madame de Staël's *salon* at Coppet would be still more welcome, if we could procure them. As many as thirty persons were often at a time the guests of the illustrious exile. Benjamin Constant, Schlegel, Bonstetten, Sismondi, M. de Barante, Madame Récamier, M. de Sabran, were among the most assiduous. Zacharias Werner was introduced in 1809; Lord Byron and "Monk" Lewis represent the genius of England in 1816. The days were spent in intellectual enjoyments, discussions on literature, and critical readings; a spirited opposition was maintained against antiquated formulas and despotism of every description. The book on Germany (*de l'Allemagne*) may be considered as the result of this epoch in the life of Madame de Staël. It was written with the manifest intention of protesting against a threefold tyranny. Buonaparte had enslaved France; philosophy withered under the oppression of the materialist school; and literature knew nothing beyond a blind acknowledgment of tradition. Madame de Staël felt how much her adopted country stood in need of some stimulant to awaken it to a consciousness of its powers, and she sent *l'Allemagne* to the press. It was launched, as it were, to defy the violence of the tempest, and to rescue sinking France itself, which, as Madame de Staël believed, had well-nigh lost all its dearly-bought liberties. Convinced that nations should guide and support one another, she sought in the bosom of defeated and humbled Germany the safety of France. There was more patriotism than national pride in the book of Madame de Staël. Buonaparte's police gave it a character which it did not deserve. Despite a persecution quite in accordance with the traditions of military despotism, the spirit of the times, and the general bent of the public mind, insured success to the obnoxious work. Two ideas it contained became popular: the men whom victory had not rendered insensible to freedom, felt that a powerful voice had embodied, in an eloquent address, their hopes and their fears; the panegyric of the descendants of the Teutons appeared in its true light—a proclamation of resistance.

Many a battle was fought in the arena of periodical criticism for or against *l'Allemagne*, and it soon became manifest that Madame de Staël had successfully maintained her own doctrine on literature and the fine arts. Already a decided tendency might be traced throughout the reading public towards something more true to nature than the dull and fastidious imitations of Racine and Corneille; the veil was drawn, and from behind it a glorious landscape burst upon the sight of the astonished gazers; for many a young and ardent mind, *l'Allemagne* was replete with the perfumes and emanations of unknown but fragrant stores. That literature described by Madame de Staël, strange, wild, as it appeared, brought to the imagination pleasing fancies and beautiful ideas. Germany became to France as a long-forgotten sister, who had treasured in her heart, and was ever discerning old family traditions, otherwise lost for ever. Then there came along with her the bewitching prestige of liberty, a literature free from all restraints, whose resources were to be increased a hundred-fold; and the young generation, tired of a classicism which was nothing more than the echo of an echo, thought that, with independence, they had recovered all the earnests of real happiness, whether for good or for evil. Madame de Staël's new work had an immediate influence. It brought to a close the coldness, the enmity which had so long existed between two great people. Many years after, Goethe wrote thus of the book we are now alluding to. "It ought to be considered as a powerful battery which made a wide breach in the sort of wall raised up between the two nations by superannuated prejudices. Thus, beyond the Rhine, we were once more exactly inquired after; and we could not, consequently, fail to acquire great influence throughout the whole western part of Europe."

The principle which Madame de Staël sought to inoculate on her side of the Rhine was *enthusiasm*. But she pursued her plan cleverly, without proclaiming it, without any flourish of trumpet. Considering her country as an invalid, to whom change of air is prescribed as the first remedy, she accompanied the patient on a tour through Germany. In reading her work, one can fancy a well-informed and judicious guide pointing out to her friend the most striking features of a foreign land. There is nothing polemical, no attack upon particular feelings or tastes; calmness and impartiality prevail, on the contrary, throughout all the descriptions. Madame de Staël's purpose is not to preach a crusade on behalf of Germany. She simply states the facts, and leaves her readers to judge. Of the Teutonic race she is a decided champion; yet in spite of her acknowledged predilection, she did not find favour in the sight of all her Trans-Rhenish cities. Many accused her of having disguised the truth, and of being a very superficial judge. It is true that she had not within her reach all the information which should have formed the proper ground-work of her observations. As for society itself, she knew nothing beyond the manners of aristocratic circles and the fashionable world; whereas, amongst the higher orders, cosmopolitism is too prevalent, and the national character is worn away by a constant moral and mental friction with those around.

No one will be astonished at hearing that Madame de Staël's *Memoirs* contain a very unfavourable account of Napoleon Buonaparte. Besides the complete antagonism which must exist between military despotism and intellectual powers of the highest description, the French emperor's behaviour towards the author of *Corinne* had been marked by a want of courtesy doubly inexcusable. When a man is so circumstanced that he can say, *sit pro ratione volantas*, rudeness is the characteristic of petty cowardice. At the same time the evident unfairness stamped upon most of the verdicts pronounced in *Dix Années d'Exil*,[1] is much to be regretted; Madame de Staël would certainly have best considered the interest of her glory had she not stooped to the tone of a common pamphlet writer.

Illusions, however, were beginning to vanish around *Corinne*; her circle of friends lost, one by one, its choicest gems;

[1] Such is the title of Madame de Staël's autobiography.

sufferings, disappointments, persecutions, the weight of years, all told upon her mental energies. For a short time she believed she saw in M. Rocca's attachment to her, and in her marriage with him, the phantom of that happiness which genius had failed to give her; but gradually the brightest pictures of her fancy lost their hues, and she wisely sought in the solid joys of religion both peace here and hope for hereafter. The restoration of the Bourbon family brought her back to France, so completely altered from what she was when she left it, that to those who knew her at both periods of her life, the difference could not but be painful. And yet it was a change for the better; it was a shaking off of "every weight," a preparation for the last struggle. The friendship of persons such as Madame de Duras, M. du Chateaubriand, and Sir James Mackintosh, made up, in some measure, for old ties which the rude hand of death had broken asunder; but she did not lean too much upon those earthly supports; and when, in July 14, 1817, she breathed her last, it was with those firm hopes that alone can light up the passage through the dark valley.

Madame de Staël left two children, who were both removed from this world in the midst of a career of piety and of usefulness. Baron Auguste de Staël died in 1827, at the early age of thirty-seven; he had already evinced talents, energies, and dispositions which caused him to be regarded as a new Duplessis Mornay, or as the Wilberforce of Protestant France. He took a prominent part in the establishment of the Bible Society, of savings-banks, and in the abolition of the slave trade. His *Letters on England*, published in 1825, are full of interesting remarks, though necessarily incomplete, from the fact that the author died before he could finish the second volume. Madame de Staël's daughter had married, in 1816, the Duke de Broglie. Her death, in 1838, was felt throughout France as a public calamity. M. Rocca did not long survive his wife. He went into Provence, to be near a brother whom he loved, and there he succumbed under the pressure of sorrow and disease. (G. M—N.)

STAFFA, an islet among the Hebrides, celebrated for its basaltic rocks and caverns, lies off the west coast of Mull, about 8 miles distant from it. It consists of an uneven tableland of an irregular oval form, about a mile and-a-half in circumference, and the highest point, which is towards the south-west, reaches an elevation of 144 feet above the sea. The base of the island is a ledge of conglomerated trap-rock, above which rise basaltic columns, surmounted by a mass of basalt which has not assumed a columnar form. The lowest part of the island is on the eastern shore, and this is where visitors usually land on Staffa. From this point towards the south the principal objects of interest occur in succession. The first of these is the Clam Shell Cave, one side of which consists of large columns of basalt, carved like the ribs of a ship, or one of the shells from which it has its name, while the other side has, from the projecting ends of columns, a tesselated appearance somewhat resembling a honeycomb. Near this is the islet of Bouchaillie, or the Herdsman, a very beautiful basaltic structure of a conical form, and of great symmetry and regularity. From this place a long colonnade of basaltic pillars extends as far as the entrance of Fingal's Cave, which is the most beautiful and sublime of all the basaltic wonders of Staffa. This cave extends back from its mouth 227 feet; its breadth at the entrance is 42, and at the inner extremity 22 feet. The sides are formed by perpendicular columns of great size, beautifully jointed and arranged in varied groups. The roof is beautifully marked with the ends of pendent columns, and has a deep fissure extending through its whole length parallel to the sides of the cave. The sea never leaves the cavern, and there is a depth of 18 feet at low water. The height of the roof from the mean level of the sea is 66 feet, and the cliffs above rise 30 feet higher. The singular resemblance of this magnificent work of nature to a work of art has called forth the well-known lines of Sir Walter Scott on Fingal's Cave:—

> "Where, as to shame the temples deck'd
> By skill of earthly architect,
> Nature herself, it seemed, would raise
> A minster to her Maker's praise."

The Boat Cave, which lies a little to the west of this one, is smaller, but even more symmetrical in its structure; it is 14 or 15 feet in height above high water, about 12 feet broad, and 150 long. The last cave of any beauty or interest is Mackinnon's, also called the Scart or Cormorants Cave, which approaches the dimensions of Fingal's Cave, but is less regular in its structure. There are various other caves in the island, but none of them so remarkable for size or beauty as those already mentioned. Though Staffa is green and fertile, it is entirely destitute of trees, and there is not a dwelling of any kind, even a hut, on the island.

STAFFORD, the county town of Staffordshire, a municipal and parliamentary borough and market-town of England, on the left bank of the Sow, 123 miles N.W. by W. of London. It was anciently walled, and defended by a castle; the latter, about a mile and a half to the south-west, has been recently rebuilt; but of the walls, which were destroyed by the parliamentary forces in the 17th century, few vestiges remain. The houses are for the most part built of brick and slated, and most of the buildings stand in two main streets, called Green Gate Street and Gaol Gate Street, which extend to the north-west of a bridge spanning the Sow. There are also two squares, in one of which, the Market Square, stands the County Hall, a spacious building of stone, containing court-rooms, an assembly-room, and other handsome apartments. But the finest buildings in Stafford are the Established churches, two of which are parochial and of considerable antiquity, while two others, Christ Church and St Paul's, have been recently built. St Mary's is a large cruciform edifice, with a lofty octagonal tower in the centre. Its architecture is chiefly of the early English style, but some portions have more resemblance to the Norman and the perpendicular. In 1847 the church was repaired and restored at considerable expense. The church of St Chad is of smaller size; it has a Norman chancel, but is partly of modern date. There are other places of worship in the town for Presbyterians, Independents, Methodists, Quakers, Baptists, and Roman Catholics. The educational establishments in Stafford comprise a grammar school of ancient date, much enlarged by Edward VI., National, British, and Ragged schools. The town has also a Mechanics' Institute, a public library, almshouses, an infirmary, two lunatic asylums, and a county jail. Tanning is carried on to some extent in the town and neighbourhood; and the principal articles manufactured in the town are shoes, which are exported in considerable quantities. Markets are held weekly, and there are five annual fairs. The borough is governed by a mayor, 5 aldermen, and 18 councillors, and it returns two members to the House of Commons. Assizes and quarter sessions for the county are held at Stafford. The town seems to have grown up round a castle, which was built here in 913 by Ethelfleda, sister of King Edward the Elder, and at the time of the Norman conquest it was a borough, called by the name of Statford or Stadford. In the civil war of the 17th century, Stafford was occupied by the king's forces, after the capture of Lichfield by their adversaries. An indecisive battle was fought at Hopton Heath, in the vicinity, in 1643, and at a later period the town was taken by the Roundheads, under Sir William Brereton. The castle was also taken shortly after, and at the close of the war was entirely demolished. Stafford was the birth-place of the celebrated Isaac Walton. It com-

municates with London by the Trent Valley and London and North-Western Railways, and has also easy intercourse by railway with Liverpool, Manchester, and other towns in the north. Pop. (1851), 11,829.

STAFFORDSHIRE, an inland county, nearly in the centre, but rather to the W. of England. It is bounded on the S. by Worcestershire and a detached part of Shropshire, W. by the main body of Shropshire, N.W. by Cheshire, N.E. by Derbyshire, E. by a small portion of Leicestershire, and S.E. by Warwickshire. Its greatest length from N. to S.E. is 60 miles, and its greatest breadth 38 miles. The southern boundary is very irregular and much involved with that of Worcestershire. A portion of the latter county, including the important town of Dudley, is entirely insulated by Staffordshire, whilst a portion of Staffordshire, including the Clent Hills, lies within Worcestershire. An effort was recently made by the Right Hon. Sir John Pakington and the Worcestershire magistrates to rectify this irregularity, but it was opposed by the Staffordshire magistrates, on the ground that great expense would be incurred in increasing the county jail at Stafford to provide for the prisoners from Dudley. Staffordshire contains 1250 square miles, or 781,000 statute acres. It is the 18th county in England in superficial extent, and the 6th in population.

Its physical aspect is marked by great variety. It includes within it a part of the great watersheds of England, different portions of it draining into the German Ocean, the Irish Sea, and the Bristol Channel. The main part of the county, however, belongs to the basin of the Trent; a small portion to the W. drains into the Mersey, and a larger strip on the S. into the Severn, which crosses a narrow limb of the county. The N.E. part of the county forms the termination of the Pennine range of mountains, which, stretching southwards from the Cheviot Hills, form the backbone of that part of England. The river Dove, which separates Staffordshire from Derbyshire on the N.E., flows through a valley formed by two spurs of this range, which presents a succession of scenery of exquisite beauty. From the S. or Staffordshire slope of its basin the Dove receives the Manyfold, Hamps, and Churnet. The two former streams disappear underground and flow for some miles in subterranean channels, uniting their streams before they emerge, and fall into the Dove at Ilam. The Dove enters the Trent near Burton. Extending from the basin of the Dove on the N.E. to the N.W. of the county is a continuous range of hills and moorlands of a wild and varied character, sloping gradually towards the Trent, and forming the boundary of its basin to the N. To the E. of this range, which includes the Weavèr Hills, there are eminences rising to the altitude of 1200 or 1500 feet above the level of the sea. They gradually subside towards the W., but are still high enough to give a decided feature to the scenery, which is mainly moorland. To the W. much lower elevations separate the basins of the Trent and Mersey. This line of division is marked by large pools, called meres, and considerable deposits of peat, which are to be found extending to the confines of Shropshire. Aquilate (*aqua lata*, broad water), near Newport, in Shropshire, is one of the largest of these pools.

To the south of the county a range of hills extends from Wolverhampton to Rowley Regis, and forms at once the southern boundary of the coal-field of South Staffordshire, and of the basin of the Trent. Wolverhampton itself is on the apex of this ridge, and its streams drain partly into the Bristol Channel and partly by the Trent into the German Ocean. These hills rise at Rowley to the height of 700 feet. They have been most interestingly described by Hugh Miller in his *First Impressions of England.* They belong to the Silurian system, and are very rich in fossils. From the great extent to which they have been quarried for limestone, they present extensive sections, open to the observation of the geologist. Very pure basalt exists in large masses at Rowley, and is locally known as Rowley Rag. It is used very extensively for paving. "The Silurian islets," as Miller calls the principal eminences in this chain, are precipitous; and two, "The Wren's Nest" and the site of Dudley Castle, are very striking objects.

The basin of the Trent extends from the summit of these hills in the south to the rugged heights which bound it on the north; but near the centre of the county rises an elevated *plateau*, known as Cannock Chase, which extends from the west of Rugeley to the east of the county, rising rather abruptly on all sides, except the east. It forms a striking feature in the scenery, viewed either from the Trent Valley Railway, which it closely approaches, or from the line between Stafford and Wolverhampton, which is on its opposite side. Between this central elevation and the hills to the south of the county, lies the coal-field of South Staffordshire, which drains eastward into the Tame, a river rising to the north-west of Walsall, which town is on the edge of the Chase. The Tame enters Warwickshire near Birmingham, but sweeping north and north-east, re-enters Staffordshire at Tamworth, and falls into the Trent a few miles north of Lichfield.

Between Cannock Chase and the northern range of the Staffordshire Hills the country is generally level. Through this district runs the River Trent, the third river in England for length. It rises in the moorlands near Biddulph, in the north-west of the county, on the borders of Cheshire, flows south by Trentham, south-east by Rugeley, east to the boundary of Derbyshire, when it turns north-east, forming the boundary between the two counties, and enters Derbyshire just below Burton, its length to that point being 50 miles. It only becomes navigable at Burton. Its chief tributaries on the left bank are the Blythe and the Dove, the latter already described. On the right bank is the Sow, with its tributary the Penk, which latter stream drains the country north-west of the southern ridge of hills, terminating west of Wolverhampton. The Tame has already been described.

The new red sandstone is the prevailing geologic formation throughout the county. Gypsum is quarried in Needwood Forest, an elevated tract of land in the north-east, and in the adjacent parts of the valley of the Dove. The basalt at Rowley Regis has been noticed in defining the boundaries of the river basins. Trap-rock, apparently part of a thick vertical greenstone dyke, is found near Walsall.

The coal-fields form, however, the most important mineral feature of the county. The largest is in the south, extending from near Walsall to Rowley, and from Wolverhampton to within a few miles of Birmingham. The south part of this coal-field contains a seam of coal 30 feet thick, of excellent quality. The coal-measures in this basin have an average aggregate thickness of about 40 feet, and the ironstone of about 40 inches. Ironstone is found in strata intervening between the coal-measures in each of the coal-fields.

The Pottery coal-field, in the north-west, is triangular in shape, its greatest length from base to apex being 13 miles, and 8 or 10 miles along the base. East of this is a small insulated basin, called the Cheadle coal-field; and near Tamworth, on the east of the county, the Warwickshire coal-field just enters Staffordshire. Colliery operations are now being energetically conducted near that town. Nearly the whole of the elevated district of Cannock Chase is found to contain valuable beds of coal; and this, hitherto a barren heath, formerly covered with timber, is rapidly becoming intersected by canals and railways, which the mining operations call into existence. Ironstone is also found, but is not yet extracted to any large extent. In

the north of the county, near Froghall, valuable beds of limestone and ironstone are worked, and the minerals conveyed to the ironworks of South Staffordshire. Copper and lead are mined in the north of the county, in the neighbourhood of Oakamoor. Salt-springs occur at Shirleywitch and Weston, to the west of Colwich.

The climate is colder than in other counties in corresponding latitudes, and the fall of rain is large, averaging about 36 inches a year. The highlands, which form part of the great watershed of the county, intercept the vapours from the Atlantic, whilst the quantity of snow which falls upon them tends to reduce the temperature. The arable land forms about four-fifths of the land under cultivation. Clay and heavy loams, gravelly and sandy loams, and light gravel and sand, exist in various proportions. The meadows along the banks of the rivers are very fertile. Great progress has been made within the last few years in the improvement of the breeds of animals and the processes of agriculture. Lord Hatherton, the lord-lieutenant of the county, is a most enterprising and successful agriculturist, and at a very early period adopted steam culture, the use of the reaping machine, and other improvements. His extensive farm adjoining his residence at Teddesley, near Penkridge, is a remarkable illustration of profitable reclamation.

Staffordshire occupies an important position amongst the manufacturing counties of England. The leading branches of industry are the manufacture of iron and hardwares on the South Staffordshire, and of earthenware and iron on the Pottery coal-field. The iron manufacture has been long carried on in the former district, but has been immensely extended since coal was rendered applicable to smelting the ore instead of charcoal, and again since the hot-blast was employed. The supply of the superior qualities of ironstone in the district is now, in consequence of the vast quantities raised, unequal to the demand, and the supply of native stone is largely supplemented by the hematite ore from Cumberland, calcined stone from the Potteries, &c. The opening of the coal-mines on Cannock Chase has greatly increased the supply of fuel. The works for the manufacture of iron extend over the whole of the coal-field. In the commencement of 1860 there were 189 blast furnaces in the district, including a few in East Worcestershire, of which 135 were in and 54 out of operation. The average yield of a furnace is about 120 tons of pig-iron per week, which would give an annual production from the furnaces then in blast of 842,400 tons a year. Very little is exported in the shape of pig-iron. In 1826, there were 109 furnaces in the district, of which 90 were in blast, the annual yield being estimated at 197,280 tons. The produce per furnace has been much increased of late years. The competition of districts where the minerals can be raised at less expense, and which are nearer the seaboard, limits the manufacture of iron in South Staffordshire for export chiefly to the superior kinds. Rails are not now largely made in the district.

Almost every branch of hardware manufacture is carried on in South Staffordshire. Locks are produced to a large extent in Wolverhampton and Willenhall; tin and japan wares in Wolverhampton and Bilston—this being one of the most progressive branches in the district—cast hollow wares at Wolverhampton, West Bromwich, Sedgley, &c.; saddlers' ironmongery and saddlery at Walsall; ironwork for coach-building, and wheels and axles for railways, at Wednesbury; chains and nails at Dudley, and the district to the south; gas-tubes, Wednesbury and Walsall; gun-locks, Wednesbury and Darlaston; and foundries abound in various parts. There is scarcely an article of ironmongery which is not produced in the district. The hardware trades are fully as flourishing as the iron trade. A large proportion of articles of hardware are got up at the houses of the workmen, in many cases the various portions of an article being collected by the factors or merchants from the separate artificers, and put together in their establishments. They are extensively exported to every part of America, Australia, the East Indies, China, the Cape, the Mediterranean, &c.

The other principal manufacturing district is situated on the Pottery coal-field, on the north-west of the county. The manufacture of earthenware in that locality, originally confined to the commoner kind of articles, has been gradually improved, until now not only is the most exquisite china produced there, but new kinds, as encaustic tiles, parian, jasper, majolica, &c., raise the productions of the district to a distinguished position in art-manufactures. The pottery art is greatly indebted for its improvement to the genius and perseverance of Josiah Wedgwood, who founded the town of Etruria, where his descendants still carry on the manufacture. A statue of this benefactor of the Potteries is about to be erected at the railway station, Stoke; and an institute, which is to bear his name, for instruction specially in art and science applicable to the production and ornamentation of the staple manufacture, is shortly to be established in Burslem, his native town. It is worthy of remark, that the workmen engaged in the earthenware manufacture are engaged from year to year, instead of by the week or fortnight, as in other trades. The principal towns are Hanley, Burslem, Stoke, Shelton, Longton, Tunstall, Fenton, Etruria, Dresden, &c.

Within the last few years the iron trade has been rapidly extending in the Pottery district. In January 1860 there were 31 blast furnaces, of which all but 8 were in operation. The Earl Granville is the proprietor of extensive mines and ironworks in the Potteries.

The manufacture of ale and beer at Burton-on-Trent is carried on to a very large and increasing extent, and that town is rapidly rising into great importance. No branch of trade in the county is making more remarkable progress.

At Stafford and Stone the manufacture of shoes is extensively carried on, and hats are made at Newcastle-under-Lyme. Glass-works exist in various parts, and branches of cotton manufacture are prosecuted in some of the rural districts, but several of these manufactories have long been closed. At Leek, in the north-west of the county, silk goods are made to a considerable extent.

Staffordshire is admirably supplied with the means of internal communication. In addition to good roads, there is a perfect network of canals and railways, which the development of its mineral riches, and the progress of its manufactures, have rendered necessary. The Grand Trunk Canal, the work of the distinguished Brindley, connects the navigation of the Trent and Mersey. It extends from the junction of the Derwent with the Trent in Derbyshire, entering the county near Burton to Runcorn Gap, where it joins the Mersey. Of its entire length of 93 miles, about 50 are in Staffordshire. At Harecastle, west of the Potteries, it is carried through two tunnels, one of which is 2926½ yards in length. The Staffordshire and Worcestershire Canal connects the Grand Trunk east of Stafford with the Severn, and thus the communication between the German Ocean, the Irish Sea, and the Bristol Channel is completed. The Birmingham Canal, extending from near that town, traverses the South Staffordshire coal-field, uniting with the Staffordshire and Worcestershire Canal south of Wolverhampton. It is thence extended to Nantwich in Cheshire, forming a direct line of communication for Birmingham and South Staffordshire with the Mersey. From the nature of the district through which the Birmingham Canal passes, it has been extended in every direction by branches. A splendid tunnel, in connection with one of these branches, recently constructed at Netherton near Dudley, pierces the lofty range of hills which intersect the thick coal-basin in that locality. By the Coventry and

Oxford Canal, which joins the Grand Trunk Canal near Alrewas, the latter is connected with the Thames. Other canals in South Staffordshire connect every part of the district with the main lines, and important extensions on Cannock Chase are in progress.

The county is well supplied with railways. The Grand Junction line traverses it from Birmingham to near Crewe, where it enters Cheshire. The Trent Valley, a shorter route from Rugby to Stafford, passes by Tamworth, Lichfield, and Rugeley, south of Cannock Chase; the Stour Valley from Birmingham to Bushbury, a mile north of Wolverhampton, where it unites with the Grand Junction, was formed to obviate the original defect of the latter, which scarcely touches any of the South Staffordshire towns. The South Staffordshire Railway extends from Dudley, crossing Cannock Chase to Barton, a few miles from which it runs into the Midland. A branch from Walsall extends to Cannock, on the summit of the central tableland; and a short line, the Cannock Mineral, opened in the autumn of 1859, connects Cannock with Rugeley, where it unites with the Trent Valley. Other branches from the South Staffordshire line are in progress. The Oxford, Worcester, and Wolverhampton Railway, passing through Dudley, connects the South Staffordshire line with the south of England and London. The North Staffordshire, constructed specially for the convenience of the Pottery district, connects it with the Grand Junction Line at Norton Bridge, near Stafford, with the Trent Valley at Colwich, with the Midland at Burton and Willington, and extends to Macclesfield on the north-east, and thence along the north of the county, in an eastern direction, to Uttoxeter, where it unites with the Midland branch. Besides these, the Great Western Railway traverses the district between Birmingham and Wolverhampton, extending from that town by Shrewsbury to Birkenhead.

The county is divided into five hundreds, each of which is subdivided into north and south. They do not include the city of Lichfield, which is a county of itself. For parliamentary purposes it is divided into North and South Staffordshire, each of which returns two members. The population in 1851 was 608,716, having doubled in forty years. The following are the numbers of the population at each of the decennial periods named:—1801, 254,084; 1811, 308,129; 1821, 361,859; 1831, 425,140; and 1841, 520,867.

The population of the principal towns is as follows:—Wolverhampton, 49,985; Walsall, 25,680; Wednesbury, 11,914; Stafford, 11,829; Newcastle-under-Lyme, 10,569; Leek, 8877; Burton-on-Trent, 7934.

The parliamentary boroughs, with their population in 1851, are as follow:—Wolverhampton, including Bilston, Willenhall, Wednesfield, and Sedgley, 119,748; Stoke-upon-Trent, including the Pottery towns, 84,027; Walsall, 25,680; Stafford, 11,829; Newcastle-under-Lyme, 10,569; Tamworth, 8,655; and Lichfield, 7,012. Except Walsall, which only returns one member, all these boroughs return two each, making 17 members for the whole county.

The rapid collection of large populations on the coal-fields in the north and south of the county, earning high wages, has had its usual effect in occasioning much sensual depravity. This is increased by the influence on the physical aspect of these districts of the mining and manufacturing pursuits. The former cover the surface with the refuse matter raised from the mines; whilst the volumes of smoke emitted by the works darken the whole atmosphere, causing the South Staffordshire district to be locally termed "the Black Country," and destroy vegetation. Hence garden culture, and the enjoyment of natural scenery, are prohibited to the residents; cleanliness is very difficult; and the higher classes usually live at a distance beyond the smoke, thus depriving the working-classes of much of the influence they would otherwise exert over them. In the recollection of many persons, bull-baiting and cock-fighting on Sunday were common in South Staffordshire. Great improvement is, however, manifest. Schools have been extensively established for the artisans and labourers. Their influence is greatly diminished by the temptation which high wages offer to parents to send their children to work at an early age; and prizes, contributed by proprietors of the mines and ironworks in South and North Staffordshire, are given to encourage protracted attendance at school. At an early period the active efforts of the Methodists and Dissenters did much to keep alive religious and moral sentiments; and within the last twenty years the Church of England has made extraordinary exertions to provide for the religious and educational wants of the population. The census of 1851 showed that there were then 863 places of worship within the county, containing 304,292 sittings. Of these, 317 places of worship and 163,856 sittings belonged to the Established Church. The proportion of sittings to population was 50 per cent., of which 26·9 were connected with the Church of England. As an indication of the progress made lately, it may be mentioned that the present Bishop of Lichfield has consecrated 121 new churches since his elevation to the see in 1843, and very much the greater part of these were in Staffordshire. The building of churches in the diocese is assisted by a society; and the present bishop (Lonsdale) has on three several occasions of appealing for its support, headed the subscription list with L.1000. The census of 1851 showed that there were in the county 1318 day schools, attended by 66,187 scholars, of which 44,489 were at public, and 21,698 at private schools.

An efficient police force has for many years been established in the county, Wolverhampton, Walsall, and one or two of the smaller boroughs, having separate forces. The towns of Wolverhampton and Hanley have been incorporated under the Municipal Reform Act of 1835—the former directly after its passing, the latter in 1859. The other municipal boroughs are Stafford, Lichfield, Tamworth, Walsall, and Newcastle-under-Lyme. Most of the towns now possess local boards of health, under the Public Health Act of 1848, or of Commissioners; and paving, lighting, and sewerage are better attended to than they were. In both the south and north coal-fields, the sinking of the ground, and the destruction of buildings, roads, &c., from the mining excavations, is common. South Staffordshire was last year supplied with water by works intercepting streams and springs at Lichfield, whence the water is raised to the summit of Cannock Chase. Wolverhampton is supplied mainly from surface water from the south, and by borings into the red sandstone, the water having to be pumped to the level of the town. There is also a waterwork in North Staffordshire.

In the Roman period Staffordshire was inhabited by the Cornavii. The Roman roads, Watling Street, Ryknield Street, and Via Devana (Chester Road), crossed the county. At Wall (Etocetum) Roman remains are extensively found, and at Rowley Regis and other places. In the Saxon period the county formed a part of Mercia; and Tamworth was the place of residence, and of the death, of the celebrated Ethelfleda. The beautiful cathedral at Lichfield occupies the site of a church erected as early as the seventh century. A part of its south side has been admirably restored in stone within the last fifteen years; and the interior of the choir is now being restored, at a cost of about L.10,000, under the direction of Mr G. G. Scott. Croxden Abbey, in a small valley between Cheadle and Uttoxeter, is a fine old ruin.

STAGNELIUS, Erik Johan. See Scandinavian Literature.

STAHL, Georg Ernst, an eminent German chemist, was born at Anspach, on the 21st of October 1660, and chosen professor of medicine at Halle, when a university

was founded in that city in 1694. The excellency of his lectures while he filled that chair, the importance of his various publications, and his extensive practice, soon raised his reputation to a very great height. He received an invitation to Berlin in 1716, which he accepted, and was made counsellor of state and physician to the king. Stahl is without doubt one of the greatest men of which the annals of medicine can boast: his name marks the commencement of a new and more illustrious era in chemistry. He was the author of the doctrine of *phlogiston*, which, though now completely overturned by the discoveries of Lavoisier and others, was not without its use, as it served to combine the scattered fragments of former chemists into a system, and as it gave rise to more accurate experiments and a more scientific view of the subject, to which many of the subsequent discoveries were owing. This theory maintained its ground for more than half a century, and was received and supported by some of the most eminent men which Europe has produced—a sufficient proof of the ingenuity and the abilities of its author. He was the author also of a theory of medicine, founded upon the notions which he entertained of the absolute dominion of mind over body; in consequence of which he affirmed, that every muscular action is a voluntary act of the mind, whether attended with consciousness or not. This theory he and his followers carried a great deal too far; but the advices, at least, which he gives to attend to the state of the mind of the patient are worthy of the attention of physicians. "Stahl," says Dr Cullen, "has explicitly founded his system on the supposition, that the power of nature, so much talked of, is entirely in the rational soul. He supposes that, upon many occasions, the soul acts independently of the state of the body; and that, without any physical necessity arising from that state, the soul, purely in consequence of its intelligence, perceiving the tendency of noxious powers threatening, or of disorders anyways arising in the system, immediately excites such motions in the body as are suited to obviate the hurtful or pernicious consequences which might otherwise take place. Many of my readers may think it was hardly necessary for me to take notice of a system founded upon so fanciful a hypothesis; but there is often so much seeming appearance of intelligence and design in the operations of the animal economy, that many eminent persons, as Perrault in France, Nichols and Mead in England, Porterfield and Simson in Scotland, and Gaubius in Holland, have very much countenanced the same opinion, and it is therefore certainly entitled to some regard." (Cullen's *First Lines of the Practice of Physic*, vol. i., p. 12.) Stahl died in 1734, in the seventy-fifth year of his age.

His principal works are, *Experimenta et Observationes Chymicæ et Physicæ*, Berlin, 1731, 8vo; *Dissertationes Medicæ*, Halle, 2 vols., 4to; *Theoria Medica vera*, 1737; 4to; *Opusculum Chymico-physico-medicum*, 1740, 4to; *A Treatise on Sulphur, both Inflammable and Fixed*, written in German; *Negotium Otiosum*, Halle, 1720, 4to—it is in this treatise chiefly that he establishes his system concerning the action of the soul upon the body; *Fundamenta Chymiæ Dogmaticæ et Experimentalis*, Nürnberg, 1747, 3 vols., 4to; *A Treatise on Salts*, written in German. Haller, in his *Bibliotheca*, gives 250 works which were either written, edited, or superintended by Stahl.

STAINDROP, a market-town of England, in the county and 16 miles S.S.W. of Durham, in a beautiful valley on a branch of the Tees. It consists of one long street, and contains an old and handsome church, four Dissenting places of worship, and several schools. In the vicinity there are lead-works. Pop. 2447.

STAINES, a market-town of England, in the county of Middlesex, on the left bank of the Thames, 18 miles W. by S. of London. It has a market-house, places of worship belonging to the Established Church, and to Methodists, Independents, Baptists, and Quakers; a bank; several schools; flour-mills; and gas-works. Pop. 2577.

STAIRCASE. See Architecture.

STALEYBRIDGE, a market-town of England, in Lancashire, on both sides of the Tame, 8 miles E. by N. of Manchester, and 185 N.W. by N. of London. It is built on ground which slopes down to each side of the river, and consists of three principal streets, one of which is old and somewhat irregular; while the others are straight and regular, lined, for the most part, with brick-houses two storeys high. As the town is almost entirely modern, and owes its importance chiefly to the cotton manufacture, there are few buildings of much interest or antiquity; the oldest of them being an octagonal church, which occupies a prominent position on a rock overhanging the river. There is also a market-house, which was built in 1832, at a great expense. Besides the Established church, various sects of Methodists, the Independents, Baptists, and Roman Catholics have places of worship here. There are several schools, a mechanics' institute, and a savings bank. The town contains nineteen establishments for spinning cotton-yarn and weaving calicoes, which employ in all about 9500 hands; some of the single factories being very large, and employing from 1000 to 1500. Woollen cloth is also made at Staleybridge, and there are brass and iron foundries, brick-works, collieries, and quarries. Markets are held weekly, and fairs twice a year. Pop. 20,760.

STALIMENE. See Lemnos.

STAMENS. See Botany.

STAMFORD, a parliamentary borough and market-town of England, in the county and 39 miles S. of Lincoln, on a pleasant slope above the Welland, 89 miles N. by W. of London. The river is crossed by an old stone bridge of five, and a modern one of three arches. The town is old and straggling, consisting of houses, substantially built of freestone from the neighbouring quarries, and roofed with slate. There are five parish churches, most of which are old and interesting buildings. All Saints, which was built in 1465, is partly early English and partly perpendicular, and has a fine crocketted spire, and several old monuments. St George's church, rebuilt in 1450, is a plain building, with some portions very ancient; and that of St John the Baptist, which is about the same age, has a fine embattled tower, and some good carving in wood. St Mary's dates as far back as the thirteenth century; and St Michael's has been recently rebuilt on the site of one still older. In the church of St Martin, a fine building in the late perpendicular style, the remains of the great Lord Burleigh lie in the family vault; and a handsome monument has been erected to his memory. Of the Benedictine priory of St Leonards part of the nave is still standing, used now as a barn; and there is also to be seen the west gate of a Carmelite friary to the north-east of the town. Stamford once had, besides these, several other ecclesiastical buildings, of which few or no remains now exist. The grammar-school occupies part of the old church of St Paul, a building in the Norman and early English styles; and near it is a Norman gateway, which anciently belonged to Brasenose College, a monastic school now no longer in existence. The grammar-school, which was founded in 1530, has an endowment of about L.580 annually. Stamford has also a blue-coat school, two free schools, national schools, and an infant school. There are places of worship for independents, Roman Catholics, Wesleyan and Reformed Methodists. All these, as well as the large town-hall, market-house, and jail, are comparatively modern buildings. The charitable institutions of Stamford are very numerous. There are several hospitals for different classes of the poor; alms-houses, establishments for lending money to tradesmen, and for apprenticing poor boys, and several others. A literary and scientific institution was

Stammering.

established here in 1838, with a library, museum, and lecture-room. There are also in Stamford an assembly-room, a theatre, and public baths. The town contains several large breweries, and a manufactory of agricultural implements. Malt is also made to some extent, but on the whole Stamford is not an important manufacturing town. It has an extensive retail trade with the neighbouring country, which is facilitated not only by the connection of the town by railways with all parts of the country, but by its situation on the Welland, which is navigable up to the town for boats and barges. The borough is governed by a mayor, six aldermen, and eighteen councillors, and is represented in Parliament by two members. Stamford is a very old town, and is mentioned in history soon after the departure of the Romans from Britain. The Picts and Scots, who at that time greatly harassed the country by their invasions, were defeated here by the Britons and Saxons in 449. At a later period it was in the possession of the Danes, who lost it in 922 to Edward the Elder; but afterwards recovered it, and remained in possession until 1041, though it was taken from them for a time by Edmund I. in 942. About this time it had risen to be a place of some size, and was a market-town and king's borough. In the twelfth century it was inhabited by many wealthy Jews, who were plundered and maltreated by the Crusaders setting out for the Holy Land. Many of the English sovereigns visited the town, and by some of them parliaments or councils were held here. It was at one time fortified and defended by a castle, but it was much injured by the Lancasterian party, who captured it during the Wars of the Roses, and the castle was demolished by Richard III. In 1572 Lord Burleigh, who was lord of the manor, procured the settlement here of some Flemish Protestant refugees, silk and serge weavers, and thus conferred a great benefit on the town. Pop of the borough (1851) 8933.

STAMMERING is a term which has been loosely employed to denote all kinds of defective utterance; neither is any distinction generally made between the terms stammering and stuttering, but they are used synonymously to designate a difficulty in uttering or in articulating without interruption certain sounds, or an absolute inability to do so. The Greeks designated these affections somewhat indiscriminately by the words—*psellismos*, faltering; *traulismos*, lisping; *asapheia*, indistinctness; *ischnophonia*, feebleness of voice; and *battarismos*, stuttering. Among the Romans a stammerer, or any one having an impediment of speech, was called *balbus;* a lisper, *blæsus;* and Cicero uses the term *hæsitantia linguæ*. The terms stammering and stuttering, properly used, designate kinds, and not degrees of the evil. The same confusion exists in the use of these terms as in the use of the words *articulation* and *pronunciation*, which also have been erroneously regarded as synonymous.

Stammering and *stuttering*, as contra-distinguished, may be regarded—the former as mainly an organic or symptomatic, the latter as chiefly an idiopathic or functional affection. Stammering may be defined as a difficulty in enunciating, or an inability to enunciate certain elementary sounds. This difficulty does not, as is frequently asserted, occur only in the pronunciation of consonants, but extends also to the vowels. Stuttering, on the other hand, consists chiefly in the difficulty fluently to enunciate words and sentences. The great variety of defects which constitute stammering arises naturally from as great a variety of causes; which causes may be either organic or merely functional. Among organic causes may be enumerated harelip, cleft palate, abnormal length of the uvula, inflammation or enlargement of the tonsils (a deficiency or disarrangement of teeth), tumours of the tongue or in the buccal cavity, &c. When the organs are in a normal state, and the person is unable to place them in the proper position for producing the desired effect, the cause is functional. General debility, paralysis and spasms of the tongue, glottis, lips, &c., owing to a general or local affection of the nerves of the vocal organs; bad habit, imitation, &c.; are some of the functional causes of stammering. The cause of the imperfection of the vowel-sounds must be sought in the respiratory organs, the larynx, or the buccal cavity. The sounds may be deficient in timbre, from affection of the vocal ligaments; or the larynx being in a healthy condition, the tone may be altered in the buccal or nasal cavities; while the vowels may be ill formed from misemployment or defective association of the various organs upon which articulation depends. The cause of the defective enunciation of consonants must be sought in the organs of articulation, although it may be found to proceed sometimes from affection or misuse of the respiratory organs or the larynx. The tongue is frequently too large for the buccal cavity, in which case most of the speech-sounds will be affected; while individual muscles often lose their contractility.

Stuttering, as distinguished from stammering, has been described as consisting, in a momentary difficulty, in pronouncing, or inability to pronounce, certain syllables or words. The stoppage of sound may take place at the second or third syllable, but generally occurs at the first. The stutterer usually finds no difficulty in articulating the elementary sounds of which speech is composed (in which respect he differs from the stammerer); but his affection becomes apparent when he attempts to form syllables and words. His greatest difficulty is experienced in the pronunciation of the explosives K, T, P, and their medials G, D, B, or M; because in articulating these elements, the buccal cavity requires to be closed, and immediately reopened for the following vowel. Instead of doing so, the stutterer allows the respective organs to remain in the same position longer than is necessary, and compresses the cavity in trying to force out the sound. The difficulty of the stutterer is much less when the word begins with a vowel. The opening of the glottis, in the transition from the explosive to the vowel, is in fact the chief and most distressing difficulty of the stutterer; and it is this which causes him to repeat the words or syllables until articulation is effected. Stuttering, however, is not confined to the consonants, but may also affect all vowel sounds. It is a remarkable fact, that most stutterers can *sing* without difficulty; the reason being, that in singing, the continuous action of the vocal organs is not so frequently interrupted; and consequently singing is less difficult than speech, in which a constant change is demanded in the position of the vocal organs. The causes of stuttering may be distinguished as predisposing, exciting, and proximate. As belonging to the two former may be enumerated—abnormal irritability of the nervous system; mental emotions; affections of the brain and spinal cord; solitary vices; mimicry and involuntary imitation. The proximate cause of stuttering has been asserted by Drs Müller, Arnott, and others, to be the spasmodic closure of the glottis. Such a theory is not however tenable; the glottis is rarely or ever *per se* at fault, and the cause must be sought for, either in those muscles which regulate the inspiration and expiration of the breath, or in the organs of articulation. If the action were strictly spasmodic, the speaker would be unable to arrest it; whereas all stutterers possess this power. With persons thus affected, expiration is frequently retarded, and all the muscles concerned in vocalization and articulation are thrown into inordinate action. In some cases the tongue may be seen flying about the mouth, and vaguely endeavouring to regulate itself for the articulation of a particular word; while the other organs either sympathise or are in a dormant state. This derangement gradually extends to the larynx and organs of respiration, until the

whole of the vocal organs are influenced, and all voluntary control is lost. When a person thus affected attempts to speak, you see the eyes open and close spasmodically, the face redden, the head jerk backwards and forwards, the veins of the neck swell, the respiratory muscles act spasmodically, the arms and legs even sympathise with the general contortion; while the heart palpitates violently (sometimes intermittently), till, with a violent voluntary effort of the whole muscular system, the word explodes. In less severe cases, the vocal organs are alone affected. In such you may see the lips closing and opening, the under-jaw and tongue working at random; while the air enters the lungs with a croup-like sound, and is immediately expelled again; until at last the stutterer feels that his organs are in the right position, and the word is articulated. In other cases, the facial muscles and all the vocal organs are in a quiescent state, and the ordinary observer could not discover that any effort at articulation was being made; a slight spasm of the eyelid being the only external sign of the great internal struggle. The forms which stuttering assumes are so varied that no two cases are alike. Stutterers may, however, be classed under two heads—the psychical and the physical—a classification which has not often been employed. The psychical or mental stutterer is acted upon by every external influence both mental and physical; while on the physical stutterer external influences have little or no effect. His speech is alike on all occasions, uninfluenced by the places in which, or the persons before whom he is speaking; whereas these circumstances would exercise the greatest possible influence upon the former class. In psychical stuttering the affection is sometimes intermittent, disappearing for various periods of time, and increasing or diminishing according to the mental and physical condition of the sufferer; all pleasurable mental emotions tend to diminish the affection; while those of an opposite character produce a contrary effect. The physical influences liable to increase the stutter are—changeable or damp weather, fatigue, dissipation, tobacco, and alcoholic liquors. These last, however, not unfrequently produce fluency so long as the sufferer is under their influence, but have a corresponding reaction. Cheerful society, healthy mental occupation, athletic sports, and constant observance of the universal law, "To be temperate in all things," are the physical influences which tend to diminish the affection. It may be laid down as a general principle, that everything which tends to lessen the voluntary control increases the stuttering, and *vice versâ*. The statistics respecting the number of persons suffering from impediments of speech are very unsatisfactory. Some writers assume that there is about 1 person in 5000 who stammers; while others believe that there are 2 in 1000. Colombat, who made the former calculation, acknowledged that he only reckoned those who were suffering under a severe impediment. Colombat is possibly right as to the number of bad stammerers, but it is equally true that there are nearly 2 in 1000 who suffer from affections which may be included under the general term *stammering*. The number of severe cases of stammering in the world would thus be 257,200; and the entire number, 2,572,000; thus would give to Great Britain—of the former cases, 5,498; and a total of 54,978. The number of females who stammer is much less than that of males. Some authors maintain that there are only 5 females out of every 100 stammerers. The writer believes that the average is about 10 per cent: his practice has given a proportion of 12½ per cent. The reason why females should stammer less than males is by no means certain.

To the anomalous forms that stammering assumes may probably be traced the variety of remedies that have been employed for its removal. Amongst other remedies proposed by scientific writers are the following:—Colombat employed rhythm to produce harmony between the nervous action and the organs of articulation. Bertrand recommends motions of the fingers and toes, and the introduction of foreign substances into the mouth. Dr Rullier considers that the cause of all stammering must be sought for in the brain, and his remedies correspond. Professor Itard uses a gold or ivory fork about an inch in length, which is to be applied by its convex surface to the alveolar arch of the lower jaw. Dr Serres advises the patient to shake the words out by movements of the arms. Dr M. Hall advises speaking in a chanting voice. Dr Arnott would prefix the vowel *e* to every word, and thus connect words together. Mrs Leigh of New York made her patients put the tongue at the top of the palate. This plan was also adopted by M. Malbouche and by Mr John Broster. Professor Diffenbach performed upon eighty persons the operation of cutting a transverse wedge out of the tongue. Sometimes one of these remedies was in public favour and sometimes another; but all failed to remove stammering on physiological principles. Such a state of public opinion afforded, however, a harvest to quacks and charlatans, each of whom had some secret panacea. One plan was to enforce talking with the teeth closed; another to place bits of India-rubber under the tongue; another advised chanting; another speaking through the nose; another drawling; another the full inflation of the lungs; while another set of professors cut away tonsils, uvula, and portions of the tongue. The Rev. C. Kingsley, in writing of the various systems says:—

> "Meanwhile the true method of cure, or at least its elements, had suggested itself to the late Mr Hunt. He found out by patient comparing of health with unhealth, a fact which seems to have escaped all before him—that the abuse neither of the tongue, nor of any single organ, is the cause of stammering—that the whole malady is so complicated that it is very difficult to perceive what organs are abused at any given moment—quite impossible to discover what organ first went wrong and set the rest wrong. For nature in the perpetual struggle to return to a goal to which she knows not the path, is ever trying to correct one morbid action by another, and to expel vice by vice; ever trying fresh experiments of mis-speaking, and failing, alas! in all: so that the stammer may take very different forms from year to year; and the boy who began to stammer with the lips, may go on to stammer with the tongue, then with the jaw, and last, and worst of all, with the breath; and in after-life try to rid himself of an abuse by trying in alternation all the other three. To these four abuses—of the lips, of the tongue, of the jaw, and of the breath—old Mr Hunt reduced his puzzling mass of morbid phenomena; and I, for one, believe his division to be sound and exhaustive."[1]

From this it will be seen that the great object must be first to discover the true cause of the stammer. To do this with any success, much experience and patient labour are necessary. When the cause has been ascertained, we must return to nature through art, and teach the stammerer to do consciously, what the healthy subject does unconsciously; but as the misuse of organs produces weakness, considerable time is often necessary to restore the vocal apparatus to healthy action. Great attention must likewise be paid to the *economy* of nature, to prevent that waste of nervous energy which generally accompanies psellismus. The art of speaking must be really learned, and the same control gained over the vocal organs as the musician has over his mechanical instrument. The stammerer cannot, however, be treated like a mere machine, for his organs are under the influence of an ever-varying agent—the mind. The physically abnormal condition in psellismus reacts most powerfully on the mind, as is proved by the curious phenomena that most stammerers can read aloud when alone, can talk fluently if in the dark, or if they wear a mask; and can recite or speak in an assumed tone without difficulty. The peculiar disposition of the mind must be studied, and every means used to rouse it into

[1] See *Frazer's Magazine* for July 1859, "The Irrationale of Speech."

Stanhope. vigilant and vigorous control over the vocal apparatus. The same authority before quoted says:—

"Of course the very condition of cure—the conscious use of the organs of speech—makes it depend on the power of self-observation, on the attention, on the determination, on the general intellectual power, in fact, of the patient; and a stupid or volatile lad will give weary work."

The sudden improvement frequently produced on first commencing treatment, induces the belief that the enemy is conquered. A perfect cure, however, can only be effected after much diligent application, and those cases which are quickly cured, are the most liable to relapse. The advice given by Dr J. Mason Warren, the highest authority on this subject in the United States, is most valuable. He says:—

"Seek out a person who has experience in the treatment of impediments of speech. Place him under his care, and if he is benefited do not remove him and think to perfect the cure yourself. Three months is a very short time for him to remain under the superintendence of an instructor; six months is better, and where it is practicable, he should remain a year. If this interferes with other studies, it is of no consequence; he will derive benefits enough to compensate for the loss. The age I should fix upon for this trial should be from eight to twelve. At this period the loss of a year's study may be a gain. If he meets there others who are affected as he is, it is all the better; he will no longer look upon his case as a peculiar one; and if he sees others whose impediments are worse than his, it will give him additional courage.

"Whatever method may be employed for the relief of this affection, no permanent advantage will be gained in the majority of cases unless resolutely persevered in for one or two years."

The writer cannot give his unqualified adherence to the last paragraph; but he believes, with Dr Warren, that the longer the treatment is continued, the more likely is the cure to be perfect and permanent. (J. H—T.)

STANHOPE, Philip Dormer, the fourth *Earl of Chesterfield*, was born at London, on the 22d of September 1694. He was the son of Philip, the third Earl, by his wife, Lady Elizabeth Savile, daughter of George, Marquis of Halifax. At the age of eighteen he was sent to Trinity Hall, Cambridge, where he studied assiduously, and, according to his own account, became an absolute pedant. In 1714 he quitted the university, and travelled on the continent, where a familiarity with good company soon convinced him he was totally mistaken in almost all his notions, and an attentive study of the air, manner, and address of people of fashion soon polished a man whose prominent desire was to please, and who, as it afterwards appeared, valued exterior accomplishments beyond any other human acquirement. While Lord Stanhope, he obtained an early seat in Parliament, and in 1722 succeeded to his father's estate and titles. In 1728 and in 1745 he was appointed ambassador extraordinary and plenipotentiary to Holland. This high character he supported with the greatest dignity, serving his own country, and gaining the esteem of the States-General. Upon his return from Holland, he was sent as lord-lieutenant to Ireland, and, during his administration there, gave general satisfaction to all parties. He left Dublin in 1746, and in October succeeded the Earl of Harrington as secretary of state, in which post he officiated until February 6, 1748. In 1752, being seized with a deafness which incapacitated him for the pleasures of society, he from that time led a private and retired life, amusing himself with books and his pen, in particular, he engaged largely as a contributor to a periodical called *The World*, in which his contributions have a distinguished degree of excellence. He died on the 24th of March 1773, leaving a character for wit and abilities that had few equals. He distinguished himself by his eloquence in parliament on many important occasions, of which we have a characteristic instance of his own relating. He was an active promoter of the bill for altering the style, and on this occasion, as he himself writes in one of his letters to his son, he made so eloquent a speech in the house that every one was pleased, and said he had made the whole very clear to them, "when," says he, "God knows, I had not even attempted it. I could just as soon have talked Celtic or Sclavonian to them as astronomy, and they would have understood me full as well." Lord Macclesfield, who was considered as a great mathematician, and who had a principal hand in framing the bill, spoke afterwards, with all the clearness that a thorough knowledge of the subject could dictate, but not having a flow of words equal to Lord Chesterfield, the latter gained the applause which was more justly due to the former. He left no issue by his lady, Melusina de Schulemburg, Countess of Walsingham, but he had a natural son, Philip Stanhope, Esq., whose education was for many years a close object of his attention, and who was afterwards envoy-extraordinary at the court of Dresden, but died before him. The high character which Lord Chesterfield supported during life received no small injury soon after his death, from a fuller display of it by his own hand. After Lord Chesterfield's death, Mr Stanhope's widow published a series of letters, written by the father to the son, filled with instructions suitable to the different gradations of the young man's life to whom they were addressed. These letters contain many fine observations on mankind and rules of conduct, but it is observable that he lays a greater stress on exterior accomplishments and address than on intellectual qualifications and sincerity, and allows a much greater latitude to fashionable pleasures than good morals will justify. Lord Mahon, now Earl Stanhope, who is the last and the most correct editor that Chesterfield's works have received (5 vols. 1853), says regarding his character—"The defects of Chesterfield were neither slight nor few, and the more his contemporaries excused them, lost as they were in the lustre of his fame, the less should they be passed over by posterity. A want of generosity, dissimulation carried beyond justifiable bounds, a passion for deep play, and a contempt for abstract science, whenever of no practical or immediate use, may, I think, not unjustly be ranked among his errors." These *Letters to his Son* appeared in 1774, in 2 vols. 4to. This publication was followed by a collection of his *Miscellaneous Works*, 1777, 2 vols. 4to. A third volume was added in 1778.

Stanhope, *Charles*, third Earl, born in 1753, was the eldest son of Philip, the second Earl, a man equally remarkable for his mathematical talents, and his liberal political opinions. The subject of this notice succeeded to the peerage in 1786. By his first marriage he became the brother-in-law of Pitt, and on the mother's side he was closely allied to the Scottish Earls of Haddington. By this marriage he had three daughters, one of them Lady Hester Stanhope, who gained so great a notoriety by retiring to the Syrian deserts and fixing her residence at Djoun, among the mountains of Lebanon, where she died in 1839. This eccentric but public-spirited and most inventive man, while he divided his attention among a variety of inquiries, sufficient to have prevented excellence in any, had the rare merit of excelling in several most important pursuits, while in more than one he has bequeathed to the world discoveries that have proved most extensively useful. In politics he was a decided Whig, an assertor of religious toleration, and of non-intervention in the internal affairs of foreign states. Sometimes, however, he carried out the principles of his party with a boldness which other minds scrupled to follow, and in the latter years of his parliamentary life, Earl Stanhope used to be called "the minority of one." His political works were a refutation of Price's scheme of the *Sinking Fund*, an answer to Burke's *Reflections on the French Revolution*, and an *Essay on Juries*. But his inventions in mechanical science are those by which he has secured the gratitude of posterity. They are too

Stanhope.

many to be here so much as completely enumerated. The principal of them, the Stanhope press, has been described in the article PRINTING, where notice has also been taken of his exertions for improving the process of stereotype printing. He was an early student of Franklin's theory of electricity, to which he contributed several valuable observations. Another of his most useful inventions was one for improving the locks of canals, and more curious ones were his two calculating machines, one of which performed addition and subtraction, the other multiplication and division. He died in 1816.

STANHOPE, *George*, an eminent divine of the Church of England, was born at Hartshorn, in Derbyshire, in the year 1660. His father was rector of that parish, vicar of St Margaret's at Leicester, and chaplain to the Earls of Chesterfield and Clare. His grandfather, Dr George Stanhope, was chaplain to James I. and Charles I., had the chancellorship of York, where he was also a canon residentiary, held a prebend, and was rector of Weldrake, in that county. For his loyalty he was driven from his home with eleven children, and died in 1664. The son was sent to school, first at Uppingham, in Rutland, then at Leicester; he was afterwards removed to Eton, and thence chosen to King's College, in Cambridge, in the place of W. Cleaver. He took the degree of A.B. in 1681 and of A.M. in 1685, was elected one of the syndics for the University of Cambridge, in the business of Alban Francis, 1687, minister of Quoi, near Cambridge, and vice-proctor, 1688. He was that year preferred to the rectory of Tring, in Hertfordshire, which after some time he quitted. In 1689 he was presented to the vicarage of Lewisham, in Kent, by Lord Dartmouth, to whom he had been chaplain, as well as tutor to his son. He was also appointed chaplain to King William and Queen Mary, and continued to enjoy that honour under Queen Anne. He commenced D.D. July 5, 1697, performing all the exercises required to that degree publicly and with great applause. He was made vicar of Deptford in 1703, succeeded Dr Hooper as dean of Canterbury the same year, and was thrice chosen prolocutor of the lower house of convocation. His uncommon diligence and industry, assisted by his excellent parts, enriched him with a large stock of polite, solid, and useful learning. His discourses from the pulpit were equally pleasing and profitable, a beautiful intermixture of the clearest reasoning with the purest diction, attended with all the graces of a just elocution. In him were happily united the good Christian, the solid divine, and the fine gentleman. His conversation was polite and delicate, grave without preciseness, facetious without levity. His piety was real and rational, his charity great and universal, fruitful in acts of mercy and in all good works. He died March 18, 1728, aged sixty-eight years, and was buried in the chancel of the church at Lewisham. The dean was twice married, first to Olivia Cotton, by whom he had one son and four daughters. His second lady, who was sister to Sir Charles Wager, survived him, dying October 1, 1738, aged about fifty-four. One of the dean's daughters was married to a son of Bishop Burnet. Stanhope's writings, which are considered as a treasure of piety and devotion, are—*A Paraphrase and Comment upon the Epistles and Gospels*, 1705, 4 vols., 8vo; *Sermons at Boyle's Lectures*, 1706, 4to; *Fifteen Sermons*, 1700, 8vo; *Twelve Sermons on Several Occasions*, 1727, 8vo; *A Translation of Thomas à Kempis*, 1696, 8vo; *Epictetus's Morals, with Simplicius's Comment, and the Life of Epictetus*, 1700, 8vo; *Parson's Christian Directory*, 1716, 8vo; *Pious Breathings*, from the works of St Augustine, with select contemplations from St Anselm and St Bernard; *Rochefoucault's Maxims*, 1706, 8vo; *A Funeral Sermon on Mr Richard Sare, bookseller*, 1724, two editions, 4to; *Twenty Sermons*, published singly between the years 1692 and 1724; *Private Prayers for every Day in the Week, and for the several Parts of each Day*, translated from the Greek Devotions of Bishop Andrews, with Additions, 1730. In his translations it is well known Dr Stanhope did not confine himself to a strict and literal version; he took the liberty of paraphrasing, explaining, and improving upon his author.

Stanislas Leszczynski.

STANISLAS LESZCZYNSKI, or LESZINSKI, King of Poland, was born at Lemberg, the capital of Red Russia, on the 20th of October 1677. His father was a Polish nobleman, distinguished by his rank and the important offices which he held, but still more by his firmness and courage. In 1704 Stanislas was sent ambassador by the Assembly of Warsaw to Charles XII. of Sweden, who had conquered Poland. He was at that time twenty-seven years old, was general of Great Poland, and had been ambassador-extraordinary to the Grand Signior in 1699. Charles was so delighted with the frankness and sincerity of his deportment, and with the firmness and sweetness which appeared in his countenance, that he offered him the crown of Poland, and ordered him to be crowned at Warsaw in 1705. He accompanied Charles into Saxony, where a treaty was concluded with King Augustus in 1705 by which that prince resigned the crown and acknowledged Stanislas King of Poland. The new monarch remained in Saxony with Charles till 1707, when they returned into Poland and attacked the Russians, who were obliged to evacuate that kingdom in 1708. But Charles being defeated by Peter the Great in 1709, Augustus returned into Poland, and being assisted by a Russian army, obliged Stanislas to retire first into Sweden and afterwards into Turkey. Soon after, he took up his residence at Weissenburg, a town in Alsace. Augustus despatched Sum, his envoy, to France to complain of this, but the Duke of Orleans, who was then regent, returned this answer:—"Tell your king that France has always been the asylum of unhappy princes." Stanislas lived in obscurity till 1725, when Louis XV. espoused the Princess Mary, his daughter. Upon the death of King Augustus in 1733 he returned to Poland, in hopes of remounting the throne of that kingdom. A large party declared for him, but his competitor, the young Elector of Saxony, being supported by the Emperor Charles VI. and the Empress of Russia, was declared king, though the majority was against him. Dantzig, to which Stanislas had retired, was quickly taken, and with great difficulty the unfortunate prince made his escape in disguise, after hearing that the Russians had set a price upon his head. In 1736, when peace was concluded between the Emperor and France, it was agreed that Stanislas should abdicate the throne, but that he should be acknowledged King of Poland and Grand Duke of Lithuania, and continue to bear these titles during life; that all his effects and those of the Queen, his spouse, should be restored; that an amnesty should be declared in Poland for all that was past, and that every person should be restored to his possessions, rights, and privileges; that the Elector of Saxony should be acknowledged King of Poland by all the powers who acceded to the treaty; that Stanislas should be put in peaceable possession of the duchies of Lorraine and Bar, but that immediately after his death those duchies should be united for ever to the crown of France. In Lorraine, Stanislas succeeded a race of princes who were beloved and regretted, and his subjects found their ancient sovereigns revived in him. He then tasted the pleasure which he had so long desired, the pleasure of making men happy. He assisted his new subjects; he embellished Nancy and Luneville; he formed useful establishments; he founded colleges, and built hospitals. He was engaged in these noble employments, when an accident occasioned his death. His night-gown caught fire, and burned him so severely before it could be extinguished, that he was seized

with a fever, and died the 23d of February 1766. He was a protector of the arts and sciences. He wrote several works of philosophy, politics, and morality, which were collected and published at Paris in 1763, in 4 vols. 8vo., under the title of *Œuvres du Philosophe Bienfaisant.* An octavo volume, ornamented with engravings, was published in 1825, under the title of *Œuvres choisies de Stanislas, Roi de Pologne, Duc de Lorraine et de Bar*, to which an historical notice was prefixed by Madame de Saint-Ouen.

STANISLAWOW, or Stanislau, a town of the Austrian Empire, in Galicia, capital of a circle, on the Bistritza, 71 miles S.S.E. of Lemberg. It is strongly fortified, and contains a castle, now used as a military hospital, three handsome churches, a gymnasium, normal seminary, and other schools. Here also is a column, erected in 1838 in honour of the late Emperor Francis. Stanislawow is the seat of public offices and courts of law; it is generally well built, and has an active trade in the produce of the surrounding country. Pop. (1851) 10,864.

STANLEY, Thomas, a very learned writer, was the son of Sir Thomas Stanley of Laytonstone in Essex, and Cumberlow in Hertfordshire, by his second wife Mary, the daughter of Sir William Hammond of St Alban's Court. He was descended from a natural son of Edward earl of Derby. He was born in the year 1625, and received a domestic education under the tuition of William the son of Edward Fairfax, the well-known translator of Tasso. In 1639, he became a fellow-commoner of Pembroke Hall, Cambridge, where he distinguished himself by his progress in classical learning. After having travelled on the continent, he resided for some time in the Middle Temple. Here he lived on terms of particular intimacy with his cousin Edward, afterwards Sir Edward Sherburne, who cultivated similar studies, and who dedicated a volume of poems to this learned kinsman. Stanley published *Poems and Translations* in 1649, 8vo. They were reprinted, with additions, in 1651. But his principal work was his *History of Philosophy, containing the Lives, Opinions, Actions, and Discourses of the Philosophers of every Sect.* Of the original edition, printed in folio, the first part appeared in 1655, and the third in 1660. The work is dedicated to his uncle-in-law, Sir John Marsham, author of the *Canon Chronicus*, who first suggested the undertaking. There are four editions of the History, the last and best being that of 1743, 4to. The author has displayed solid as well as extensive erudition, but his valuable materials are not disposed to the best advantage. The reputation of his work extended to the continent; and a Latin translation of it by Olearius was published at Leipzig, in quarto, in the year 1711. The part relating to the history of Oriental philosophy had been translated into the same language by Le Clerc, and published at Amsterdam in 1690, with a dedication to Bishop Burnet. This version Le Clerc afterwards inserted in the second volume of his *Opera Philosophica.* Stanley next prepared his elaborate and valuable edition of Æschylus, Lond., 1633, fol. Some copies of the same impression bear the date of 1664. This edition, which includes the fragments and the Greek scholia, and is accompanied with a commentary and a Latin version, was of great importance when it first appeared; but since the death of the learned editor, so much has been effected by Schütz, Wellauer, Dindorf, and Scholefield, that it has lost a great portion of its original value. It was thought expedient to reprint Stanley's edition, with the commentary, corrected and enlarged from his papers preserved in the university library at Cambridge. The charge of this edition was committed to a very competent scholar, Samuel Butler, afterwards promoted to the bishopric of Lichfield; who, with the addition of his own annotations, published it at Cambridge in the year 1809, in 4 vols. 4to, and in 8 vols. 8vo. Some notes on Demosthenes, ascribed to Stanley, have recently been published in the ninth volume of Dobson's *Oratores Attici.* He died at his lodgings in Suffolk Street, in the parish of St Martin's-in-the-Fields, on the 12th of April 1678. He had married Dorothy, the daughter and co-heiress of Sir James Enyon of Flower in Northamptonshire, Bart. He had a son, who bore his own name, and, like himself, was educated at Pembroke Hall. At a very early age, he published *Aelian's Various Histories, translated into English*, Lond., 1665, 8vo. A memoir of Stanley will be found prefixed to the edition of his *Poems*, published in 1814–15, by Sir Egerton Brydges.

STANNARY COURTS (Lat. *Stannum*, tin), are legal institutions in Devonshire and Cornwall, for the administration of justice among the tinners. They are held before the lord-warden and his substitutes, by a privilege granted to the workers in the tin-mines, to sue and be sued only in their own courts, that they may not be drawn from their business by attending their lawsuits in other courts.

STANOVOI, or Yablonoi Mountains, a chain in Siberia, extending for about 3000 miles in a direction for the most part N.E. from the Altai range, parallel to the shores of the sea of Ochotsk, as far as Behring Strait. This chain sends out numerous smaller branches, but it is more remarkable for length than for altitude. South of 55. N. Lat., the mountains are densely wooded; from that point as far north as 63., they gradually become more and more bare, and beyond the latter point they are quite covered with snow. Many considerable rivers take their rise in the Stanovoi Mountains.

STARAJA RUSSA, a town of European Russia, in the government and 40 miles S. of Novgorod, on the south side of Lake Ilmen. It is generally ill built, but has several churches and other edifices. Here there are celebrated salt-works, and an active trade in linseed. Pop. 8044.

STARCH. See Chemistry and Food.

STAR-CHAMBER, Court of (*Camera Stellata*), a famous, or rather infamous, English tribunal, said to have derived its name from the room in which it sat, the old council-chamber of the palace of Westminster, because the roof was at first garnished with gilded *stars.* This was a court of very ancient origin, but new-modelled by statutes 3 Henry VII., c. 1, and 21 Henry VIII., c. 20, consisting of divers lords spiritual and temporal, being privy councillors, together with two judges of the courts of common law, without the intervention of any jury. Their jurisdiction extended legally over riots, perjury, misbehaviour of sheriffs, and other notorious misdemeanours, contrary to the laws of the land. Yet this was afterwards, as Lord Clarendon informs us, stretched "to the asserting of all proclamations and orders of state; to the vindicating of illegal commissions and grants of monopolies; holding for honourable that which pleased, and for just that which profited; and becoming both a court of law to determine civil rights, and a court of revenue to enrich the treasury: the council-table by proclamation enjoining to the people that which was not enjoined by the laws, and prohibiting that which was not prohibited; and the star-chamber, which consisted of the same persons in different rooms, censuring the breach and disobedience to those proclamations by very great fines, imprisonments, and corporal severities: so that any disrespect to any acts of state, or to the persons of statesmen, was in no time more penal, and the foundations of right never more in danger to be destroyed." For these reasons, it was finally abolished by statute 16 Car. I., c. 10, to the general joy of the whole nation.

STARGARD, a town of the Prussian monarchy, Pomerania, in the government and 21 miles E.S.E. of Stettin, on the navigable river Ihna. It was anciently the chief town of Farther Pomerania (*Hinterpommern*), and is still surrounded by ancient walls and watch-towers, and entered by three gates. The town has 4 churches, one of which,

that of St Mary, a Gothic building of the 14th and 15th centuries, is remarkable for its richly adorned exterior, and for the majestic proportions of the interior. The town-hall, which dates from the 16th century, is also a fine building. Stargard has a gymnasium and several other schools, various hospitals, and an orphan asylum. Woollen and linen cloth, hosiery, hats, &c., are extensively manufactured here, and an active trade is carried on. Pop. 13,107.

STARGARD, a town of Prussia, on the Ferse, in the government, and 29 miles S., of Danzig. It has a town-hall, Protestant and Roman Catholic churches, a school, and an hospital. Tanning, brewing, and distilling, are carried on here. Pop. 4875.

STARK, WILLIAM, a physician of Scottish descent, was born at Manchester in the month of July 1740. He was sent to the University of Glasgow, where, under the tuition of Dr Smith and Dr Black, with other eminent masters, he learned the rudiments of science, and acquired the mathematical accuracy, logical precision, and contempt of hypotheses, with which he prosecuted all his future studies. Having chosen physic for his profession, he removed from the University of Glasgow to that of Edinburgh, where he was soon distinguished, and honoured with the friendship of the late Dr Cullen. Having finished his studies at Edinburgh, though he took there no degree, Mr Stark, in the year 1765, went to London, and devoted himself entirely to the study of physic and the elements of surgery; and looking upon anatomy as one of the principal pillars of both these arts, he endeavoured to complete with Dr Hunter what he had begun with Dr Monro; and under these two eminent teachers he appears to have acquired a high degree of anatomical knowledge. He likewise entered himself, about this time, a pupil at St George's Hospital; and with what industry he prosecuted this plan, with what success his labours were crowned, may be seen in a series of *Clinical and Anatomical Observations*, which were made by him during his attendance at the hospital, and were published after his death by his friend Dr Carmichael Smyth.

In the year 1767 he went to Leyden, where he took the degree of M.D., publishing an inaugural dissertation on dysentery. On his return to London, he recommenced his studies at the hospital; and when Dr Black was called to the chemical chair in Edinburgh, Dr Stark was solicited, by several members of the University of Glasgow, to stand as a candidate for their professorship of the theory and practice of physic. This, however, he declined, being influenced by the advice of his English friends, who wished to detain him in London, and having likewise some prospect of an appointment in the hospital. In 1769 he commenced a series of experiments on diet, which he was encouraged to undertake by Sir John Pringle and Dr Franklin, whose friendship he enjoyed, and from whom he received many hints respecting both the plan and its execution. These experiments, or rather the imprudent zeal with which he prosecuted them, proved, in the opinion of his friends, fatal to himself; for he began them on the 12th of July 1769 in perfect health and vigour, and from that day, though his health varied, it was seldom if ever good, till the 23d of February 1770, when he died after suffering much uneasiness.

STARODUB, a town of European Russia, on the Babinza, in the government and 100 miles N.E. of Tchernigov. It is surrounded by earthen ramparts, and contains a cathedral, a monastery, an extensive copper-work, a bell-foundry, and tanneries; and it has a considerable trade with the Baltic and Black Sea. Pop. 9500.

STATEN ISLAND. See NEW YORK.

STATICS

Is that branch of mechanical science which treats of the laws of equilibrium or repose; it is divided into three distinct sections, according as it may refer to solid, to fluid, or to gaseous matter. Hydrostatics and Aërostatics have already been treated of under their proper heads; and in the present article we shall confine our attention to the equilibrium of solid bodies, or to Geostatics, as this section may, with propriety, be termed.

If we could place a body in space so as that nothing might obstruct its motion, it would move on the application of the slightest pressure, and could then only be kept at rest by the application of antagonistic pressures, so that the doctrines of statics must relate to the manner in which pressures applied to a solid body keep that body at rest, or, as we say, in which they balance each other.

Our idea of pressure is obtained directly from the experience of resistance to muscular effort; and as our knowledge of the very existence of resistance is experimental, so our acquaintance with the laws of resistance must also be derived from experience, and cannot possibly be the result of mere intellectual ratiocination: the attempt to make statics a branch of pure logic must, in the very nature of things, be a vain one.

When a piece of solid matter is entirely detached from all other solid bodies, it, except in certain very peculiar circumstances, moves and continues to move until it come in contact with some other solid body, and all the repose of which we have any actual cognisance, exists among solid bodies in contact with each other.

On attempting to displace a body which is at rest, we experience three distinct kinds of resistance:—in the first place, on trying to lift it, we experience an opposition, as it were, in the object itself, and if we succeed in raising it we still feel that it tends to go down again; to this well-known and yet very wonderful quality, the name *weight* is given, and we recognise in it that very tendency in virtue of which the object, when let go, descends until it meet an obstacle. In the second place, on attempting to push the object against the body on which it is resting, we find that that body resists our utmost endeavours which never succeed unless by its displacement or by its fracture; this kind of resistance may, for the convenience of language, be called *direct*. And in the third place, on trying to push the object along the surface on which it is resting, we experience a resistance, not insuperable as before, but varying according to the nature of the surfaces and to other circumstances; this kind of resistance is commonly called *friction*, but as this word implies motion, it would be more accurate to use the expression *resistance to friction* or *lateral resistance*. When the surfaces are smooth and the substances hard, the friction is comparatively small, and, as is well-known, becomes less when grease or oil is applied.

EQUILIBRIUM OF TWO PRESSURES.

If we place an object O upon a smooth flat surface, and push it gently by means of a stick BA, we find that it remains at rest, unless the intensity of the pressure be sufficient to overcome the friction. If

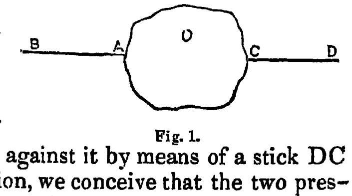


Fig. 1.

now another person press against it by means of a stick DC so as to prevent the motion, we conceive that the two pressures are of like intensity, or differ from each other only by

Equilibrium of Two Pressures.

the friction, while everyday experience shows that their directions must be exactly opposed to each other. The object O seems to be the means of communication between the two pressing bodies, and if the two sticks were applied end to end with pressures equally intense, there would also be equilibrium. so that we very readily admit the general proposition, "*Two pressures equal in intensity and opposite in direction balance each other.*"

When the object O is hard, we do not readily perceive that any change is made upon it by the pressures at A and C, but if a soft body, such as a cork or a bit of elastic gum, be subjected to such pressures, a visible change is made in its form; this change increases as the pressures are augmented, so that it becomes a kind of index of the intensity of the pressure, and careful experiments show, that though often imperceptible in extent, analogous changes take place in even the hardest substances. When the pressure is removed, the body resumes its original shape more or less accurately, and with greater or less rapidity according to the nature of the material. With some subtances, as lead, a permanent change of form results if the pressure be considerable; with others, as vulcanised caoutchouc, a considerable time elapses; while with the generality of what are called hard substances, the resumption of form is complete and almost instantaneous. The communication of pressure, then, from the point A to the point C, implies important and complicated changes in the form and position of the parts of the intervening body.

We have not, however, completely examined this experiment; for if one person press against the end B of the stick BA, while another presses against the end D of DC, the object O is almost invariably found to turn round: the slightest error in the direction of either of the rods is followed by a dislocation of the arrangement. The same thing takes place if two parties attempt to make trial of their strength by pushing the buttons of their foils against each other, and it is only by laying the rods between guides that we can prevent this inconvenience.

If we make two holes in the object O, one at A and the other at C, and having passed a cord through each, pull at the ends B and D of these cords, the object no longer gets displaced; but, on the contrary, the threads AB and CD always come into one straight line. The two pressures are still opposite in direction and equal in intensity.

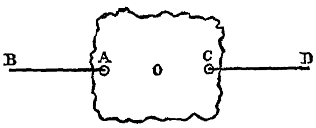


Fig. 2.

These two modes of conducting this fundamental experiment furnish excellent examples of *unstable* and *stable* equilibrium, the contrast between them is instructive in another way. It appears at first sight, that there are two modes of urging a body in a given direction, one by pushing, the other by pulling; but a closer examination of the matter shows that pulling or *traction* is, in reality, pushing or *pressure*. No body can influence another body to move (setting aside gravitation and such influences as magnetic or electric attractions and repulsions), except by pressing upon it. We cannot draw an object to us by stretching out the hand unto it and withdrawing the arm again; no: the hand must be reached to and beyond some integral part of the object, the fingers must be bent round, and *pressure* must be applied to the further surface; we must take hold of it. Even when, as in the case of pulling a rope or seizing the end of a stick, we do not reach to a surface opposed to the direction of the intended effort, we grasp the object in the hand so as to occasion friction, and thus our ultimate resort is still to pressure. The perception of this truth leads to the use of hooks, eyes, loops, rings, ties, &c., which are all contrived for the very purpose of reaching beyond and pressing upon the further surface.

Equilibrium of Two Pressures.

Vices and forceps, again, are constructed for pulling by friction; their jaws are pressed against the lateral surfaces of the object, and the friction thus occasioned offers resistance to the pulls.

Traction occasions complicated changes in the internal part of the bodies subjected to it. Thus, if a pin A driven firmly into the block B be drawn towards E by means of the hook CDE, the parts of the pin near C are compressed, but of the parts near the lower end *a* some are compressed and some are distended. The hook at C is compressed, the parts D on the one side of the line of traction are partly distended and partly bent, while the parts E in the line of strain seem to be merely distended; so that in this little arrangement we have compression, lateral flexure, and distension combined, and this combination is to be found in every case of traction.

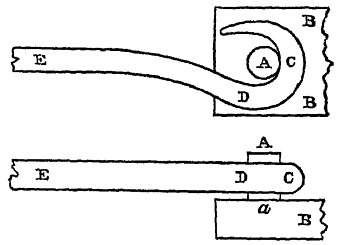


Fig. 3.

When we pull by means of a chain, each link is strained, on the whole lengthened, and communicates its tension to the next, so that we have a series of examples of the equilibrium of two opposing pressures. So, when a rope is used, we imagine that each part is distended, and communicates the pressure to the adjoining part; but as we, in truth, know very little of the internal constitution of matter, this idea rather furnishes us with a convenient mode of speech, than with an explanation of the matter; it clearly points to the well known fact that the length of the cord does not, unless its weight has to be considered, in any way influence the transmission of pressure from the one end to the other.

It is apparent that we cannot strain a rope by pulling at the one end unless the other end be held fast; and therefore, when two men pull at opposite ends of a rope, the rope is not strained by the exertions of two men, but only by the exertion of one man, and he the weaker of the two. This is very obvious, yet we have examples of its misapprehension. Thus, Otto von Guericke, when exhibiting publicly his famous experiment of the hemispheres, yoked eight horses to the one and eight horses to the other cup, in order to pull them asunder, thinking that he thus employed the strength of sixteen horses, whereas, had he fastened one of the hemispheres to the adjacent tree, the eight horses yoked to the other cup would have pulled quite as effectively as when pulling against the other teem.

The change which pressure causes in the form of a solid is well seen when the strain acts transversely. Thus, if a wire AB (fig. 4) be bent into the form of a screw, a slight pressure applied to the end is accompanied by a perceptible alteration in the length of the spiral. By using a thin wire with large and numerous convolutions, any degree of delicacy may be obtained in this kind of spring, so that we can construct a convenient indicator of pressure. Tension gauges of this kind are in common use; the spiral spring being generally inclosed in a tube, and the divisions to indicate the quantity of compression or distension are marked either along the side of the tube or on a style protruding from one end.

We are not entitled to assume, nor, indeed, is it strictly true, that the intensity of the pressure applied is proportional to the lengthening or shortening of the spiral spring, yet such spring gauges can be made truly to indicate the pressures, and they are the most convenient instruments for examining experimentally the laws of equilibrium. The unit of pressure is usually

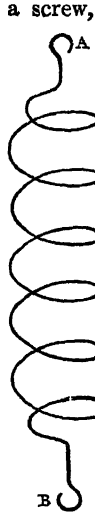


Fig. 4.

taken as the weight of some known heavy body, such as a pound, an ounce, or a grain; and this will answer sufficiently well our present purpose, although it be a fact that gravitation is not quite the same all over the world.

Let then a weight, say of one pound, be hung from the hook of a spring-balance, and let the protrusion of the style be marked: remove now the pound, substitute for it a mass somewhat heavier, and by paring or filing adjust it so as to bring the index exactly to the same mark, and you have another pound weight; in this way we may prepare as many weights as may be required. Hang on now two, three, four, and so on of these weights at once, marking the indication corresponding to each, and you have the spring-balance graduated to show pressures of one, two, three, etc., pounds. Having prepared several of such pressure gauges, we are ready to make experiments on the manner in which pressures balance each other.

On hooking two of these gauges together, directly or by the intervention of a cord, we obtain at once a confirmation of the law already stated, that two pressures balance each other when they are equal in intensity and opposite in direction.

EQUILIBRIUM OF THREE PRESSURES.

In order to examine the simplest case of the equilibrium of three pressures, we may knot three threads together, and attach the loose ends of these to the hooks of three pressure-gauges. On stretching the threads of this little arrangement, the first thing which offers itself to our notice is, that, sensibly, they are always in one plane; and we are convinced that, when three pressures acting on one point balance each other, this is always the case. Let (fig. 5) PA, PB, PC represent the three threads knotted together at P; in PA and PB take any points a and b, then if we join these by a fine line, as a silk fibre, the continuation of CP always cuts it; this is in accordance with the well-known property of plane surfaces. A very slight examination of a few cases shows us that the continuation of the direction of one of the pressures always passes between the other two, and also that the greater pressure has the lesser angle opposite to it. If the distances Pa, Pb be measured off proportional to the intensities of the pressures, it is found *invariably* that the continuation of the third line CP divides the line joining a and b into two equal parts. Any observer may convince himself of the truth of this law by bringing a strained system of three threads over a sheet of paper, by noting the arrangement and by making the appropriate delineation.

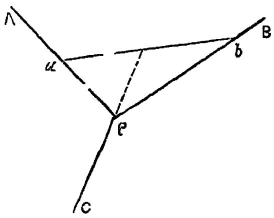


Fig. 5.

In order to be a general law, this statement must apply as well to the two pressures PB and PC as to PA and PB, wherefore if Pc be measured proportional to the tension of PC, bc should be bisected by the continuation of AP, and ca by the continuation of BP; and this is in accordance with the truth that the three lines which join the corners of any trigon with the middles of the opposite sides all meet in one point. Having produced the line CPf until fg be equal to Pf, join ag and bg, then it can easily be shown that ag is equal to Pb, bg to Pa, and Pg to Pc, so that *the intensities of three pressures which balance at a point are proportional to the three sides of a trigon drawn parallel to the three directions of the pressures:* thus the tensions of the cords PA, PB, PC are proportional to Pa, ag, gP. Again, since the sides of a trigon are proportional to the sines of their opposite angles, and since the sine of an angle is equal to the sine of its supplement, it follows that, *of three pressures which balance each other at a point, the intensities are proportional to the sines of the opposite angles.* The same truth may be stated yet in another way. The two pressures Pa and Pb may be regarded as balancing or resisting the third pressure Pc; but a pressure represented by Pg would alone resist Pc, so that we may, as it were, regard the single pressure represented by Pg as equivalent to the two Pa and Pb; the pressure represented by Pg is called the *resultant* of Pa and Pb; and thus, *if the two sides of a rhomboid represent in direction and in intensity two pressures acting on a point, the diagonal of the rhomboid represents the resultant of those pressures.*

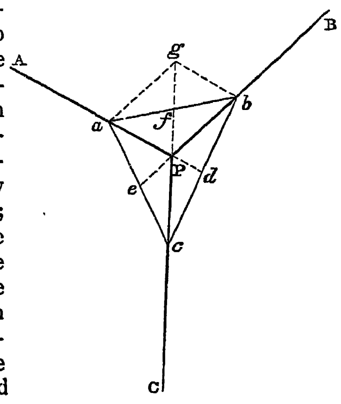


Fig. 6.

This theorem, in whichever way we may prefer to state it, is the foundation of all mechanical science. Various attempts have been made to show that it ought, necessarily, to be true, or, in other words, to deduce our knowledge of it from some fancied intuitive perception of what should be; but the authors of all such attempts proceed by assuming, stated in one form of words, the very law which, disguised in another form, they wish to establish. Experience, and experience alone, tells us that this law *is*, but *why it is*, is utterly beyond our comprehension.

If three pressures, not acting on one point, balance each other, they must act through the intervention of some solid body, and must produce strains in the parts of that body; for we have no example of pressures applied to one being resisted by other pressures applied to another and disconnected object. Let us then suppose that three points, Q, R, S, are connected by three slender rods, QR, RS, SQ, and let us endeavour to trace the effects of three pressures, QA, RB, SC, acting on these points and balancing each other.

In this arrangement, putting out of view the weights of the tie-rods, the point Q is kept in equilibrium by three pressures—one QA, one the strain on QR, and one the strain on QS; so, according to the previously observed

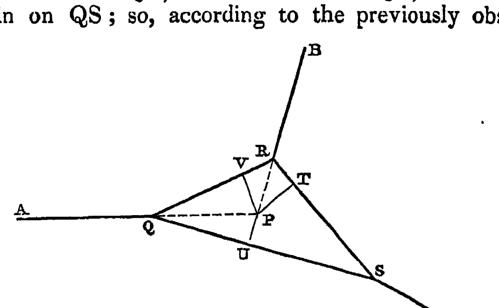


Fig. 7.

law, the direction of QA must be in the plane QRS, and as the same may be said of RB, SC, it seems that, in such an arrangement as this, the directions of the three pressures must lie in one plane. Let us produce AQ and BR to meet in P, and draw the perpendiculars PT, PU, PV to the lines RS, SQ, QR. Then since PU is the sine of the angle AQS to the radius QP, while PV is the sine of AQR to the same radius, it follows that the strain on QR is to the strain on QS as PU is to PV, or denoting strain by a superscribed line,

$$\overline{QR} : \overline{QS} :: PU : PV.$$

Equilibrium of Three Pressures.

In the same way, by considering the three strains balancing at the point R, we find that

$$\overline{RS} : \overline{QR} : : PV : PT ;$$

wherefore by compounding the ratios we obtain

$$\overline{RS} : \overline{QS} : : PU : PT.$$

Now this is what would ensue if the direction of the third pressure CS were to pass through P ; and thus we conclude that *when three pressures acting on three points connected by tie-rods balance each other, their directions must all tend to one point;* and farther, it is very easy to show that the intensities of these pressures must be just as if they had acted directly on that point.

This proposition, which we have easily deduced from our first law in the case of a linear frame QRS, is also true of pressures applied to any three points in a solid body; but without having recourse to farther experiments, we are unable to show that it is so.

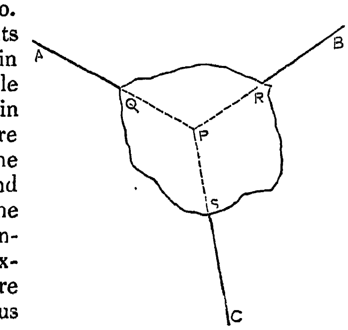


Fig. 8.

If, for example, the points Q, R, S be taken in a thin flat plate, we are unable to trace the manner in which the strains are transmitted from the one point to the other, and are thus without the means of pursuing the investigation. A few experiments, however, are enough to convince us that the three directions, AQ, BR, CS, converge to one point, and that the intensities of the pressures bear to each other the very same ratios that they would have had if the strings had been attached to that point.

If the plate have a forked form, as shown in fig. 9, the tendency is to lengthen the arms QR and RS, and to open the angle QRS, so that we have a cross or angular strain upon the arms of this, which is called a *bent lever*. On making trials with such a form as this, we find, as before, that the three pressures balance just as if they had been attached directly to their point of common intersection; and thus we may accept it as a general law, that *when three pressures balance each other, their directions meet in one point, and are in one plane, and their intensities are proportional to the sides of a trigon drawn parallel to them.*

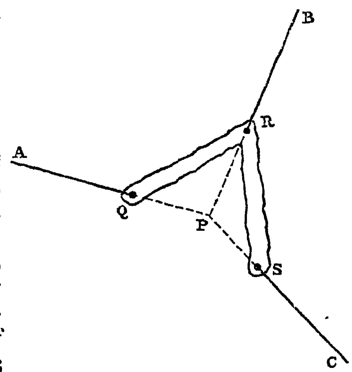


Fig. 9.

From this law it follows that the resultant of two pressures is always less than their sum. If the pressure $\overline{QA}$ were made nearly equal to the sum of the other two $\overline{RB}$, $\overline{SC}$, the trigon formed with its sides proportional to these three would have the angle opposite to the representative of $\overline{QA}$ very obtuse, so that its supplement BPC would be a small angle, and the point P would necessarily be situated considerably beyond Q, in the direction QA, as shown in fig. 10. If the pressure $\overline{QA}$ were gradually augmented, so as to become almost equal to the sum of the others, P would move off to a very great distance, and the lines QA, RB, SC, would be nearly parallel; so that in the limiting case, when we may suppose these lines to have become absolutely parallel, the middle pressure must be equal to the sum of the other two. From Q let fall the perpendiculars QT, QU upon the directions of the pressures RB, SC; then, since these are proportional to the sines of the angles QPB, QPC, they must also be proportional to the intensities of the pressures $\overline{SC}$, $\overline{RB}$; and as this proportion, viz., $\overline{SC} : \overline{RB} :: QT : QU$, holds true of every case up to the very limit of parallelism, we must conclude that it is true of parallel pressures also.

Equilibrium of Four Pressures.

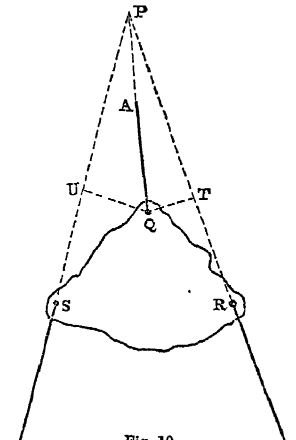


Fig. 10.

This brings us to the very well known doctrine of the lever. When a rigid body RQS, of any form whatever, is made to rest at one point, as Q, against an obstacle, and has pressures applied to it at two other points, it is called a *lever*, the resisting point being called the *fulcrum*, and the distances, as QR, QS, of the other two points from the fulcrum, being called the *arms* of the lever.

When the three points Q, R, S are in one straight line, the lever is said to be straight; and in that case, if the pressures SC, RB be parallel, the perpendiculars QU and QT are proportional to QS and QR; hence, when a straight lever is kept in equilibrium by weights hung on at its two extremities, these weights must be inversely proportional to the lengths of the arms; and when these lengths are equal, the weights also must be equal to each other.

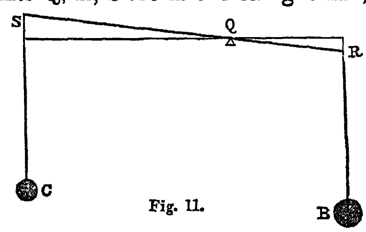


Fig. 11.

This proposition concerning the equilibrium of three pressures applied to three points in a solid body, contains the essential principles of *balances*, *steelyards*, and other weighing machines; but it must be remarked, that such an equilibrium is hardly to be obtained in practice, even though it were desirable. The balance is always made to rest on the two ends of a knife edge, and thus there are at least four pressures acting on four points. (See the article BALANCE in Vol. IV.)

EQUILIBRIUM OF FOUR PRESSURES.

When four pressures, acting in the directions PA, PB, PC, PD, balance each other, we may seek to investigate their relations by finding the resultants of two of them, as $\overline{PA}$, $\overline{PB}$, which we shall suppose to be $\overline{PG}$, and by then considering the equilibrium to subsist among the three, $\overline{PG}$, $\overline{PC}$, $\overline{PD}$; but in following such a course we would be assuming that because $\overline{PA}$, $\overline{PB}$ would be resisted by a pressure

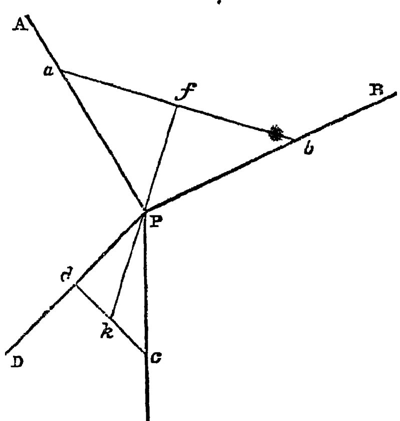


Fig. 12.

Equilibrium of several Pressures.

equal and opposite to $\overline{PG}$, the pressure $\overline{PG}$ may, in all cases, be substituted for them. This, however, we cannot demonstrate logically; it is a mere surmise, and cannot be admitted as an established truth, until it shall have received a substantial confirmation.

On tying together four cords, and straining them by help of pressure-gauges, we observe, on varying the directions of the pulls, that they no longer necessarily lie all in one plane; and we readily notice that the continuation of any one of the directions passes within the solid angle or corner formed by the other three. If we now measure along PA and PB distances, Pa, Pb, proportional to the tensions, join the points a, b, by a fine thread, and mark f the middle of $a\,b$, we find, on bringing the eye into the plane of the two other cords PC, PD, that f is in that plane. Thus, the line Pf must be the intersection of the two planes APB, CPD. Similarly, if this be really a law, on measuring Pc, Pd proportional to the respective strains, and joining $c\,d$, the middle, k of that line must be in the plane APB, so that Pk must be the intersection of the same two planes, and must therefore be a continuation on fP. In the same way, the line joining the middles of $a\,d$ and $b\,c$ ought to pass through P, as also that joining the middles of $a\,c$ and $b\,d$. Now it is a well known property of the tetrahedron, that the straight lines joining the middles of the opposite sides meet in one point, and bisect each other, so that this statical law, which we have observed, is not inconsistent with the truths of geometry.

The double of $\overline{Pf}$ represents in direction, and in intensity, the resultant of $\overline{PA}$ and $\overline{PB}$, and also represents a pressure which alone would resist $\overline{PC}$ and $\overline{PD}$, so that we have our surmise confirmed, and may safely conclude that, so far at least as statical effect is concerned, the resultant of two pressures may be substituted for them.

Having taken any point p in space, draw $p\,a$ parallel and equal to Pa of fig. 12, and $a\,g$ parallel and equal to Pb, then it is evident that $p\,g$, if joined, would be parallel and equal to the double of $\overline{Pf}$; it would, therefore, represent the resultant of $\overline{PA}$ and $\overline{PB}$. Draw now $g\,e$ parallel and equal to Pc, and it is obvious that $e\,p$ is also parallel and equal to Pd, so that we have this general law, that *when four pressures acting on one point are represented in direction and in intensity by four connected lines taken in order, they balance each other;* and this proposition is true whether the connected lines $p\,a$, $a\,g$, $g\,e$, $e\,p$, be or be not all situated in one plane.

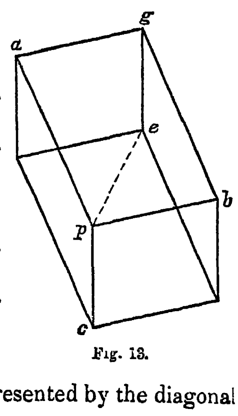


Fig. 13.

The pressure represented by $p\,e$ may be regarded as the resultant of two represented by $p\,g$, $g\,e$; but $p\,g$ itself represents the resultant of $p\,a$, $a\,g$; so that $p\,e$ may be regarded as the resultant of the three pressures $p\,a$, $a\,g$, $g\,e$. Complete now the rhomb or parallelopiped, of which $p\,a$, $p\,b$, $p\,c$ are three concurring sides, and we see that, of three pressures, $\overline{PA}$, $\overline{PB}$, $\overline{PC}$, represented by those lines, the resultant, viz., the opposite of $\overline{PD}$, is represented by the diagonal $p\,e$ of the solid.

EQUILIBRIUM OF SEVERAL PRESSURES.

These observations on the equilibrium of four pressures applied to one point, may be extended to that of any number; and we have this general law, that if there be any number of lines connected in the manner of the sides of a polygon, but not necessarily in one plane, pressures represented in intensity and in direction by these lines, taken in order, will balance each other when they all act on one point. The equilibrium of many pressures is, however, best investigated by help of the

Decomposition and Recomposition of Pressures.

DECOMPOSITION AND RECOMPOSITION OF PRESSURES.

We have seen that the resultant of two pressures may be substituted for those pressures, and so, conversely, we may put, instead of a single pressure, any two or more pressures of which it would be the resultant: this substitution is called, though with a little impropriety of language, the decomposition of the pressure. As, for the purpose of indicating the relative positions of points, we use the method of co-ordinates, so we employ, with great advantage, the same method in examining the conditions of equilibrium of a system of pressures. We decompose each pressure into three acting in the directions of the axes of co-ordinates, and thus carry on our investigations more readily.

For the convenience of description let us refer the positions of the points of a system to three planes—one horizontal; one vertical, passing from east to west; and one also vertical, and passing from north to south. Let us measure x northwards, y eastwards, and z upwards. The direction in which a pressure acts may be indicated by what astronomers call its zenith distance, that is the angle which it makes with the vertical line z, and its azimuth or bearing, that is the angle which its projection upon the horizontal plane makes with the north line x.

In the first place, we may regard the actual pressure p as the resultant of two imaginary pressures—one, which we shall denote by $p(h)$, horizontally in the direction of the projection, and the other $p(z)$ towards the zenith; and, in the second place, we may consider $p(h)$ as the resultant of $p(x)$ towards the north, and $p(y)$ towards the east. The values of these, expressed in trigonometric language, are—

$$\left.\begin{array}{l} p(x)=p\times\text{sin zen. dist.}\times\text{cos bearing} \\ p(y)=p\times\text{sin zen. dist.}\times\text{sin bearing} \\ p(z)=p\times\text{cos zen. dist.} \end{array}\right\} \quad . \quad . \quad (1.)$$

By making this decomposition for each one of the pressures acting on a point, and taking the sums of all those acting in each direction, we obtain the three elements of the resultant, viz.:—

$$\Sigma p(x)\,;\ \Sigma p(y)\,;\ \Sigma p(z)\,;$$

from which we can compute the bearing, the zenith distance, and the intensity of the resultant; and, if these pressures keep each other in check, we must have

$$\Sigma p(x)=0\,;\ \Sigma p(y)=0\,;\ \Sigma p(z)=0 \quad . \quad . \quad . \quad . \quad (2.)$$

three equations which contain the conditions of equilibrium.

When the system under examination contains several points acted on by various pressures, the above equations must hold good of each separate point, as, otherwise, that point could not be at rest.

FLEXIBLE POLYGON.

When a number of points are connected by a succession of ties which bind each one to only two others, the polygon thus formed is flexible whenever the number of the points exceeds three. Let ABCDEF (fig. 14) be such a polygon acted on by pressures Aa, Bb, . . . Ff, the directions of which may or may not be all in one plane; and let $\overline{AB}$, $\overline{BC}$, &c., represent the tensions on the various parts of the cord; then, since the point A is kept in equilibrium by the three tensions $\overline{Aa}$, $\overline{AB}$, $\overline{AF}$, the direction and intensity of $\overline{Aa}$ could be discovered if the tensions $\overline{AB}$, $\overline{AF}$ were known; and hence the problem, " to find those pressures in virtue of which the parts of a flexible polygon may be

Flexible Polygon.

strained with prescribed strains and kept in given positions," admits of a very easy solution.

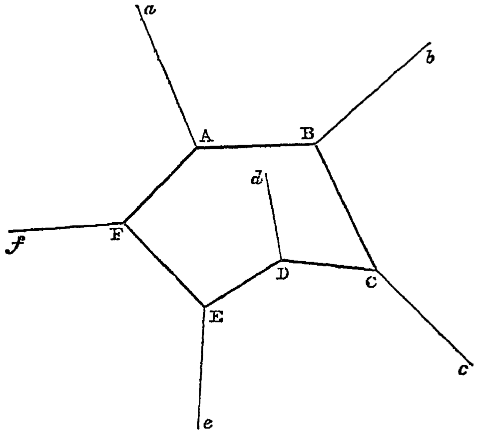


Fig. 14.

If we decompose each of these strains in the directions x, y, z, we have for the point A,

$$\overline{Aa}\,(x)+\overline{AB}\,(x)+\overline{AF}\,(x)=0\,;$$

and again, for the point B,

$$\overline{Bb}\,(x)+\overline{BA}\,(x)+\overline{BC}\,(x)=0\,;$$

and so on for every other point in the series. Adding all these equations together, and observing that since $\overline{BA}$ and $\overline{AB}$, being representatives of the tension on the cord AB, are equal and opposite to each, $\overline{BA}\,(x)+\overline{AB}\,x$ is zero, we have

$$\overline{Aa}\,(x)+\overline{Bb}\,(x)+\&c.=0\,;$$

and similarly,

$$\overline{Aa}\,(y)+\overline{Bb}\,(y)+\&c.=0$$
$$\overline{Aa}\,(z)+\overline{Bb}\,(z)+\&c.=0\,;$$

wherefore, the extraneous pressures would, applied to one point, produce equilibrium.

The same kind of demonstration may be applied to any system whatever, and we have this general proposition, that "*the extraneous pressures which, when acting on any system, keep it in equilibrium, would balance each other if they acted on one point.* The converse of this proposition is not true.

The most interesting case of a flexible polygon is that of a chain fixed at its two extremities, and carrying weights attached to it at intervals along its length. As the theory of this kind of polygon forms the foundation of the doctrine of chain-bridges, and of arches in general, it deserves our particular attention.

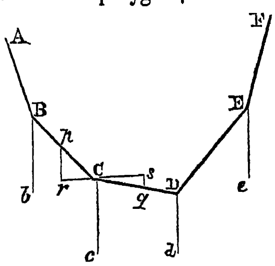


Fig. 15.

Let ABCDEF (fig. 15) represent a chord to which are attached strings Bb, Cc, Dd, &c., carrying weights; and let us examine the conditions of its equilibrium. Since the three tensions $\overline{BA}$, $\overline{BC}$, $\overline{Bb}$ balance each other at B, we have

$$\overline{BA} : \overline{BC} :: \sin bBC : \sin bBA :: \text{cse}\, bBA : \text{cse}\, bBC\,;$$

and again, on account of the equilibrium at C,

$$\overline{CB} : \overline{CD} :: \text{cse}\, cCB : \text{cse}\, cCD\,;$$

wherefore, compounding these ratios we have, since the angle cCB is the supplement of bBC,

$$\overline{BA} : \overline{CD} :: \text{cse}\, bBA : \text{cse}\, cCD\,;$$

and, as this reasoning can be continued, it follows that, in every such suspended chain, the tensions at the various parts are proportional to the cosecants of their inclinations to the vertical line, or the secants of their inclinations to the horizon.

Suspension Bridges.

Let the distance Cp be measured along cB to represent the intensity of the strain on BC, and similarly Cq along CD; also, having drawn a horizontal line through C, draw the vertical lines pr, qs to meet it: then the strain Cp may be decomposed into cr, rp; and the strain Cq into Cs, Sq. The two horizontal strains, Cr, Cs, are equal to and balance each other; while the difference between the two vertical strains, rp, sq, must be equal to that caused by the weight hung on at c. Hence, if h denote the horizontal strain,

$$\left.\begin{array}{l}\overline{BA}=h.\text{sec incl.AB};\ \overline{CB}=h.\text{ sec incl. BC}\\ \text{weight at C}=h(\text{tan incl.AB}-\text{tan incl.BC}).\end{array}\right\} \quad (3.)$$

wherefore the weights hung on any part of such a chain are equal to the horizontal tension multiplied by the difference between the tangents of the inclinations at its two extremities.

These are the well known principles which regulate the construction of bridges; they are most distinctly seen in the case of suspension-bridges, but they are not less essentially connected with stone-arches.

SUSPENSION-BRIDGES.

The essential parts of a suspension-bridge are—*first*, the chain attached to two well secured supports; *second*, the suspending-rods; and, *third*, the roadway. In general, the weight of the roadway far exceeds that of the other parts; so that, in a first examination of the matter, we may take it alone into consideration, and

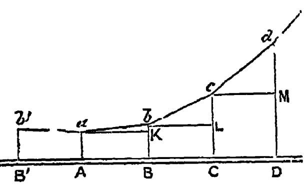


Fig. 16.

suppose that the weights of the chain and of the suspending-rods are so small as not to be worth notice. Let, then, B'ABCD, &c., represent the roadway of a chain-bridge suspended, at equal intervals B'A, AB, BC, &c., by rods B'b', Aa, Bb, Cc, &c., from the chain $b'abcd$; and let us suppose that a is the lowest point of the chain, the parts ab' and ab being equally inclined to the horizon.

Put h to represent the horizontal tension, r the weight of one foot of the road-way, and a the distance between the vertical roads, ar being thus the weight supported by each rod. Then, since the links ab' and ab are equally inclined, the tangent of the inclination must be $\frac{ar}{2h}$. Draw aK parallel to the horizon, and we must have

$$a\text{K} : \text{K}b :: 2h : ar, \text{ whence } \text{K}b=\frac{a^2r}{2h}.$$

Passing to the point b, at which again there is an equilibrium of three pressures, and drawing the horizontal line bL we have

$$\tan \text{L}bc-\tan \text{K}ab=\frac{ar}{h}, \text{ but}$$

$$\tan \text{K}ab=\frac{ar}{2h}\,; \text{ wherefore,}$$

$$\tan \text{L}bc \qquad =\frac{3ar}{2h}\,; \text{ and}$$

$$\text{L}c=a\tan \text{L}bc=\frac{3a^2r}{2h}.$$

Proceeding in this way, we easily show that the distances Kb, Lc, Md, &c., must be as the successive odd numbers, 1, 3, 5, &c., and therefore the rises above the lowest point a, must, at b, c, d, &c., be as the successive square numbers 1, 4, 9, and so on; wherefore, the length Nn of a rod situated at n intervals from aA, would be given by the equation

$$\mathrm{N}n = \mathrm{A}a + \frac{n^2a^2r}{2h};$$

and thus it seems that the chain $b'abcb$ must be inscribed in a parabola.

If, however, we take into account the weights of the links of the chain, and the varying lengths and weights of the suspending-rods, we must obtain a form differing perceptibly from the parabola. Putting c for the weight of one foot of the chain, where it is horizontal, and i for the inclination at any other part, the strain there is h sec. i, and, therefore, as the chain ought to be thickened to bear the greater strain, the weight of one foot of it should be c sec. i, and consequently the weight of that portion of the chain which is vertically over one foot of the roadway must be c, sec. i^2, and thus, exclusive of the suspending-rods, the whole weight above a foot of the roadway is

$$r + c \sec i^2, \text{ or } r + c + c \tan i^2.$$

The suspending-rods, having to carry equal weights all along, must be of uniform strength; and hence their own weights are proportional to their lengths, so that the weight of the suspending-rods may be assumed as proportional to the area AadD of the elevation of the arch. Let, then, x be the horizontal distance measured along AH, z the ordinate Pp, reckoned from the horizontal line passing through a, and let s be the weight of the suspending-rods, corresponding to one square foot of side-area: then the weight above a minute element, dx, of the horizontal line is

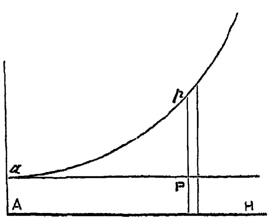


Fig. 17.

$$dw = (r + c + c \tan i^2 + sz)\, dx;$$

and this, according to the law already explained, is equal to the differential of the tangent of the inclination, multiplied by the horizontal strain; wherefore

$$h \,.\, d \tan i = (r + c + c \tan i^2 + sz)\, dx$$

expresses the condition of the equilibrium in chain-bridges when none of the accidents of their formation is neglected.

The complete integration of this expression cannot be obtained in finite formulæ, but we can develop the value of the ordinate z in a series containing the even powers of x; thus, if we put

$$z = \mathrm{A}x^2 + \mathrm{B}x^4 + cx^6 + \mathrm{D}x^8 + \mathrm{E}x^{10} + \&c.;$$

and if, for shortness sake we make

$$\alpha = \frac{2cr + c^2}{h}, \text{ we have}$$

$$\mathrm{A} = \frac{r + c}{2h};\ \alpha = 4\mathrm{A}c;$$

$$\mathrm{B} = \mathrm{A}\frac{\alpha + s}{3\,.\,4\,.\,h};\ \mathrm{C} = \mathrm{B}\frac{4\alpha + s}{5\,.\,6\,.\,h};$$

$$\mathrm{D} = \mathrm{B}\frac{34\alpha^2 + 20\alpha s + s^2}{5\,.\,6\,.\,7\,.\,8\,h^2};$$

$$\mathrm{E} = \mathrm{B}\frac{496\alpha^3 + 474\alpha^2 s + 84\alpha s^2 + s^3}{5\,.\,6\,.\,7\,.\,8\,.\,9\,.\,10h^3}, \&c.$$

In all practical cases, the fractions $\frac{\alpha}{h}$ and $\frac{s}{h}$ are small, so that the coefficients B, C, D, &c., decrease rapidly in value, and for all the wants of the engineer, the above terms are amply sufficient.

The question, "What is the extreme limit to which a chain-bridge can be thrown?" is an interesting one, particularly in reference to proposals which have, from time to time, been made for throwing such bridges across our estuaries, across even the Bosphorus, or the Dardanelles. In order to answer this question definitely, we may remark that an unloaded chain, no part of which is thicker than the strain upon it requires, must be capable of spanning the utmost stretch which the material will allow. Let us, then, suppose a chain having its horizontal tension h as great as is compatible with the thickness of c pounds per foot at the lowest part, to be thickened towards each end in such a way as in every part to be just able to bear the strain; then c sec. i will be the weight per linear foot at any point in the curve, and the condition of equilibrium will be expressed by the differential equation

$$h \,.\, d \tan i = c \,.\, \sec i^2 \,.\, dx,$$

from which we at once obtain

$$i = \frac{cx}{h};$$

so that in this, which may be called the *catenary of regulated strength*, the inclination of the curve at the point p is proportional to the horizontal ordinate aP, and becomes 90°, when $x = \frac{\pi h}{2c}$; and thus the utmost horizontal stretch of such a chain is

$$2\mathrm{X} = \frac{h}{c} \times 3{\cdot}1415926,$$

and even to attain this the vertical height would need to be infinite. By putting for $\frac{h}{c}$ the *modulus of strength*, or the length of itself which a uniform chain can support, we would have the absolute limit of span for any given material.

The form of the *catenary of regulated strength* is given by the equations

$$z = \frac{h}{c} \,.\, \text{nep. log sec } \frac{cx}{h},$$

$$l = \frac{h}{c} \,.\, \text{nep. log tan } \left(\frac{\pi}{4} + \frac{cx}{2h}\right),$$

in which l is the length of the curve reckoned from the lowest point a to the top of the ordinate z.

When the chain is of uniform thickness all along, the form which it assumes is called the *catenary*. This curve, although of no great importance in regard to chain-bridges, has a close connection with the theory of equilibrated arches, and possesses besides certain very remarkable geometrical properties. The same notation remaining, its equation of condition is

$$h \,.\, d \tan i = c \sec i;$$

whence we obtain, on integrating,

$$z = \frac{h}{c} \times \frac{1}{2}\left\{e^{\frac{cx}{h}} + e^{-\frac{cx}{h}}\right\} - \frac{h}{c},$$

$$l = \frac{h}{c} \times \frac{1}{2}\left\{e^{\frac{cx}{h}} - e^{-\frac{cx}{h}}\right\}$$

e being the basis of the Neperian system of logarithms. The utmost horizontal distance which can be spanned by a chain of uniform thickness is 1·3254838, or about $\frac{4}{3}$ths of its modulus of strength.

The theory of stone-arches is almost a counterpart of that of chain-bridges; the difference consisting principally in this, that the load on the stone-arch is the quantity of material included between the surface of the roadway and

Equilibrium of parallel Pressures.

the lower face of the arch-stones. Let AR (figure 18) represent the line of road over a bridge, apq the arch-stones; then the load upon the part ap of the *intrados* is the quantity of material included in the figure aA Pp. When the entire space is filled up and the arrangements made suitable to this condition, the arch is said to be *equilibrated.* The roadway is commonly almost level; but, in the general investigation, we shall suppose it sloped at an angle α to the horizon. The point a, as before, being made the origin of rectangular co-ordinates, we have

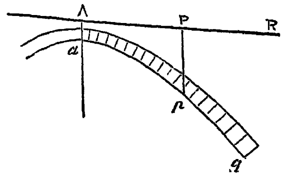


Fig. 18.

$$Pp = Aa - x \tan \alpha + z$$

or putting v for the distance Aa, and u for Pp,

$$u = v - x \tan \alpha + z,$$

and the condition of equilibrium is

$$hd \tan i = k \frac{d^2u}{dx} = u\,dx;$$

wherefore, if a be taken at that point of the curve where it is parallel to the roadway, we have, on integrating,

$$u = \frac{v}{2} \left\{ e^{\frac{x}{\sqrt{h}}} + e^{-\frac{x}{\sqrt{h}}} \right\}$$

which is the equation of a modified catenary.

It may be remarked, that the chords of this curve drawn parallel to the roadway are bisected by the vertical axis Aa; and that, contrary to what has been supposed, the case of bridges with oblique roadways differs in no essential point from that of bridges with the roadway horizontal.

EQUILIBRIUM OF PARALLEL PRESSURES.

Parallel pressures can only balance each other by the intervention of some solid body, which may form a connection between the points to which the various pressures are applied. The simplest mode of viewing the subject is to imagine the points to be connected by straight rods, the lengths of which would, geometrically, determine the relative positions of the parts, and to investigate at each point of attachment the distribution of the pressures. But this method is inapplicable when all the points of attachment are situated in one plane; in such a case, we should have to assume some accessory points out of the plane so as to communicate firmness to the system.

If, in some plane which passes entirely to one side of the system of connected points, three points not in one straight line be chosen, the distances of any point in the system from these three arbitrary points will determine its position, and we may thus regard the rigidity of the system as obtained by means of inextensible rods connecting each point in it with each one of the three assumed points. Let, then, A, B, C (figure 19), be the three arbitrarily assumed points, and P one of the points in the system to which the pressure $\overline{Pp}$ is applied. These being connected by slender rods, the pressure $\overline{Pp}$ is resisted by the tensions of PA, BP, CP. In order to obtain the values of these tensions, let the direction Pp be continued, to meet the plane ABC in p, and through p lead planes parallel to BPC, CPA, APB; these, with the planes to which they are parallel, include a rhomb, of which Pp is the diagonal, so that if, for the moment, Pp be taken to represent the intensity of the pressure $\overline{Pp}$, the sides of that rhomb would represent the strains $\overline{AP}$, $\overline{BP}$, $\overline{CP}$. To avoid confusion, this rhomb is not drawn in the figure, but only the plane passing through p parallel to BPC is shown, cutting PA in α; Pα in this case represents the tension $\overline{PA}$.

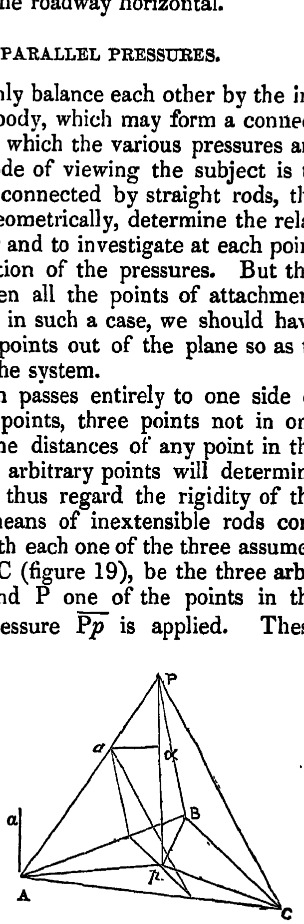


Fig. 19.

The rod PA conveys this strain to the point A, which is acted on by three pressures $\overline{PA}$, $\overline{AB}$, $\overline{AC}$; and these not being in one plane, cannot be in equilibrium; a fourth pressure must therefore aid in establishing the balance. Through α draw $a\alpha$ parallel to Ap; the pressure Pa acting at A may be decomposed into two, one parallel and proportional to $a\alpha$, another parallel and proportional to Pa. That part represented by $a\alpha$ being exerted in the direction pA is resisted by the tensions of the rods AB, AC; and the other part represented by Pa, exerted in the direction of a line drawn through A parallel to Pp, must be resisted by the other pressures, to which the system is subjected.

Since Pp : Pa :: PA : Pα, and since the altitudes of the trigons BAC, BpC are evidently in the same ratio, we have—

$\overline{Pp} : \overline{P\alpha}$ :: ABC : BpC; and similarly
$\overline{Pp} : \overline{P\beta}$ :: ABC : CpA,
$\overline{Pp} : \overline{P\gamma}$ :: ABC : ApB,

so that the pressure $\overline{Pp}$ is distributed among the points A, B, C in shares proportional to the areas of the opposite trigons BpC, CpA, ApB.

If the same process be followed for each pressure, we obtain, on summing up all the shares which are resisted at each of the points A, B, C,

$$\Sigma\,\overline{P\alpha} = 0;\ \Sigma\,\overline{P\beta} = 0;\ \Sigma\,\overline{P\gamma} = 0.$$

Since each pressure $\overline{Pp}$ is equal to the sum of the three $\overline{P\alpha}$, $\overline{P\beta}$, $\overline{P\gamma}$, it follows, from the addition of the above equations, that the sum $\Sigma\,\overline{Pp}$ of all the parallel pressures must be zero; or, in other words, that the sum of those which act in the one direction must be equal to the sum of those which oppose them.

The trigons BAC and BPC having a common base BC, are proportional to their altitudes, and these altitudes again are proportional to the distances of the lines Aα' and $\overline{Pp}$ from BC, wherefore the tendency which the pressure $\overline{Pp}$ has to turn the system round BC as an axis, is just equal to that which $\overline{A\alpha'}$ would have, and thus the expression, $\Sigma\,\overline{A\alpha'} = 0$ or $\Sigma\,\overline{P\alpha} = 0$, may be interpreted as signifying that the tendencies of the several pressures to turn the system round any assumed axis BC must amount to zero; and it is easy to see that if, while $\Sigma\,\overline{Pp}$ the sum of the pressures themselves is zero, the sum of the tendencies round any two axes having different azimuths round the direction Pp be also zeroes, the system must be in equilibrium.

The above reasoning can, in strictness, only apply to a network or skeleton of straight rods connecting the points to which the pressures are applied; and seeing that we know nothing, and are not likely ever to know anything of the manner in which pressure is conveyed from one point to another of a solid body, it is only by inference that we can extend the doctrine to the general case of points anyhow connected. Experience, however, abundantly testifies that this law of equilibrium is universal.

This course of reasoning leads us to the remarkable conclusion that the pressure $\overline{Pp}$ exerts the same influence, so far as the ultimate resistances are concerned, at whatever point in the line of its direction it may act; but it is to be noticed, that the strains internal to the system of connecting-rods are altered by every change in the position of the point of attachment.

Centre of Gravity.

CENTRE OF GRAVITY.

Gravitation affords the best example of parallel pressures; each part of a body tends downwards, or has weight, and thus the mere resting of any object whatever upon a support implies the equilibrium of a multitude of conflicting pressures.

In order to examine this important subject minutely, let us consider the case of two material points, A and B, connected by a rigid straight rod AB.

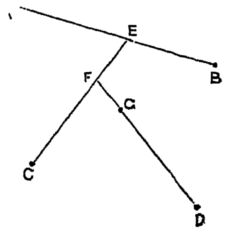


Fig. 20.

If AB be divided at E, so that $EB : EA :: \bar{A} : \bar{B}$ a pressure of $-(\bar{A}+\bar{B})$ applied at E would resist the two strains $\bar{A}$ and $\bar{B}$, and this in whatever position the rod AEB may be placed. E, in that case, is called *the centre of gravity* of the two weights A and B.

If we put x_A, x_B, x_E to represent the distances of A, B, E, from some assumed plane surface, we have—

$$(\bar{A}+\bar{B})\, x_E = \bar{A}x_A + \bar{B}x_B.$$

Suppose now that there is a third point C, the weight of which is $\bar{C}$, join CE and divide it at F, so that $CF : FE :: \bar{A}+\bar{B} : \bar{C}$; then a pressure $-(\bar{A}+\bar{B}+\bar{C})$ applied at the point F would resist $\bar{A}+\bar{B}$ applied at E, and $\bar{C}$ applied at C, that is, it would resist the three pressures $\bar{A}$, $\bar{B}$, $\bar{C}$, applied at the points A, B, C.

Taking a fourth point D, which may or may not be in the same plane with A, B, C, join DF, and divide DF in the ratio of $\bar{A}+\bar{B}+\bar{C} : \bar{D}$; the pressure $-(\bar{A}+\bar{B}+\bar{C}+\bar{D})$ acting at G would balance the weights $\bar{A}$, $\bar{B}$, $\bar{C}$, $\bar{D}$, placed at the several points A, B, C, D. In this case G is called the *centre of gravity* of the four weights $\bar{A}$, $\bar{B}$, $\bar{C}$, $\bar{D}$; and in reference to any plane,

$$(\bar{A}+\bar{B}+\bar{C}+\bar{D})\, x_G = \bar{A}x_A + \bar{B}x_B + \bar{C}x_C + \bar{D}x_D.$$

As this line of argument can be continued to any extent, it follows, generally, that if x, y, z be the co-ordinates referred to three planes, the position of the centre of gravity G of any number of heavy *points* A, B, C, &c., is given by the equations—

$$x_G = \frac{\Sigma\, \bar{A}x_A}{\Sigma\, \bar{A}};\quad y_G - \frac{\Sigma\, \bar{A}y_A}{\Sigma\, \bar{A}};\quad z_G = \frac{\Sigma\, \bar{A}z_A}{\Sigma\, \bar{A}}.$$

These formulæ, however, only apply to discrete points: in order to make them applicable to concrete matter we must extend the calculations to the infinity of infinitely minute parts of which we may conceive solid matter to be composed. For the purposes of this inquiry, we regard a solid body as composed of a multitude of slices, which may be rendered so numerous and so thin, that each one may, so to speak, be regarded as a mere surface. Such surfaces, again, we divide into elongated sections, which, when made excessively narrow, are almost lines; and these lines we again divide into multitudes of parts, which, from their smallness, we call points. The ideas of physical points, lines, surfaces, thus differ essentially from those which the geometer designates by the same names; and it is also to be noticed that this ideal decomposition of a solid body into an infinity of infinitely minute particles, does not show either the infinite divisibility of matter, or any other fact concerning its physical constitution.

The centre of gravity of a uniform physical straight line is, clearly, at its middle. This becomes evident when we consider it as composed of equal parts symmetrically arranged from either end.

Fig. 21.

The centre of gravity of each pair of such particles is at the middle point, wherefore that middle point is the centre of gravity of the whole. But this mode of reasoning will not apply in more complex cases. Representing by w the whole weight of the thin rod AB, and by l its length, let us divide the whole length into a great number p of equal parts, of which Pp may represent one; the weight of this part Pp must be $\frac{w}{p}$, and the tendency of this weight to turn the rod round A as a fulcrum must be more than if an equal weight were hung on at P, and less than if it were suspended at p; hence, if the number of parts in AP be n, and therefore AP itself $\frac{nl}{p}$, the effect of Pp in turning the rod round A is more than $\frac{nwl}{pp}$, and less than $\frac{(n+1)\, wl}{pp}$. As the same may be said of each of the other parts Pp, it follows that the tendency of the whole weight to turn the rod round A as a fulcrum is more than $(0+1+2+3 \ldots\ldots \overline{p-1})\, \frac{wl}{pp}$ and less than $(1+2+3+ \ldots\ldots p)\, \frac{wl}{pp}$; or, summing these series of natural numbers, more than $\frac{p}{p}\, \frac{p-1}{2p}\, wl$, but less than $\frac{p}{p}\, \frac{p+1}{2p}\, wl$; these limits may be otherwise written $\left(1-\frac{1}{p}\right) \frac{wl}{2}$ and $\left(1+\frac{1}{p}\right) \frac{wl}{2}$. By taking the number p enormously large, the value of the fraction $\frac{1}{p}$ is made insignificant, and each of the limits approaches to $\frac{1}{2}\, wl$, which thus takes the place of the sum $\Sigma\, \bar{A}x_A$ of the general formula. Dividing this by w, we find for the distance of the centre of gravity G from the end A, the value $AG = \frac{1}{2}\, l$; that is, G is in the middle of AB. The ordinary operation of integrating is, virtually, this process in disguise. Thus, if we put $AP = x$, $Pp = dx$, the weight of Pp is $\frac{wdx}{l}$, and its effect in turning the lever round A (or its *moment* as it is called) $\frac{wxdx}{l}$; the integral of this, viz., $\frac{w}{l}\, \frac{1}{2}\, x^2$, represents the *moment of* AP, which, on putting l for x becomes $\frac{1}{2}\, wl$ for the *moment* of the whole rod as before.

The position of the centre of gravity of a uniform flat trigonal surface may be found by an extension of the same method.

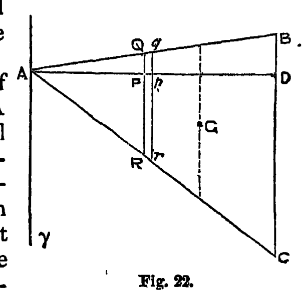


Fig. 22.

Let w be the weight of the trigon ABC; through A draw an axis Aγ parallel to BC, and suppose the surface to be divided into trapezoids by lines QR, qr drawn also parallel to BC. Put l for the length of the perpendicular AD, and suppose it divided into p equal parts n of which go to AP; then the weight of the trigon AQR is $\frac{n^2}{p^2}w$, while that

of Aqr is $\frac{(n+1)^2}{p^2} w$, so that the weight of the trapezoid QRrq is $\frac{2n+1}{pp} w$. The moment of this in reference to the axis Aγ is more than $\frac{n}{p} \frac{2n+1}{pp} wl$, and less than $\frac{n+1}{p} \frac{2n+1}{pp} wl$; it is therefore between $(2n^2+n) \frac{wl}{p^3}$ and $(2n^2+3n+1) \frac{wl}{p^3}$. Giving to p all values from 0 to $p-1$ successively, and summing, we find that the *moment* of the whole surface is between

$$\{2\,(0^2+1^2+\ldots\ldots \overline{p-1}^{\,2})+(0+1+\ldots\ldots \overline{p-1})\} \frac{wl}{p^3} \text{ and}$$

$$\{2\,(0^2+1^2+\ldots\ldots \overline{p-1}^{\,2})+3\,(0+1+\ldots\ldots \overline{p-1})+p\} \frac{wl}{p^3},$$

or, summing these series, between

$$\left(\frac{2}{3}-\frac{1}{2p}-\frac{1}{6p^2}\right) wl \text{ and } \left(\frac{2}{3}+\frac{1}{2p}-\frac{1}{6p^2}\right) wl.$$

Wherefore, on supposing p to be an enormously large number, the true value of the moment of the whole trigon is $\frac{2}{3} wl$, and the distance of the centre of gravity from the axis Aγ is two-thirds of the altitude AD. Now the centre of gravity must also be at the distance of two-thirds of the altitude drawn from C to AB: wherefore, it is the intersection of the lines which join the corners with the middles of the opposite sides. The centre of gravity of the surface of a trigon coincides with that of three equal weights placed at its three corners.

Similarly it may be shown that the centre of gravity of a tetrahedron or triangular pyramid, is the intersection of the four lines which join the four corners with the centres of gravity of the opposite faces, and therefore coincides with that of four equal weights placed at the four corners.

Since all polygons may be decomposed into trigons, and all polyhedrons into tetrahedrons, we can easily find the centre of gravity of any rectilineal figure, or of any flat-faced solid, by imagining the weight of each of the component parts accumulated at its centre of gravity, and then finding the centre of gravity of these points. In the cases of surfaces bounded by curved lines, or of solids bounded by curved surfaces, the nature of the curve necessarily enters as an element of the computation. One or two examples may suffice to explain the procedure.

Let it be required to find the centre of gravity of a parabolic segment CAD.

Draw any chord QR parallel to CD, bisect CD in B, QR in P, and join BP, producing it to A; then, according to the property of the parabola, the line Aγ drawn parallel to CD is a tangent to the curve; all chords parallel to CD are bisected by AB, and their lengths are in ratios subduplicate of the distances intercepted from A. Hence, if we put, as before, w for the whole weight or area, l for AB, x for AP, dx for Pp, also b for CD, and α for the angle ABD, we have QR $= bl^{-\frac{1}{2}} x^{\frac{1}{2}}$; wherefore the area of the surface comprised between the proximate ordinates QR and qr is $bl^{-\frac{1}{2}} \sin \alpha \,.\, x^{\frac{1}{2}}\, dx$, and its moment round the axis Aγ is this, multiplied by $x \sin \alpha$ or $dm = bl^{-\frac{1}{2}} \sin \alpha^2 \,.\, x^{\frac{3}{2}}\, dx$. On integrating these expressions, we find for the area

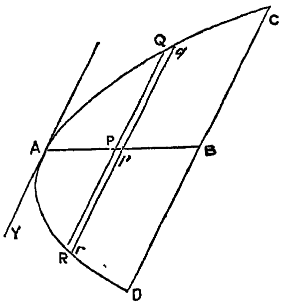


Fig. 23.

QAR, $\frac{2}{3} bl^{-\frac{1}{2}} \sin \alpha x$; and for its moment $\frac{2}{5} bl^{-\frac{1}{2}} \sin \alpha^2 . x^{\frac{5}{2}}$; so that, making x equal to the whole length l, we have $w = \frac{2}{3} bl \sin \alpha$, while the whole moment is $\frac{2}{5} bl^2 \sin \alpha^2$; and therefore the distance of the centre of gravity from the tangent Aγ is $\frac{3}{5} l \sin \alpha$: wherefore, if AG be made three-fifth parts of AB, the centre of gravity must lie in the ordinate drawn through G; but, as all these ordinates are bisected, their centres of gravity must be in AB, wherefore G itself is the centre of gravity of the parabolic segment.

As an example from among solids, we may take the segment of a sphere. Let OA $= r$ be the radius of a sphere, and let it be proposed to find the centre of gravity of the segment having AP $= x$ for its altitude. Making Pp $= dx$ and leading planes PQ, pq perpendicular to AO, the solid comprised between these two planes is the differential of the solidity, or dw, but the area of the circle described by PQ is π . PQ^2, or π . AP . PB $= \pi\,(2rx - x^2)$, wherefore $dw = \pi\,(2rx - x^2)\,dx$, and the moment of this is $dm = \pi\,(2rx^2 - x^3)\,dx$ round an axis passing through A. Integrating these we have $w = \pi \left(rx^2 - \frac{1}{3} x^3\right)$, $m = \pi \left(\frac{2}{3} rx^3 - \frac{1}{4} x^4\right)$; wherefore the distance of the centre of gravity from A is $\frac{x}{4} \frac{8r-3x}{3r-x}$, and its distance from P is $\frac{x}{4} \frac{4r-x}{3r-x}$. On making $x = r$ we find that the distance of the centre of gravity of a hemisphere from the vertex is $\frac{5}{8} r$, and from the centre $\frac{3}{8} r$.

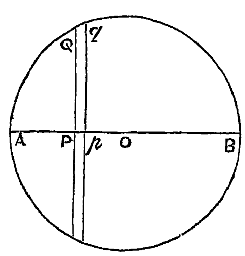


Fig. 24.

When a solid body is suspended by a thread, it takes such a position that its centre of gravity lies in the direction of the thread: hence, if we suspend an object first from one point and then from another, noting the direction each time, the intersection of these two directions will give us the position of the centre of gravity.

If, when a body is laid upon a flat surface, the vertical line drawn through the centre of gravity pass within the convex polygon formed by joining the points at which it touches, it rests securely. Any attempt to overturn it is accompanied by a rise in the position of the centre of gravity, and as soon as the disturbing influence ceases, the body returns to its former site. But if the under surface of the object be curved, the slightest influence causes a displacement: if the arrangement be such that the centre of gravity tend to rise, as is the case with a spherical segment laid on a flat surface, the tendency is to return again to the first position; in such a case the equilibrium is said to be *stable;* if, as in the case of a complete sphere or cylinder, the centre of gravity describe a horizontal line, the equilibrium is *indifferent;* and if, as when the centre of gravity lies above the centre of curvature, that point tend to come lower, the body falls still farther, and the equilibrium is said to be *unstable.*

In all statical computations we may proceed as if the whole weight of a body were concentrated at its centre of gravity; but whenever we have to consider *motion* this hypothesis must be abandoned, because the motion of the

General Condition of Equilibrium.

centre of gravity does not represent the whole motion of a body.

GENERAL CONDITION OF EQUILIBRIUM.

The equilibrium of a number of pressures, acting in various directions upon a solid body, may be investigated by decomposing each pressure into three, acting severally in directions parallel to the axes of co-ordinates x, y, z, and considering that each set of components should, separately, be in equilibrium.

VIRTUAL VELOCITIES.

The whole doctrines of statics are summed up in one general proposition, from which we can most readily obtain the solution of any particular case. To this proposition the name, *law of virtual velocities*, has unfortunately been given: in its statical aspect it has nothing to do with velocity. As a thorough comprehension of its import almost amounts to a complete knowledge of this department of science, we shall endeavour to lay it clearly before the reader.

Let us suppose that the point P is kept in equilibrium by three ropes PA, PB, PC, stretched each from a considerable distance. This being the case, let us imagine that, by some agent exterior to the system, the point P has been displaced to p, the ropes now taking up the positions pa, pb, pc. By this derangement some of the ropes may have been pulled forwards, some may have been let backwards. Let us suppose that three thin, straight wires are thrust, at right angles, one through each of the ropes, so as to form a trigon EDF; then, since this trigon is evidently similar to any trigon formed by drawing lines parallel to the directions of the three ropes, each of its sides may be taken to represent the strain on the rope to which it is perpendicular; that is, EF may represent the tension of PA, FD the tension of PB, and DE the tension of PC. With the derangement of the system the trigon EDF is displaced, being brought into the position edf, such that the lines Dd, Ee, Ff are parallel and equal to Pp. The distance between EF and ef, measured perpendicularly, is, obviously, the distance by which the rope PA has been pulled forward; so the distance between FD and fd shows by how much the rope PB has been let backwards, and so of the third rope PC. The area of the rhomboid EFfe thus represents the product of the tension of the rope PA by the distance through which that tension has been overcome; that is, the quantity of *work* which has been gained upon it. In the same way the area FDdf represents the quantity of *work* lost by the letting down of the rope PB, and DdeE the *work* lost by letting down the rope PC. Now, if, from the pentagon EFfde we take away the trigon edf, there remains the rhomboid EFfe; while if, from the same pentagon, we take away EDF, the two rhomboids FDdf, DdeE remains; wherefore the gain of *work* on the rope PA is exactly equal to the sum of the two losses on PB and PC: on the whole, then, there is neither gain nor loss.

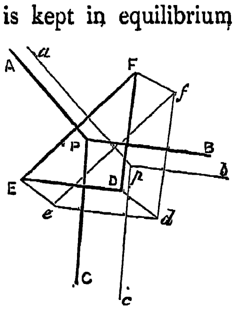


Fig. 25.

Virtual Velocities.

The same kind of reasoning can be applied to all combinations of pressures, and thus we obtain the following general law, that "if any system of pressures in equilibrium be slightly disturbed, there is neither gain nor loss of *work* by the disturbance."

Strictly speaking, this proposition is only true of infinitesimally small disturbances, and this circumstance is intended to be pointed out by the use of the word *virtual* in the title, *law of virtual velocities*, which is given to this theorem.

Using the word *work* to mean the product of a pressure by the distance through which that pressure has been overcome, and representing it in general by the letter w, let us suppose that by the performance of a certain quantity of work some system has been brought into its actual position, as represented by the co-ordinates x, y, z. If now the system be subjected to a definite change, represented by the symbols δx, δy, δz of finite or actual differences, the quantities of work gained or lost on the several strains may be deduced from purely geometrical considerations, and, according to Taylor's well-known theorem, the change in the quantity of work is given by the expression—

$$\begin{aligned}\delta w = {} & \frac{dw}{dx}\frac{\delta x}{1} + \frac{dw}{dy}\frac{\delta y}{1} + \frac{dw}{dz}\frac{\delta z}{1} \\ & + \frac{d^2w}{dx}\frac{\delta x^2}{1\,.\,2} + \frac{d^2w}{dx\,.\,dy}\frac{\delta x}{1}\frac{\delta y}{1} + \frac{d^2w}{dx\,.\,dz}\frac{\delta x}{1}\frac{\delta z}{1} \\ & + \frac{d^2w}{dy^2}\frac{\delta y^2}{1.2} + \frac{\delta^2 w}{\delta y\,.\,\delta z}\frac{\delta y}{1}\frac{\delta z}{1} + \frac{d^2w}{dz^2}\frac{\delta z^2}{1\,.\,2} + \&c.\end{aligned}$$

Now, the law enunciated above refers only to the first differential co-efficients; that is to say, for mere equilibrium we must have $\frac{\delta w}{\delta x}$, $\frac{\delta w}{\delta y}$, $\frac{\delta w}{\delta z}$ each zero; and these conditions must hold good in reference to every separate point of the system.

The values of the second derivatives determine whether the equilibrium be *stable*, *indifferent*, or *instable*. When these derivatives have positive values the equilibrium is *stable;* it required the application of actual *work* to change the position of the system; and when the extraneous pressures cease to act, the system again returns to the position of equilibrium. When the higher derivatives also are zeroes, the equilibrium is indifferent; and, when the second derivatives are negative, the system, if once disturbed from the position of equilibrium, will tend to go still farther from that position.

This theorem, besides being of great value as enabling us readily to investigate the strains in any structure, is important as throwing a clear light upon the general action of machines as transmitters of force. As the machine contains in itself no source of power, it can only convey force, it cannot augment it: thus, although a crane enable one man to raise at once a load which he could only have lifted piece-meal, it does not enable him to do more *work* than he could have done in the same time with the load divided to suit his strength, it only enables him to perform the work more conveniently; nay, on account of the friction of the parts, it even reduces slightly the actual amount of work done. This consideration at once dispels all those dreams about perpetual motions which have emptied the purses of so many schemers, and, at times, even ruined their intellects. (E. S.)

STATISTICS is a term derived from the German word *Staat*, a state or body of men existing together in social union. It was first introduced (at least in its present sense)[1] in 1749 by Professor Achenwall of Göttingen, who has the credit of being the founder of the science. He was the first that attempted to estimate the power and character of a state at a given time, by a systematic examination of its social condition, its progress in civilization, and its natural resources; and to determine the nature and force of those various circumstances in the history and condition of a people that go to form their character.

Statistics, therefore, concerns itself with man as existing in society, and its province comprises everything that bears upon his condition. "As all things on earth were given to man for his use, and all things in creation were so ordained as to contribute to his advantage and comfort, and as whatever affects man individually affects also man in a state of society, it follows that statistics enter more or less into every branch of science, and form that part of each which immediately connects it with human interests." (*Journal of the London Statistical Society*, vol. i.) It is difficult to define the limits of a science embracing so wide a field, and comprehending so great a variety of subjects. Its main object, however, is the collection and arrangement of facts, from which a knowledge may be attained of the nature and power of those laws on which the character, condition, and happiness of man depend.

Man in this world is subject to certain fixed laws, which form his character and determine his condition, and in proportion as these are understood and acted upon will his happiness be increased and his progress in civilisation accelerated. These are, however, so various, and act and react upon each other in so many different ways, that it is difficult or impossible to trace their workings in individual cases, and hence it is only by taking bodies of men in similar circumstances that we can arrive at a satisfactory knowledge of them, and estimate their effects. The laws themselves are as certain, fixed, and complete, as those of astronomy. We cannot indeed predict the history of society like that of the celestial appearances for thousands of years to come; but this arises not from any uncertainty in the laws themselves, but from the data to which these laws are to be applied. The data in astronomy are as certain as the laws themselves: "The circumstances, on the contrary, which influence the condition and progress of society are innumerable and perpetually changing; and though they all change in obedience to causes, and therefore to laws, the multitude of causes is so great as to defy our limited powers of calculation." But while it may be impossible to attain an amount of knowledge necessary for prediction, "there is nothing chimerical in the hope that general laws . . . . really admit of being ascertained," sufficient to enable us, "in any given condition of social affairs, ... to understand by what causes it had, in any and every particular, been made what it was; whether it was tending to any and what changes; what effects each feature of its existing state was likely to produce in the future; and by what means any of those effects might be prevented, modified, or accelerated, or a different class of effects superinduced." (*See* J. Stuart Mill's *Logic*, b. vi., c. 6, § 2.)

We cannot, however, by *à priori* reasoning discover the laws which regulate the complex fabric of human society; we must proceed by induction from well-ascertained facts, and hence the value of that science that more particularly concerns itself with the collection and arrangement of facts, by which alone these can be ascertained. Statistics, then, is that important branch of social science which collects, arranges, and compares the facts from which the politician may ascertain those principles in accordance with which governments may best promote the wellbeing and happiness of their subjects, and the political economist those laws that regulate the production and distribution of wealth. But while the statist collects materials for the politician and political economist, he must from them learn in what manner and in what directions to pursue his investigations; how to arrange his facts so as to bring out the truths which they are calculated to convey; what to collect as valuable, and what to reject as worthless. Facts collected in ignorance of the manner in which they are to be applied, or of the principles which they tend to illustrate, are in most cases of little value. Hence it is that we so frequently find facts collected that convey no useful information, or arranged in such a way as that they tend only to mislead.

But while the statist furnishes the politician and political economist with facts on which to found their reasonings, and from which to draw their conclusions, he, on the other hand, avails himself largely of the labours of the historian and geographer. Indeed, statistics is that science that takes up and shows the practical bearings of the facts of history and geography upon the condition of man. Thus, while history narrates the long series of occurrences that are to be found in the annals of a country, statistics only deals with those of them that may have contributed to form the character and fix the political and social condition of the people. The historian, too, usually travels over an extended period, while the statist brings his facts to bear upon a particular time. Hence, in the words of Professor Schlözer, the pupil and successor of Achenwall, "Statistics is history at a stand; history is statistics in a state of progression." With geography the science of statistics is even more intimately connected, for the physical characteristics of a country are a chief element in determining the condition of the inhabitants. The heat, cold, moisture, &c., of the climate affect their health and energies; while the climate is influenced by the position and physical features of the country,—its mountains, valleys, plains, lakes, marshes, vegetable productions, and state of cultivation. The climate, position, elevation, and nature of the surface and soil determine the animal and vegetable productions, which in their turn impart a distinctive character to the people, and direct their labours. A fertile and plain country draws their attention to the peaceful pursuits of husbandry and pasturage; a mountainous, rugged, and barren country, abounding in wild animals, renders them active, hardy, and fearless, and leads them to seek subsistence in the chase; while in the vicinity of seas and rivers abounding in fish, piscatory pursuits are fostered. Harbours and navigable rivers incline them to commerce, which increases as the want of foreign products is felt, as the country affords them articles of exchange, and as the means of internal communication are favourable; while mineral wealth draws their attention to mining and the working of metals. Hence, while geography describes the position and physical conditions of a country, its mountains, rivers, climate, productions, &c., statistics treats of the political importance of these, and of their bearings upon the condition of the inhabitants at a given time. As the statist looks for direction to the politician and political economist, not less ought the geographer and historian to learn from him how to prosecute their researches, so as to bring into due prominence those circumstances that tend chiefly to stamp the character of a people; for in reality their labours are of value as they can be brought practically to bear upon the conditions of social life.

But indeed every science that bears upon the condition of man enters more or less into statistics; and on the other hand derives valuable aid from it. Law, medicine, che-

[1] The noun *Statista*, signifying a statesman, and the adjective *Statisticus*, occur about three-quarters of a century earlier in *Thesaurus Rerumpublicarum*, by Ph. Andreas Oldenburger, Geneva, 1675.

mistry, botany, zoology, geology, meteorology, ethnology, technology, and anthropology, all contribute facts that are of value in statistics. Its character, however, is distinct from all of them; for while, for example, the jurist studies the laws of a country systematically, according to their nature, or the subjects with which they deal; the statist views them only and judges of them as they affect the social system. We shall, however, perhaps, best illustrate the importance and practical bearings of the science by noticing some of the principal subjects that come within its sphere. As whatever affects the condition of man in society forms a part of statistics, it follows that a statistical account of a country ought to include an exposition of all those circumstances in the physical characteristics of the country, or in the social condition of the people that influence their character, minister to their subsistence, add to their power, or tend to increase their happiness. "*Statistik eines Landes und Volkes ist der Inbegriff seiner Staatsmerkwürdigkeiten*" (Achenwall.) A statistical account of a country therefore includes—Under

Physical Features—An account of its position, extent, and natural divisions; its boundaries; the extent and character of its coast; the height, form, and direction of its mountains; the extent and elevation of its plains; the character of its valleys; the length, direction, size, and velocity of its rivers; the nature and extent of its lakes and marshes; its springs.

Climate—The variations of temperature; fall of rain; direction of the prevailing winds; atmospheric pressure.

Geology—The geological formations of the country; its various mineral resources; character of the soil.

Botany and Zoology—The number and distribution of the various species of animals and plants, with their uses as ministering to the necessities or comforts of the people, as supplying them with materials for labour, or as furnishing them with articles of trade.

Agriculture—The extent of cultivated land, heaths, forests, pastures, &c.; the progress of agriculture; modes of cultivation; agricultural implements; fertility of the soil; the different kinds of crops; their amount, and the proportion they bear to the wants of the people; the number of the various kinds of cattle, and their uses in agriculture or domestic economy.

Mining—The number, character, and productiveness of the mines; the quantities and values of the different ores raised; the progress of mining, and modes of carrying on operations.

Fisheries—The various kinds of sea and river fisheries; their importance, and the means and manner of prosecuting them.

Manufactures—Their progress and present state; the different branches of manufacture; their principal seats; their importance, as contributing to the wealth of the country, or as affording employment and the means of subsistence to the people; the amount and value of the labour expended upon them; the machinery employed; how far the raw materials are home produced or imported; how far the manufactured articles are necessaries or luxuries, are for home consumption or for exportation.

Commerce—The amount of the exports and imports; the quantities and values of the principal articles; the principal ports; the countries with which trade is chiefly carried on, and the principal articles sent to or brought from each; by whom, or under what flags the trade is principally carried on; how far the imports are necessaries or luxuries; how far for direct consumption, for manufacture, or for exportation; how far the exports on raw or manufactured goods, are the natural production of the country or imported or manufactured. It includes, also, an account of the nature, amount, &c., of the internal or coasting trade.

Facilities for Commerce—The amount of shipping belonging to the country; amount of sailing and steam vessels; the state of the harbours; the length of the navigable rivers and canals; the nature and length of the roads and railways; nature of conveyances.

Population—The number at different periods; races; rate of increase; emigration and immigration; proportion of births and deaths; the proportion of the sexes, and marriage relations; the different ages of the population; the average duration of life, and how affected by locality, climate, occupation, or mode of life; the nature and prevalence of certain diseases; the proportion of the population to the production, wealth, and consumption of the country.

Social Condition—The general character, disposition, and habits of the people; their manners and customs; their progress in civilization; the different classes of society; their numbers and relations to one another; the social condition, and intellectual and moral culture of each; houses; the distribution of wealth and power; the occupations of the people; the proportion of capital to labour; skilled and unskilled labour; wages; prices of provisions; amount of chief articles of consumption; national vices; pauperism.

Language and Literature—Character and growth of the language; different dialects; affinity with other languages:—Literature, its character, state, and progress; the branches in which most distinguished; names of principal authors; different classes of publications; literary associations; public libraries; restrictions on literature.

Science and Art—State and progress of; branches in which principally distinguished; institutions for the promotion of, as scientific associations, academies, museums, picture galleries, &c.

Government—Its nature, form, and progress; the legislative, judicial, and executive functions, in whom vested, and how carried out; the character of its laws; the political divisions of the country; how far and in what way the different classes are represented; public works, and other means adopted by government for the encouragement of industry and commerce, or for promoting the social and intellectual progress of the people.

Religion—Its character, condition, and progress; its connection with the state; the various sects; toleration; number of churches and extent of accommodation; the various classes of the clergy; their emoluments; the amount and sources of the church revenues, as provided by the state, by voluntary contributions, &c.

Education—The number and character of the various seminaries of education; their efficiency; how supported; fees; the number of teachers; their incomes; number and ages of scholars, and their proportion to population, within the same ages; how far the state controls or interferes with education.

Crime—State of crime; different classes of offences; the social condition of offenders, age, sex, education, &c.; number of convictions; proportion of convictions to committals; the different kinds of punishment; means for the punishment or prevention of crime, prisons, reformatories, police, &c.

Defence—The natural defences of the country; its fortresses; the amount and efficiency of the army and navy.

Finance—Amount of national debt, its character and growth; the various sources of revenue; the gross and net amount received from each; the proportion of income to expenditure; the various branches of expenditure.

Taxation—Amount of; its character as direct or indirect; its branches; articles on which imposed; how levied; expenses of collection; how far protective or retaliatory; effects on industry or commerce; recent alterations and effects of.

Money, &c.—The weights, measures, and moneys of the country, and their equivalents; banks and banking system, &c.

Antiquities—The different classes of antiquities; their character and age; their state of preservation, &c.

Authorities—The various sources of information, at least so far as not previously referred to, in order to afford the means of judging what degree of reliance can be placed upon the various statements.

Information on these various points, so far as applicable to any particular state is necessary, in order to a comprehensive knowledge of it—in order to understand its present position, to trace the various circumstances by which it has been brought about, and to acquire some knowledge of the action and reaction that is constantly taking place among its various elements. How few the means are that we yet possess of drawing up a complete statistical account of any country it is scarcely necessary to say. Those who have occasion to search for such information know how meagre are the materials and how unreliable the sources. On many points, the governments of the various countries can alone be looked to for information; and they possess numerous facilities for carrying out such investigations. In our own country, a statistical department has been connected with the Board of Trade since 1832, and has collected and published many valuable facts relating to our own and other countries. We are still, however, in this respect far behind several of the continental states. Lord Stanley, in his opening address before section F (Economical Science and Statistics) of the British Association in 1856, forcibly points out the importance to the government of statistical facts, and thus alludes to the necessity of establishing a special department of government, charged with the annual publication of statistical facts relative to our national affairs. "Statistics," said he, "are the function of the state, in a

sense in which no other science is so. . . . We have statistics enough presented to Parliament every session, but they are, in the great majority of cases, called for by individuals. They are drawn out to suit the particular purpose of those who move for them: they are accordingly deficient in unity, and often of no use beyond the moment. Now I speak from some personal observation, when I say, that at a cost hardly greater than that of those desultory, fragmentary, isolated returns (which have in addition the inconvenience, coming as they do at unexpected times, and without any regularity, of throwing a sudden increase of work on particular offices), it would be possible to present to the nation such a yearly *resumé* of administrative statistics, as should, to a very great degree, supersede the present system (if system it can be called) of moving for returns as and when they are wanted. I have said, that I think a statistical department desirable instead of a statistical branch in every department; because the former method gives better security for unity of plan, and because the work will be best done by those whose sole and undivided business it is." In 1833 the statistical section of the British Association for the advancement of science was formed; and in 1834, the London Statistical Society was founded, both of which have done much in the way of collecting and collating important statistical information, and of diffusing a knowledge of the principles and value of the science.

There are indeed some who seek to confine this science exclusively to an exposition of the state of a country or people, at a particular time, and to such circumstances in their condition as may be reduced to numerical calculation and exhibited in tables. But this is to deprive the science of all that is most interesting and instructive, and to render it of little practical value. Numbers are undoubtedly a most important part of statistics. They are that which gives precision and accuracy to the science, and without which it would be little else than a mass of generalities and uncertainties. Figures, however, of themselves unaccompanied by any explanation of the nature of the subject upon which they bear, and especially without any account of the causes that may have influenced them, or the circumstances by which they were attended, can lead only to false conclusions, or to no conclusion at all. Figures are the mere dry bones of statistics, which require to be systematically arranged and explained, and the principles which they illustrate pointed out before they can be of real value. In the same way, to know merely the population, productions, or trade of a country or place at a given time, is of comparatively little value, unless we possess also the same facts for different periods, in order to compare them, and to know how far, and in what particulars, progress or decline has taken place. It is from comparing similar facts of the same country for different times, or of different countries at the same time, and noting the difference of circumstances in each, that the statist arrives at a knowledge of those principles that are constantly at work in society; and hence to confine his operations to mere figures, or to a particular time, would be to deprive them of their chief value. Indeed, nothing has tended more to bring the science into general disrepute than the attempt thus to limit the sphere of its operations. It is by being thus restricted that statistics has been so frequently made the means of promulgating or upholding gross errors. When every one is left to explain or arrange figures in his own way, there is scarcely a theory however wild, or an error however palpable, to which an ignorant or designing person may not by means of them give an air of truth; and thus occasion has been given for the saying, that "anything may be proved by figures." The confidence, too, with which they are handled, and the appearance of accuracy which they bear, lead to their being received without a due amount of examination. Hence statistics is a favourite mode of argument with certain classes of speakers and writers, as it is generally found to carry conviction in proportion as their hearers or readers are ignorant of the principles of the science, or are unable to test their assertions by the rules of sound criticism. Indeed, there is nothing about which one ought to be more sceptical than the great mass of what are called statistical facts, however accurate and imposing they may appear. Statistics, like every other science, has its principles which require to be known, and in accordance with which its facts are to be expounded. It concerns itself chiefly with the accumulation and comparison of facts, and does not admit of any kind of speculation. The statist must, therefore, not only be a man in whose judgment and honesty we can confide, but he must also come to the consideration of his subject with a mind void of preconceived theories, otherwise he may be led, even unconsciously, into a partial or deceptive exposition of the facts.

The statist has, first of all, to ascertain what reliance can be placed upon the facts or figures which are to form the basis of inquiry—from what sources they have been obtained, and how or for what purpose they have been collected. Figures collected for a specific purpose may often be of little or no value for one of a different nature, as details may have been omitted, and distinctions neglected to be made, which would materially affect the result. Even when these are collected with the utmost possible care, and under the most favourable circumstances, they may be of such a nature as that the parties applied to for information may have a direct interest in concealing the truth; and even where such temptations do not ex st, ignorance of the exact nature of the information required, or objections to inquiries of a personal or inquisitorial nature, may lead many to make false or misleading statements. It would be easy to illustrate this by referring to official or parliamentary documents of our own country; and when we find such errors among ourselves, with all our appliances for collecting information, and all our efforts to ensure accuracy, what can we expect of countries and times less civilized? There is no more frequent cause of error than that of taking as complete what is only a partial statement of facts. Where a traveller or historian is the source of information, the statist has to ascertain his character for accuracy or impartiality, the means he had of obtaining information, and the point of view from which he looks at the subject.

Having ascertained what degree of reliance can be placed upon the facts themselves, or made allowance for deficiencies, the next duty of the statist is to arrange them so as to find out what inferences may be legitimately drawn from them. By a careful analysis and comparison of the facts he attempts to ascertain the nature and force of the various laws that have been acting upon them. It is to be borne in mind, that in society no effect can have only one cause, neither can one cause have only one effect. Every one of the social phenomena is the result not of one only, but of a multitude of causes. "Whatever affects in an appreciable degree any one element of the social state, affects through it all the other elements. . . . . There is no social phenomenon which is not more or less influenced by every other part of the condition of the same society, and therefore by every cause which is influencing any other of the contemporaneous social phenomena" (Mill's *Logic*). Every effect, therefore, in the social system is produced by a complexity of circumstances, and "amounts precisely to the sum of the effects of the circumstances taken singly" (Ibid). Hence it is, that as we cannot know all the circumstances that may have been at work in producing a certain result, statistics cannot be considered as an exact science, but rather as a science of probabilities. But while we cannot know all the causes, there are yet in every case certain of them that have been more immediately concerned in bringing about the result, and it is to these that the statist

principally directs his attention. Having, for instance, ascertained the average duration of life in a country at a particular time, he arranges the figures by which that result has been obtained, according to the circumstances that tend more immediately to shorten or prolong life, and thus ascertains how far each of them affects the general result. While the statist thus deals with those causes that have been more immediately influencing a particular result, an important principle comes into operation to give precision and accuracy to his calculations—namely, that the influence of minor disturbing causes diminishes, as the area of his investigations increases, until, if the basis be sufficiently extended, he is justified in disregarding them altogether. Thus, while the number of deaths in a country from any special cause may, in a given year, be much modified or aggravated by other causes, yet by taking the number of the deaths from that cause over a number of years, or over different countries, the disturbing causes will counteract or neutralise each other. It is upon this principle that insurance companies are established. In dealing with great numbers, the average duration of life can be calculated with a surprising degree of precision. An insurance company having only a small number of members, might be ruined in a short time by a few deaths.

It is, however, in the comparison of facts of a similar nature, either of different countries at the same time, or of the same country at different times, that the statist requires to exercise the greatest judgment, and manifest the greatest care. In comparing, for example, the state of crime in this country at present with that of a previous period, there are many things that have to be taken into account besides the proportion of criminals to population. Crime may now have assumed a much lighter character, the means of detection may be greater, lesser offences may have been brought into the penal code, the meaning of terms may have changed, the temptations or facilities to crime may have increased—all these, and many other circumstances, have to be taken into account before the two periods can be properly compared, or their facts correctly reasoned upon. Much more have circumstances like these to be carefully investigated in comparing the state of crime in different countries. In comparing the crime of different towns, the ages of the population is often an important element, for in some towns, as where manufactures are largely carried on, there is always a preponderance of persons at those ages at which the tendency to crime is greatest. In towns, too, the inducements to crime are always greater than in rural districts. It is by comparing the state of crime in the same or different countries under various circumstances that the statist is enabled to discover and estimate the force of the various causes that tend to its production, and at the same time to ascertain the best means of repressing it,—of intimidating, punishing, or reforming criminals. As the astronomer, by finding a discrepancy between his calculations and observations, is led to conclude the existence of some yet undiscovered disturbing cause, so the statist, if, in comparing facts of a similar nature, and after making allowance for difference of circumstances, he finds a marked discrepancy still to exist, may readily infer that there are other causes at work in the one case or the other, of which he is yet ignorant.

Among the errors that reasoners upon statistics frequently fall into, is the attributing of a social fact to one only of its many antecedents or producing causes, without any process of elimination or comparison of instances. It is only by considering, as far as possible, all causes which conjunctly influence a given effect, and compounding their laws with one another, that we can infer the nature and force of the determining circumstances. It is by tracing a certain effect to its various producing causes, or a certain cause down through its numerous effects, that a correct knowledge of the social phenomena can be obtained. The confounding of cause and effect, and the considering of two circumstances as cause and effect which are both the result of common causes, are also frequent sources of error. To estimate the production, &c., of a country from that of a small portion of it is always a very uncertain mode of proceeding, and has frequently led to very grave errors. For while on a large scale minor disturbing causes tend to neutralize each other, on a small scale some of them are always to be found in excess, and thus greatly affect the result when many times multiplied. As every cause in the body social acts and is acted upon by numerous others, many persons err in drawing conclusions from one state of society, and applying them to others in which many of the elements are not the same. Social science, like mechanics, has to deal with conflicting forces,—with causes counteracting or modifying one another. In mechanics, we continually find two or more moving forces producing, not motion but rest, or motion in a different direction from that which would have been produced by either of the generating forces acting separately. Hence it is that the same cause is found to act very differently in different states of society, even to the extent of being beneficial to some and highly injurious to others; and hence, too, the error of "all who found their theories of politics upon what is called abstract right, that is to say, upon universal precepts." (Mill's *Logic*.) It is rarely safe to introduce great or sudden changes into a state, for however beneficial the measure may be in itself, the number of opposing elements with which it will have to contend may deprive it of all utility, if not render it absolutely injurious; whereas small changes, or changes gradually introduced, may meet with a number of favouring circumstances, which will accelerate and increase their beneficial effects. (D. K.)

STATIUS, P. PAPINIUS, a poet and grammarian, who between the age of 13 and 19 was six times crowned as a successful candidate in the Greek poetic games at Naples. Dodwell conjectures that he was born A.D. 39, and died A.D. 86. On the strength of his reputation he went to Rome, where he arrived during the civil wars between Vitellus and Vespasian. Soon after his arrival, the Capitol was reduced to ashes; and seeing in this disaster a fine opportunity for artistic effect, he composed a poem, which was published almost before the cinders had ceased to smoke. This poem excited the admiration of the great men of the day, and, above all, of the emperor himself. Statius opened a school to teach Greek literature to the young nobles, and he also instructed the Salii and other priests in various branches of their duty with equal severity and success. In spite, however, of his literary labours, he seems to have left his son very little other patrimony beside the half-dozen faded chaplets of pine and laurel which he had won in the Neapolitan contests. The story that Domitian made him a tutor, and presented him with a golden crown, only rests on the authority of Maturantius, and may be a mere mistaken inference from the language of the *Epicedion in patrem*. All his works, even the famous poem on the Capitol, have perished, and he would probably have been forgotten but for the reputation of his son.

STATIUS, *P. Papinius*, the son of the above, was probably born about A.D. 61, and at a very early age he excited by his precocious talents the admiration of his father's patrons. It was a miserable school for a young and clever boy, and we trace the flatterer and protégé in all his works. Before his father's death he won a crown at the Neapolitan games, and was thrice victor in the Alban Quinquatria. During Domitian's reign he and Martial were the accredited poets of the imperial court. At that time poems were first made known by public recitation; a pernicious custom, which had been disliked and discouraged by Horace, but which had increased under the injudicious approval of Ovid, and the practice and patronage of Nero and Domitian. A most bril-

liant and lively picture of these public readings is given by M. Nisard in his *Etudes sur les Poëtes de la Decadence*, from particulars gleaned out of the writings of Pliny, Martial, and Seneca. Statius was the most fashionable reciter of the day; and even Juvenal, who reckons "the poets spouting in the dog-days" among the curses of Rome, speaks with enthusiasm of the delight which was felt in the city when Statius had promised to read some fresh Sylva or new book of the *Thebaid*.

At length, however, even his popularity began to wane. He was defeated in the quinquennial games, and this induced him to put in execution his long-cherished design of retiring to Naples, his native city, and bidding a final adieu to the noisy but fickle plaudits of a niggardly and tasteless crowd. He hoped at Naples to enjoy, in a poverty which would be less galling when it ceased to be contrasted with so much grandeur, that domestic life for which he was eminently adapted, and of which he was deeply fond. Statius was a man of a quiet and amiable disposition; and in his private capacity, apart from the degrading accidents of his time and position, demands our honest admiration. While yet a youth, he had married a freed-woman, Claudia, to whom he was faithfully and tenderly attached. What became of Statius is unknown; he probably died in privacy at Naples, and Dodwell conjecturally places his death in the year A.D. 96. We have been unable to discover any authority whatever for the absurd stories that he was a Christian, or that he was stabbed by the emperor with an iron style.

We can only judge of the character of Statius from his own works. One or two of them are very creditable to his personal feelings; and if there are many which show him in the contemptible light of a parasite, a gossip, and a flatterer, we must remember Bacon's warning respecting the difference between *vitia temporis* and *vitia horminis.* But we must not deny that Statius sinks deeper still. We find him lending the ornaments of his ingenuity to the grossest excesses, and the vilest passions of patrician and imperial crime. What can we say of a poet who throws all the force of his charming versification into the *Consolatio ad Flavium*, and the apotheosis of a eunuch's hair? No purity or simplicity of private life can wholly atone for baseness such as this. Yet the *Coma Earini* is the theme of emulous raptures on the part of Martial and Statius, the two recognized poets-laureate of Domitian's court; and it is far from improbable that the necessity of rivalry in the celebration of such subjects led to that jealousy for his brother poet which critics have traced in the writings[1] of the epigrammatist. Both by his envious silence and his malicious sneers, Martial shows his intolerance of "a brother near the throne."

Statius belongs to that period of declining literature in which the poets sink into mere learned versifiers. In such an age, art not only predominates over inspiration, but has entirely superseded it, and for "the sensibilities of the heart are substituted the susceptibilities of the ear." Statius and his contemporaries ("et tous ces garçon-là," as Scaliger somewhat contemptuously called them) "have taste, learning, and ingenuity, but not one spark of the true Promethean fire. They desired to be poets—they fancied themselves poets; but they rarely rise above the level of rhetoricians who wrote in rythm. Statius teaches us nothing, is good for nothing, has no influence in the education of humanity; he sings of the tresses of a eunuch and the dead lion of an emperor, and yet he was endowed, and that in an eminent degree, with those qualities which, at certain privileged epochs, reveal to the poet truths of eternal interest, and suggest to him the utterance which renders them immortal."[2]

The works of Statius are—

1. The *Sylvæ*, five books of poems in various metres, and in commemoration, for the most part, of the trifling subjects of the day. Statius seems to have thought very lightly of these in comparison with his epics; and yet his claim to poetic laurels rests almost solely on these brochures, and not on his more ambitious works. Niebuhr's judgment of them was very favourable; and many of them (particularly those in which he touches on his own private affairs) are sufficiently sincere to be regarded as very interesting and agreeable compositions. They are well deserving of an attentive perusal.

2. The *Thebais*, in 12 books, each of which occupied a year in elaborating, and which were frequently recited previous to their publication. They were completed before A.D. 90, as we infer from various allusions[3] in the *Sylvæ*, and from the prose proems in which Statius dedicated them to his various acquaintances. It was on this work that Statius mainly founded his hope of poetic immortality.

3. The *Achilleid*, which is left in a fragmentary condition, and the completion of which was perhaps abandoned when the poet retired to Naples. He twice alludes to it in his *Sylvæ*.

The chief editions of Statius are—

The *Editio Princeps* of the *Sylvæ*, about 1470, 4to. The *Editio Princeps* of the *Thebaid* and *Achilleid*, folio, about the same date. Markland, Lond., 1728; Sillig, Dresden, 1827; Lemaire, Paris, 1830. Parts of Statius have been turned into English verse by Pope, Stephens, Lewis, and Howard. (F. W. F.)

STAUNTON, SIR GEORGE LEONARD, was descended from an old English family, and was born in Galway, Ireland, on the 19th of April 1737. Having gone to Montpelier, in the south of France, for his health, he studied medicine there, and on his return to London in 1760 commenced writing for periodicals. On setting out for the West Indies in 1762, Dr Johnson, whose acquaintance he had formed during his short stay in London, wrote him a kind letter, which may still be seen in Boswell's *Life*. He settled in the West Indies, where he practiced as a physician, and amassed a considerable fortune from his profession and from official situations. Investing this money in estates in the island of Granada, he returned to England in 1770. In 1772 he again went to Granada, where he was chosen attorney-general, and made the acquaintance of Lord Macartney, who became governor of that island in 1774. Staunton lost his property by the capture of Granada by the French, and he returned to England with the governor of the island in 1779. He accompanied Lord Macartney to Madras in 1781, and for his distinguished services while in India he received a pension of L.500 per annum from the East India Company, was created a baronet, and received the honorary degree of LL.D. from the University of Oxford. Sir George again accompanied Lord Macartney to China in 1792, as secretary and minister-plenipotentiary, and wrote a very interesting account of China and the Chinese on his return to London. He died in London, January 14, 1801, and was buried in Westminster Abbey.

STAVANGER, a seaport of Norway, in the diocese of Christiansand, in the Bůleke Fiord, an inlet of the German Ocean, 100 miles S. of Bergen. It is built on the N.E. side of a promontory, in the fiord, and commands a fine view towards the mountains in the E. and N.E. The principal building is the cathedral, which was built in 1013, and is, with the exception of that of Drontheim, the most perfect specimen of mediæval architecture in Norway. Stavanger has also several schools, an hospital, and a poor-house. There are here shipbuilding yards, distilleries, &c., but the inhabitants depend chiefly on the herring fishery. The harbour is good, and sheltered by a small island. Timber is exported to a considerable extent. Pop. (1855) 11,717.

STAVROPOL, a town of Russia, capital of a circle of the same name, in the province of Caucasus, stands on a hill near the Taschly, 59 miles W.N.W. of Alexandrov, and about 260 S.W. of Astrachan. It is fortified, and has several churches, a gymnasium, and manufactories of soap and leather. Pop. 7000.

[1] *Mart.* ix. 20, 91.

[2] Nisard, i. 202, 271; Charpentier *Sur les Ecrivains Latins*, 292.

[3] *Theb.* xii. 811; *Sylv.* v. 36, &c.

STEAM.

Considerations regarding Steam.

CHAP. I.—CONSIDERATIONS OF A GENERAL NATURE REGARDING THE PROPERTIES, PHENOMENA, AND APPLICATIONS OF STEAM.

STEAM is the name given in our language to the visible, moist vapour which arises from all bodies which contain juices easily expelled from them by heats not sufficient for their combustion. Thus we say, the steam of boiling water, of malt, of a tan-bed. It is distinguished from smoke by its not having been produced by combustion, by not containing any soot, and by its being condensible by cold into water, oil, inflammable spirits, or liquids composed of these. We see it rise in great abundance from bodies when they are heated, forming a white cloud, which diffuses itself and disappears at no very great distance from the body from which it was produced. In this case the surrounding air is found loaded with the water or moisture which seems to have produced it; and the steam seems to be completely soluble in air, composing, while thus united, a transparent elastic fluid. But in order to its appearance in the form of an *opaque white* cloud, the mixture with or dissemination in air seems necessary. If a tea-kettle boils violently, so that the steam is formed at the spout in great abundance, it may be observed that the visible cloud is not formed at the very mouth of the spout, but at a small distance before it, and that the vapour is perfectly invisible at its first emission. This is rendered still more evident by fitting to the spout of the tea-kettle a glass-pipe of any length, and of as large a diameter as we please. The steam is produced as copiously as without this pipe, but the vapour is transparent and colourless throughout the whole of the pipe; nay, if this pipe communicate with a glass vessel terminating in another pipe, and if the vessel be kept sufficiently hot, the steam will be as abundantly produced at the mouth of this second pipe as before, and the vessel will remain quite transparent. The visibility, therefore, of the matter which constitutes the steam is an accidental circumstance, and appears to require its dissemination in the air; and we know that one perfectly transparent body, when minutely divided and diffused among the parts of another transparent body, but not dissolved in it, makes a mass which is visible. Thus oil beaten up with water makes a white *opaque* mass.

When steam is produced, the water gradually wastes in the tea-kettle, and will soon be totally expended if we continue it on the fire. It is reasonable, therefore, to suppose that this steam is nothing but water, changed by heat into an ærial or elastic form. If so, we should expect that the privation of this heat would leave it in the form of water again. Accordingly, this is fully verified by experiment; for if the pipe fitted to the tea-kettle be surrounded with ice, or any cold substance, no steam will issue, but water will continually trickle from it in drops; and if the process be conducted with the proper precautions, the water which we thus obtain from the pipe will be found equal in quantity to that which disappears from the tea-kettle. Steam is therefore the matter of water converted by heat into an elastic vapour.

We are most familiar with steam when in the act of rising violently from heated water in the process of ebullition. The history of steam at this crisis is highly instructive, and its phenomena may be studied with advantage by examining it in a glass vessel placed over a strong lamp. When heat is first applied, a rapid circulation of the fluid ensues. The water on the bottom, being first heated and expanded, becoming lighter than the rest, rises to the top, and is replaced by the current of colder water descending, to receive in its turn a further accession of heat. By and by small globules of steam, formed on the bottom and surrounded by a film of water, are observed adhering to the glass; as the heat increases they enlarge; in a short time several of them unite, form a bubble larger than the others, and, detaching themselves from the glass, rise upwards in the fluid. But they never reach the surface; they encounter currents of water still comparatively cold, and descending to receive from the bottom their supply of heat, and encountering them, the bubbles are robbed of their heat, shrivel up into their original bulk, and are lost among the other particles of water In a short time the mass of the water becomes more uniformly heated; the bubbles, becoming larger and more frequent, are condensed with a loud crackling noise, and at last, when the heat of the whole mass reaches 212°, the bubbles from the bottom rise without condensation through the water, swell and unite with others as they rise, and burst out upon the air in a copious volume of steam, of the same heat as the water from which they are formed, and pushing aside the air, make room for themselves. In this process, by continuing the application of heat, the whole of the water may be "boiled away" or converted into steam.

The singular sounds produced from a vessel of water exposed to heat previously to boiling, have attracted attention; the water is then vulgarly said to be simmering or singing, and, when this takes place, it is because the vessel is boiling at one place and comparatively cold at another. This noise is most distinctly heard when the fire or flame applied is small and its heat intense, when the vessel is large and the water deep; for in that case the entrance of the caloric will take place more rapidly than the circulation can convey it to the remote particles of fluid, and so bubbles of steam will form rapidly at one place and be rapidly condensed at another; the degree of velocity with which such bubbles succeed will determine the pitch of the singing tone. We have observed this phenomenon in greatest perfection when we have attached a slender pipe to a close boiler producing steam, and carried its open mouth, of the diameter of $\frac{1}{8}$ or $\frac{3}{16}$ths of an inch, down below the surface of cold water in a glass jar. When the mouth of the steam-pipe is held just below the surface of the water, the steam issues with great rapidity in small bubbles, producing an acute tone; and, on the other hand, when the pipe is held at a considerable depth, the concussions become more violent and louder, their intervals of succession greater, the tone is lowered, and finally, the shocks become detached, and so violent as to shake the glass and surrounding objects with much force. On this subject Professor Robison observes that a violent and remarkable phenomenon appears if we suddenly plunge a lump of red-hot iron into a vessel of cold water, taking care that no red part be near the surface. If the hand be now applied to the side of the vessel, a most violent tremor is felt, and sometimes strong thumps; these arise from the collapsing of very large bubbles. If the upper part of the iron be too hot, it warms the surrounding water so much, that the bubbles from below come up through it uncondensed, and produce ebullition without concussion. The great resemblance of this tremor to the sensation which we experience during the shock of an earthquake has led many to suppose that the latter is produced in the same way; and their hypothesis is by no means unfeasible. Any obstruction on the bottom of a boiler on the inside, as a piece of metal or stone introduced among the water, may

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produce a succession of smart concussions by the sudden condensation of gas collected under it.

The permanence of the boiling point is one of the most remarkable of the phenomena of ebullition. When water has once been brought to boil in an open vessel, it is not possible to make the water sensibly hotter, however strongly the fire may be urged or its intensity increased. This circumstance is very striking, because we know that heat continues to be thrown in exactly as fast as before the boiling point; and that, in that case, the heat rose rapidly, whereas now it has altogether ceased to increase. If a thermometer of mercury, air, oil, or metal be placed among the water, the temperature will constantly increase, and expand the matter of the thermometer until the water boils; and then, whether it boil slowly or rapidly, with a strong fire or a gentle one, the thermometer will continue to stand at the same point. This point is so well defined as to furnish our standard for the comparison of temperature, and is the same on all thermometers, being called the *boiling point*, although it is differently numbered on each, being called 212° on our common thermometer, or Fahrenheit's, 80° on Reaumur's, and 100° on the centigrade thermometer.

It is also to be remarked that the temperature of the steam issuing from boiling water is the same with the temperature of the water itself, and remains equally invariable; so that all the steam produced from water boiling at 212° is itself at 212°. This remark will assist us in accounting for the disposal of the heat which the fire gives out during the time of ebullition; for it is manifest that the heat is all the while carried off by the large volumes of steam, at a temperature of 212°, that are diffused through the air; and so it happens that an increase of heat in the fire, instead of increasing the heat of the water, only increases the volumes of the steam thrown off and the quantity of heat carried away. This view of the subject is confirmed by a simple experiment. Take a strong glass flask, place water in it, and a thermometer among the water, and let it be held over a lamp until the water boil, and the thermometer will be observed rising till it reach 212°, when the steam will begin to escape rapidly from the neck of the flask. Let it now be corked tightly, and the heat continually applied; and it will be observed that the thermometer does not now stand at 212°, but rises rapidly from that point up to 220° and 230°, showing that the free escape of the steam into the open air is necessary to the permanence of the boiling point. If the heat be still applied, the experiment may be rendered still more instructive by suddenly pulling out the cork of the flask, when the vapour will instantly rush out in a large volume, and the thermometer sink down to 212°, showing that all the excess of heat has been carried off by the steam into the air.

It has thus been seen that a large quantity of heat may be given out in the particles of a certain quantity of water, converting them into steam; and yet that the thermometer shall afford no indication of this quantity. As soon as water boils the whole mass is heated up to 212°; and although the same heat that produced the ebullition be still continually applied, and although we know that this heat must be continually entering into the water, still it is not detected, or in any way exhibited by the thermometer. On this account the heat given to water during ebullition is said to become *latent*, or lie hid from the thermometer; and, indeed, the thermometer merely indicates the intensity of heat; the calorimeter alone can measure its quantity. The quantity of heat given out to water after it has begun to boil is more than fivefold that which is sufficient to bring it from the freezing up to the boiling point; for, if we continue the fire with the same intensity that was used in bringing it to boil, it will require more than fivefold that duration and quantity of fuel to boil all the water away, or convert it all into steam of 212° of heat. Thus the sensible heat, added from 32°, will be 180°, and that latent in the steam is more than fivefold; or, in other words, the insensible caloric in steam is fivefold its sensible heat; or the same quantity of matter in the condition of steam at 212°, and of water at 212°, will hold different quantities of caloric, in the proportion of above 6 to 1. This is called the greater capacity of steam for caloric than of water for that substance; and it is in part accounted for by the greater distances of the particles of the matter of steam and water from each other in the former than the latter condition. Dr Black was the discoverer of the admirable doctrine of latent heat.

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Dr Dalton has thus illustrated the doctrine of latent heat, and of the increased capacity of a liquid for holding caloric when it passes into the condition of vapour. The liquid and its vapour may be considered as two reservoirs of caloric, capable of holding different quantities of that fluid. Let fig. 1 represent to us such an arrangement: the internal cylinder of smaller capacity; the external one of enlarged capacity, surrounding and extending far above it; and a small open tube of glass, communicating freely at the bottom with the internal cylinder. Let us now conceive water to be poured into the internal cylinder; the water will manifestly flow into the slender tube till it stand on the same level in the tube as in the cylinder. If any additional quantity be now poured into the internal cylinder, the rise of water in the slender glass tube will serve as an index of the quantity of added fluid; and when it is filled to

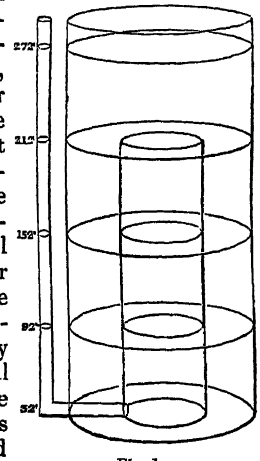

Fig. 1.

the top, the fluid will stand at the height marked 212°, and will still be a correct index of the addition of fluid. But if more water be now added to it, it will not make its appearance in the slender tube, but will simply overflow from the internal cylinder over into that of enlarged capacity, so that while a large quantity is passing into the vessel and gradually filling it up to 212°, no additional rise takes place until the whole of the outer cylinder become filled to that point, after which any further addition will again become sensible by a corresponding rise in the tube. This process is in precise analogy to the succession of circumstances in heating a liquid and converting it into a steam. The internal cylinder represents the liquid; the external one, the vapour of greater capacity; and the slender glass tube at the side, the thermometer placed in communication with them. When heat flows into the liquid, it passes equally into the thermometer; and each increment of the one produces an equal increment in the other, until the liquid reaches the limit of its capacity, when it suddenly begins to enlarge its bulk and take the form of steam; but the quantity of heat required to fill up this enlarged capacity is so great as to require about $5\frac{1}{2}$ times as much to fill it as was contained in the whole liquid before, so that all this time the thermometer is standing still, and it is not until the whole of the steam is thus supplied with 212° of caloric that the thermometer will begin to show any further elevation; after which, any increment of heat thrown into the steam will make its appearance on the thermometer, and proceed, as formerly, by simultaneous increments.

It appears, therefore, that the cause why water boiling under the open air does not reach a higher temperature than 212° is, that the steam which is raised by any additional heat carries that additional quantity of heat along with it into the air. But here a question occurs at once

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to the inquirer into these phenomena, viz., Why does water require to be heated up to 212° before it will throw off its increments of heat and vapour into the air? Why does not steam rise equally strongly from water at 200° or 180°? The categorical reply is, that the elastic force of the heat is not sufficient to enable the steam to force its way against the pressure of the air until it reaches this point. In order to understand the means by which we arrive at this conclusion, it is necessary to know that, when the pressure of air on the surface of the water is artificially diminished, the steam does actually rise, and the water bubbles and boils with great violence, at temperatures far below 212°. It is only when the surface of the water is exposed to the full *pressure of the air* in a common vessel that it is prevented from rising in vapour, at temperatures lower than the usual boiling point. If the surface of the hot water be protected from the pressure of the air, by being placed under a glass shade, and the air removed from the inside of it by an air-pump, the water may be made to boil at all temperatures below 212°.

Conceive a vessel of water first of all boiling at 212° in the open air, as the vessel A in fig. 2, the thermometer I

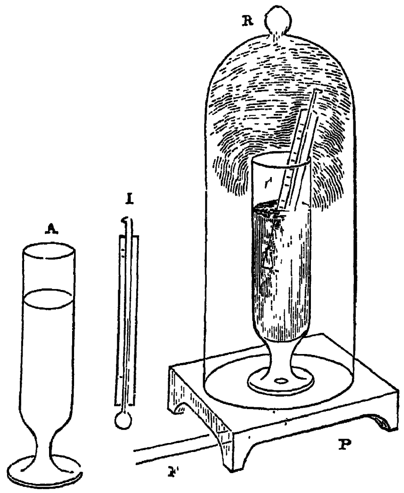

Fig. 2.

being placed in it. After allowing the water to cool to 200°, let the vessel of water and the immerged thermometer be now placed on the plate-stand P of an air-pump, and covered over with a strong glass receiver R; and let a portion of the enclosed air be now withdrawn by the pump from the inside of the receiver by the pipe F; and suppose that there are in all 30 cubic inches, or other volumes, of air in the receiver at first; then the water being at 200°, when about 7 out of the 30 parts of the air have been withdrawn, leaving only about 23 parts out of 30 pressing on the water, it will be observed instantly to commence giving off steam in rapid ebullition. If next, the process be repeated, only allowing the water to cool to 190°, the ebullition will not commence at this lower temperature till about 12 out of the 30 volumes of air have been withdrawn; and if, in a third experiment, the water be cooled down to 180°, the elastic force communicated by this degree of heat will not be capable of overcoming the resistance arising from the pressure of the air until one-half of the original pressure of 30 has been removed. To this process there is no limit, for as we go on lowering the temperature, we can always find a point at which the water will boil, provided the counteracting pressure be sufficiently diminished.

Distillation is a method of separating a liquid from extraneous matter, by first of all converting it into steam, and then condensing that steam so as to form the liquid. Different substances take the liquid form at various temperatures; and, therefore, the heat may be so regulated that only one substance of a mixture shall take the form of vapour, and being conveyed by a pipe through a vessel of cold water, or otherwise exposed to the cooling process, the vapour being condensed will give the pure liquid. A great improvement upon the process of separating liquids has been successfully introduced by Mr Howard. It consists of distillation or evaporation *in vacuo*, and has been most usefully employed in the refining process of sugar. When sugar is dissolved in water, it requires a much higher temperature than 212° to boil the mixture, or to convert the water into steam and separate it from the solid; and as the process goes on, and the solution comes to hold less and less water, the requisite degree of heat is further augmented, until the temperature becomes so high as to injure the colour and otherwise deteriorate the article of merchandise in its crystallized state. Instead of this increased temperature, Mr Howard places the syrup *in vacuo*, and thus boils it at a low and innoxious heat.

The pulse-glass, an invention attributed to Dr Franklin, is an apparatus illustrating beautifully the process of ebullition *in vacuo* at low temperatures. If two glass-balls, A and B (fig. 3), be connected by a slender tube, and one of them A be filled with water, a small opening or pipe *b* being left at the top of the other, and this be made to boil, the vapour produced by it will drive all the air out of the other, and will at last come out itself, producing steam at the mouth of the pipe. When the ball B is observed to be occupied by transparent vapour, we may conclude that the air is completely expelled. Now, shut the pipe by sticking into it a piece of tallow or wax, the vapour in B will soon condense, and there will be a vacuum. The flame of a lamp and blow-pipe being directed to the little pipe *b*, will immediately cause it to close and seal hermetically. We have now a pulse-glass. Grasp the ball A in the hollow of the hand; the heat of the hand will immediately expand the bubble of vapour which may be in it, and this vapour will drive the water into B, and then will blow up through it for a long while, keeping it in a state of violent ebullition, as long as there remains a drop or film of water in A. But care must be taken that B is all the while kept cold, that it may condense the vapour as fast as it rises through the water. Touching B with the hand, or breathing warm on it, will immediately stop the ebullition. When the water in A has thus been dissipated, grasp B in the hand; the water will be driven into A, and the ebullition will take place there as it did in B. Putting one of the balls into the mouth will make the ebullition more violent in the other, and the one in the mouth will feel very cold. This is a pretty illustration of the rapid absorption of the heat by the particles of water, which are thus converted into elastic vapour. We have seen this little toy suspended by the middle of the tube like a balance, and thus placed in the inside of a window, having two holes *a*, *b* cut in the pane, in such a situation, that, when A is full of water and preponderates, B is opposite to the hole *b*. Whenever the room became sufficiently warm, the vapour was formed in A and immediately brought the water into B, which was kept cool by the air coming into the room through the hole *b*. By this means B was made to preponderate in its turn, and A was then opposite to the hole *a*, and the process was now repeated in the opposite direction. This amusement continued as long as the room was warm enough. Instead of water, alcohol or ether may be substituted, and will act more readily.

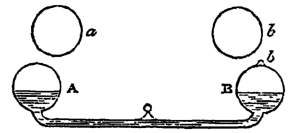

Fig. 3.

The following experiment, where ebullition is produced by the application of cold, is instructive. A Florence flask

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E (fig. 4) is about one-third full of water, and is placed over

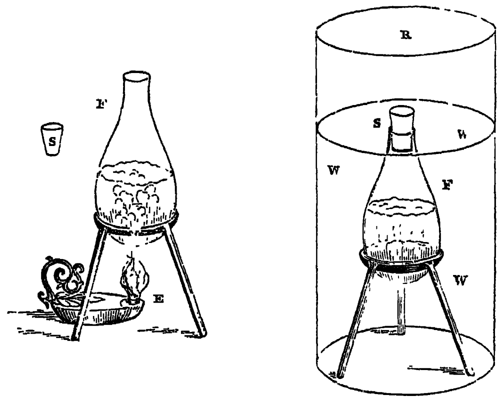

Fig. 4.

a lamp E until the water boils; and when the steam has been rising for a short time violently from the neck of the vessel, the cork S is to be applied as a stopper, and must fit with great accuracy. The flask thus closed is to be set aside for a few minutes till it have cooled considerably, and is then to be suddenly placed on a stand in the cold water W, contained in the glass reservoir R. The ebullition in the flask will recommence with a degree of violence proportioned to the coldness of the water W. The theory of this action is simple. When the flask is plunged in the cold water, two-fifths of its contents are steam: the chill water condenses it into water, it shrinks up into $\frac{1}{1642}$d part of its bulk, and would leave 1641 parts out of 1642 vacuous; but the warm water being now *in vacuo*, throws up in rapid ebullition copious volumes of vapour of its own temperature, which is, again, by coming into contact with the sides of the vessel and by directly giving off its heat to the water, chilled into water; and so in succession all the vapour thus sent up is in turn reconverted into water and the vacuum sustained, until at last, the equilibrium between the temperature of the water, within and around the flask, having been established, the interchange of caloric ceases; and even now, if the flask were plunged into freezing water, the ebullition would recommence as violently as before.

We have already noticed the fact, that, when water is confined in a close vessel, and heat is applied to it, the water will not boil even at a temperature of 212°. If heat be continually thrown into the water in this state, the particles will acquire a very high temperature; and, at the same time, the tendency of the enclosed fluid to burst the vessel will become very great. The following experiment upon this subject is one of the most interesting and the earliest of which we are in possession. It was published in 1663 by the Marquis of Worcester, and we give it in his own words:—"I have taken a piece of a whole cannon, whereof the end was burst, and filled it [with water] three-quarters full, stopping and screwing up the broken end as also the touch-hole, and making a constant fire under it; within twenty-four hours it burst, and made a great crack."

It is in virtue of the great elastic force by which water, when heated, tends to expand into many times its bulk, in the form of steam, that this element has become a mechanical mover, subject to the control of man. There are two great principles of classification upon which such machines are constructed; the one commonly called high-pressure or non-condensing steam-engines, and the other low-pressure or condensing steam-engines.

In order, however, to its successful application as a mechanical power, and its profitable use in each of the various functions which it is capable of performing, it is necessary to study its various phenomena in greater detail; to obtain an intimate acquaintance with its properties; to determine its laws in the various relations of space, time, and quantity; how much heat it requires; what fuel it consumes; what force it exerts; how fast it will move; how it will condense, expand, and contract; and what relation it bears to the fluid from which it is derived. These inquiries, and the manner in which these objects may be most satisfactorily obtained, is the subject of this article, and of the following articles on the steam-engine in its various applications.

Historical Notice of Experiments on Steam.

CHAP. II.—HISTORICAL NOTICE OF EXPERIMENTS ON THE PROPERTIES OF STEAM.

The earliest researches into the phenomena of steam, undertaken with the philosophical purpose of obtaining experimental data for the scientific investigation of its properties and relations, are to be met with in a scarce work, printed at Basle in 1769, written by Jo. Henrico Ziegler. Unhappily, he lived too remote from the scene of the philosophical discoveries of that period to adopt the precautions necessary to give value to his experiments. He allowed atmospheric air to mingle with the steam to such an extent as greatly to vitiate the results.

M. Betancourt, about the end of last century, undertook a series of experiments on the force of the vapour of water, alcohol, or other liquids, at various temperatures. His apparatus was tolerably perfect; and the precautions which he adopted for the removal of atmospheric air from intermixture with the vapour, gave his experiments considerable value and precision. Some of his experiments were made *in vacuo*; and he seems to have been one of the first philosophers who examined the production of steam at temperatures below the ordinary point of ebullition, under the pressure of the atmosphere. His experiments extend from 32° up to 279°, being 67° above the ordinary boiling point.

Of British philosophers, Dr Robison was one of the first to make accurate and systematic experiments on the phenomena of the temperature and elastic force of steam; they appear to have been made in 1778. Previously, however, Mr Watt had been led, in the course of his invention of the steam-engine, in 1764–65, to make experiments on the elastic force of steam. From the data he then obtained, he laid down a curve, in which he says, "the abscissæ represented the temperatures, and the ordinates the pressures, and thereby found the law by which they were governed, sufficiently near for my then purpose." In 1773–74, he resumed his experimental researches on the relative temperatures and pressures of saturated steam up to about 40 lb. total pressure per square inch. Having been dissatisfied with the irregularities of the results he obtained, Mr Southern and Mr Creighton, at his request, repeated his experiments in 1803, with the view of ascertaining the density of steam raised from water under different pressures above, as well as below, that of the atmosphere; they extended from a pressure of ·4 inch to 240 inches of mercury, or 8 atmospheres.

Dr Dalton appears to have been the first to escape from the natural enough error of assuming that the vapour of water at 32° Fahr., the freezing point, would be represented by 0. This apparatus was the most simple and refined of any that had been employed for temperatures below 212°, and his experiments continued for many years to possess the greatest authority. His experiments were first published in 1793; and afterwards, when more extended, in 1802. Dr Ure, in 1817, and subsequently Mr Philip Taylor, and Professor Arsberger, of Vienna, made experiments on high pressure steam through an extensive range of temperatures.

In 1823, the government of France having resolved to

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legislate on the means for obtaining security in the use of steam-engines, consulted the Academy of Sciences upon the mode of most effectually promoting the public safety, without placing useless restrictions on commercial enterprise and manufacturing industry. The examination into the state of knowledge concerning the phenomena of vapour at elevated temperatures, which resulted from this application, having brought the imperfections of this part of science prominently into notice, the Academy were induced to undertake a long and laborious inquiry, not entirely free from personal danger, into the law connecting temperature with the pressure of steam. The commission consisted of the illustrious members of the Academy, Baron de Prony, Arago, Girard, and Dulong; and the results of their investigations, finished in 1829, were published in the *Memoirs of the Academy of Sciences* in 1831. The experiments were conducted principally by MM. Arago and Dulong, and on a scale of magnitude and expense suited to the munificence of the French government and the resources of the Academy; they were carried as high as to 24 atmospheres of pressure, or about 360 lb. per square inch.

Towards the end of 1830, a committee of the Franklin Institute, of the State of Pennsylvania, United States, was appointed to examine into the causes of the explosion of steam-boilers, and to devise the most effectual means of preventing the accidents. The committee experimented on the elastic force and temperature of steam, at pressures varying from 1½ to 10 atmospheres.

In 1844, Professor Gustav Magnus published, in Poggendorf's *Annalen*, No. 2, a memoir on the expansive force of steam, in which he notices the defects in former methods, arising from the difficulty of determining with accuracy the true temperature of the vapour, and also the correct pressure, owing to the unequal heating and consequent partial expansion of the mercurial column; and explains the method he adopted to obviate these difficulties.

In July 1844, M. V. Regnault published his very valuable memoir on the *Elastic Force of Aqueous Vapour*, in the *Annales de Chimie et de Physique*, and since, more fully, in the *Memoirs* of the Institute, in 1847. "To establish a physical fact," says this ingenious and accurate physicist, "we must not confine ourselves to a single method of investigation. It is necessary to employ various methods, and even to repeat those made use of by former experimenters, unless they are absolutely faulty; and we must show that all, when used with proper precaution, conduct to the same result; or, if this be not the case, we must point out by direct experiment the cause of error in the defective methods." Acting on this principle, M. Regnault repeated the methods of Dalton, Ure, Magnus, Dulong, and Arago, with such modifications as the improved state of experimental science, and his own skill and experience suggested; and he has pointed out the defects under which they labour, and the limits within which their results may be relied on.

Mr Dalton's method may be described as consisting essentially in determining the heights of the mercurial column in two barometer tubes, the chamber of one being occupied with vapour and the other being a vacuum. In this method the temperature of the vapour is determined by that of a water-bath surrounding the chamber, and either the whole or a part of the mercurial column is maintained by the same means at the same temperature. M. Biot has remarked, that the chief defect in this method arises from the fact, that it is impossible to maintain the water surrounding the tubes at a constant temperature through all its depth, if this depth is considerable, and its temperature differs much from that of the surrounding medium. Mr Ure attempted to remedy this defect by limiting the space occupied by the vapour, and thus reducing the depth of the bath, and in this respect, certainly, his modification of Mr Dalton's method was a decided improvement. M. Regnault has shown that, if the whole of the tubes be surrounded by water, for the purpose of maintaining the columns at the same known temperature, Mr Dalton's method is capable of giving accurate results between the limits + 10° C., and + 30° C., provided the water be incessantly and rapidly agitated, the agitation being merely interrupted for a moment to observe the heights of the mercurial column. Above the higher limit, however, the separation of the liquid into strata of unequal temperature commences the instant the agitation ceases, and the observations are accordingly rendered uncertain. The following account of the apparatus and method of experiment adopted by Regnault, is derived from Dixon's *Treatise on Heat.*

Where it was intended only to raise the chambers and a part of the mercurial column to the temperature of the vapour, M. Regnault made use of the following form of apparatus:—Two barometers B, B, as similar as possible, of about 14 millimetres internal diameter, are arranged, side by side, on a frame (fig. 5). These barometers pass

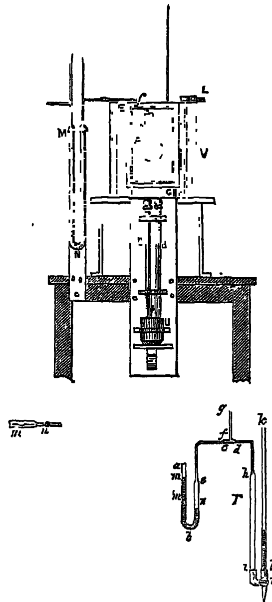

Fig. 5.

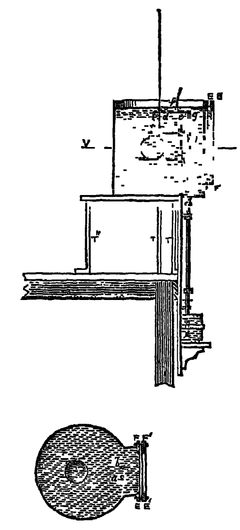

Fig. 6.

through two tubular openings in the bottom of a vessel V of galvanized sheet-iron, and are secured by means of caoutchouc collars. The vessel V, shown in section and plan in fig. 6, has, on one side, a rectangular aperture, round which is fixed an iron frame. A plate of glass, with perfectly parallel faces, is secured to this frame by means of a similar frame attached to the former by screws. A slip of caoutchouc, of the form of the contour of the aperture, is placed between the glass and the frame, and renders the joint perfectly water-tight. The two barometers are plunged in the same reservoir U. The capacity of the vessel is about 45 litres. This vessel is filled with water, which is continually agitated, and its temperature is given by a very sensitive mercurial thermometer immersed in it, which is observed by means of a small horizontal telescope L. The height of the column in the barometer is read off by means of a kathetometer, the agitation of the water being stopped for an instant at the time of the observation of each column. Observations are made with great precision at the temperature of the surrounding air; to observe the force at higher temperature, a small quantity of water is removed from the vessel by means of a syphon, and replaced with a corresponding quantity of hot-water. A spirit-lamp is then placed under the vessel, and its distance from

it, as well as the height of its wick, is so arranged that the temperature of the water, which is still kept in a state of brisk agitation, finally becomes constant. This condition is easily obtained after some trials, and if the temperature does not surpass 50° C., it may be maintained stationary and uniform for any length of time, provided only that the agitation of the water is brisk and constant. Three or four observations were made every time that the temperature was rendered stationary, an interval of eight or ten minutes being left between each. In this method of operating, the portions of the columns outside the vessel are in circumstances completely identical, and the difference of height of the portions within, which are at the temperature of the bath, being reduced to 0°, measures exactly the tension of the vapour, allowance, of course, being made for the pressure of the film of water. It is unnecessary to point out how much more accurate this method of ascertaining the temperature corresponding to observed forces is, than either M. Betancourt's or Mr Dalton's.

A second series of experiments M. Regnault made with the following apparatus:—A balloon A (figs. 5 and 6), whose capacity equals 500 cubic centimeters, contains a little glass vessel full of water recently boiled. The balloon is soldered to a curved tube, cemented into a tubular piece of copper, with three branches, *d*, *e*, *f*. In the branch *e* is cemented a tube soldered to the upper part of the barometer *h*; and in the branch *f* a tube, communicating with an air-pump, by means of the desiccating apparatus MN, filled with powdered pumice, steeped in sulphuric acid. The tube O is a perfect barometer as before. The apparatus being arranged, as in the figures, a vacuum was made forty or fifty times successively; and each time the air slowly readmitted; by this means the interior of the balloon and barometric chamber was completely dried. The vacuum was then finally made as perfectly as possible, and the tube *f* sealed by a blow-pipe. At first M. Regnault was unable to reduce the vacuum below two millimetres, but his air-pump having been cleaned, he subsequently succeeded in bringing it below one millimetre. The balloon was then surrounded with melting ice, and the difference of the columns in the two tubes gave the elastic force at 0° of the remaining air. The ice having been removed, the vessel V was filled with water, and its temperature being sufficiently raised, the little glass vessel was burst by the expansion of the water it contained, and the balloon and chamber filled with aqueous vapour, whose force at the corresponding temperatures was observed as before.

This method answers very well for temperatures below that of the surrounding medium, and for 10° or 15° C. above it; it also answers for determining the force of aqueous vapours in air of any density within those limits of temperature.

Those two forms of apparatus do not answer for tensions above 200 millimetres; beyond this force M. Regnault employed the following, which in principle is similar to Professor Magnus's, and which he also employed in the case of liquids more volatile than water.

A syphon-shaped tube *a b e* (fig. 5), of about 15 millimetres internal diameter, terminates in a fine curved tube *c e*. The closed branch *a b* is filled with mercury, which is carefully boiled to expel all air and moisture. When the mercury is cool, a small quantity of volatile liquid is introduced into the branch *b e*, and boiled for some minutes; the tube is then inclined, and a little of the liquid, yet hot, is passed up into the branch *a b*; the branch *b e* is then completely dried. The tube is now fixed in a perfectly vertical position in the vessel V, in front of the glass-plate. The tube *c e* is cemented into one branch of a piece of copper *c d f*, whose other branches communicate, one *d*, with a manometric apparatus with a stop-cock *r*, and the other *f* with an air-pump, if necessary. The tubes *h i*, *k l*, are first completely filled with mercury, the air being expelled through *f g*; the tube *f g* is then closed with the blow-pipe and a portion of the mercury being allowed to flow out through the stop-cock *r*, the pressure of the air in the branch *n e c* is so far diminished as ultimately to become nearly equal to the pressure of the vapour in *a m*, when the mercury in the two branches of the syphon-shaped tube falls nearly to the same level. The force of the vapour is then measured by the atmospheric pressure, diminished by the column *r s* in the manometer, and the column *m n* in the tube *a b*, both these columns, whose temperatures are known, being reduced to their heights at 0°. The temperature of the vapour is ascertained as in the preceding experiment.

None of the foregoing methods answer for temperatures above 60° or 70° C. At higher degrees the water in the vessel V separates so promptly into strata of different temperatures as to require constant agitation to prevent this result from taking place. For temperatures above 100° C., moreover, those methods become impracticable from other causes. For higher degrees, therefore, M. Regnault had recourse to the well-known method employed by Mr Dalton, and other physicists subsequently, of ascertaining the temperature of the vapour of water boiling under determined pressures.

In order to obtain results of the degree of accuracy which this method is capable of giving, it is necessary to boil the water in a vessel communicating freely with a space of tolerable capacity, in which we can dilate or condense at will; and by this means form an artificial atmosphere, which exerts a determined pressure on the surface of the heated liquid. We thus obtain a temperature of ebullition as perfectly stationary as that of water boiling in free air, and we can maintain this temperature stationary as long as we will. The apparatus employed for this purpose by M. Regnault is represented in fig. 7. It consists of a

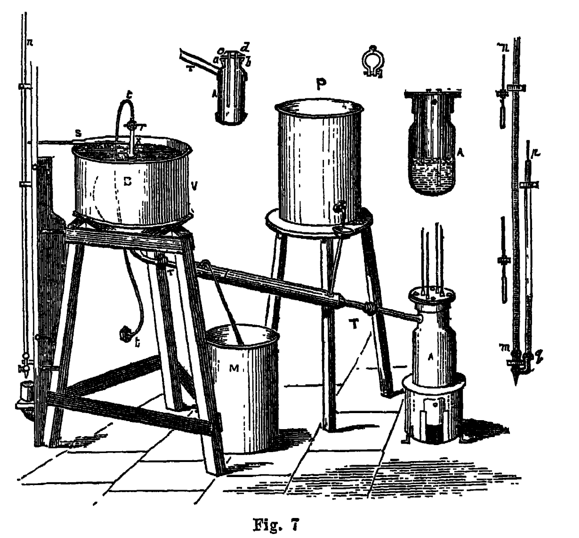

Fig. 7

retort of red copper A, closed with a cover. This cover carries four iron tubes closed below; of these, two descend to the bottom of the retort, the others only reach half-way down. These tubes, which are 7 millimetres in internal diameter, and about 1 millimetre thick, are surrounded by a case of very thin copper attached to the cover, and having apertures in its upper part. They are filled with mercury to within a few centimetres of their upper edge, and hold four mercurial thermometers, whose bulbs descend to the bottom of the tubes. From the arrangement of the tubes, it appears that two of the thermometers are plunged in vapour and two in water, as shown in section. The neck of the retort is connected with a tube TT′, about 1 metre

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in length, surrounded by a copper cylinder, through which flows a constant current of cold water, supplied by a reservoir P. This tube communicates with a copper balloon B of about 24 litres in capacity, contained in a vessel V full of water at the temperature of the surrounding medium. To the balloon is attached a pipe, with two branches, one of which is cemented to the tube *e g h* of the apparatus represented in fig. 6, when the experiments are made at pressures inferior to that of the atmosphere, or with the tube *p q* of the apparatus in fig. 7, for greater pressures. The second branch is connected by means of a lead tube *t t*, with an exhausting or condensing air-pump.

For pressures inferior to the atmospheric, the air in the balloon having been rarefied, the water in the retort is heated until ebullition commences. The vapour, according as it forms, is condensed in the refrigerator TT′, and falls back into the retort. The pressure is measured by the difference of heights of the mercury in the barometric tubes. It may be remarked that the column in the barometric tube connected with the balloon, is never absolutely stationary; the amplitude of its oscillations, however, when the fire is properly regulated, is very small, not exceeding one-tenth of a millimetre. The mercury in the barometer *o*, on the other hand, remains perfectly stationary. The difference of the heights of these columns is observed by means of a kathetometer; and an assistant, at the same instant, notes the height of the thermometers. Several observations were made, at intervals of eight or ten minutes, under the same pressure; and it was thus easy to perceive the perfect constancy of the temperatures indicated by the thermometer for the same pressure, and to show that the least change in the latter was followed by a corresponding change in the former.

The height of the kathetometers not exceeding one metre, when greater differences of level in the apparatus required to be measured, it was necessary to employ two of them. In order to ascertain if the divisions of the scales of the two instruments were identical, M. Regnault read off the divisions of one, in lengths of centimetres, by means of the other; and such was the accuracy of their graduation, that he, in no case, encountered a difference of more than one-twentieth of a millimetre. To attain such a degree of precision in the measures, it is evident that the instruments must be constructed with the greatest accuracy; the telescopes must not have too great a focal length ($0^{m}.30$), and the levels, in particular, must possess extreme sensibility. Those in the kathetometers constructed by M. Gambey indicated inclinations of one second. The verniers gave directly one-fiftieth of a millimetre, and easily admitted of the estimation of one-hundredth.

The thermometers, says M. Regnault, employed in the experiments, made at pressures inferior to the atmospheric, ranged from 0° to 100° C.; they had from six to eight divisions in 1° C.; it was, consequently, easy to read with certainty the one-sixtieth of a degree. Those employed for higher pressures had a range from 0° to 240°, and 1° C. contained 2·5 or three divisions of their scale. All these instruments were graduated and verified with the greatest care. In estimating the temperature from the indication of the thermometers, a correction required to be made for the portion of mercury in the stem unassimilated in the temperature. The temperature of this portion was ascertained by means of a sensitive mercurial thermometer suspended between the four stems. It may be remarked, that the temperature indicated by the thermometer in the liquid was always higher, at low temperatures, than that indicated by those in the vapour; the difference in some cases amounted to 0°·7. As the pressure approached the atmospheric, this difference became less, and, at high temperatures, was quite insensible.

The method by which M. Regnault investigated the force of vapours at high temperatures was similar to that last described; and the apparatus which he employed for this purpose differed from the preceding merely in the size and strength of the parts. The boiler was made of copper, about 5 millimetres thick, and had a total capacity of 70 litres. The reservoir B forming the artificial atmosphere was also of copper, 13 millimetres thick, and contained about 280 litres. The manometer destined to measure the pressure of the artificial atmosphere, and thus of the vapour in the boiler, consisted of a tube, or rather a series of tubes, placed vertically over one another, and attached to the walls of the building in the vicinity of which the experiments were performed, and continued along a strong pole or mast firmly secured to the top of the wall. This system of tubes was open above, and contained the column of mercury, which measured the tension in B. Its total height was 24 metres, and it was accordingly able to measure a pressure of 30 atmospheres.

The experiments were conducted as follows:—The water in the boiler having been raised nearly to its boiling point, the air in the reservoir B was compressed, until it had reached the pressure under which it was desired to make the experiment. A column of mercury of the corresponding height was next forced up the manometer from below by means of a force-pump, and connection was then made between the manometer and the reservoir. Meanwhile, the temperature of the water in A was rising, and continued to increase until it reached its boiling point under the pressure to which it was exposed. It was then kept in a state of ebullition for at least half an hour, and no observation was made until it was ascertained that the mercurial thermometers connected with the boiler were perfectly stationary. The temperatures indicated by these thermometers were then observed, and also the indications of an air thermometer, which, to insure greater accuracy, was employed in addition to the former. At the same time, the difference of level of the mercury in the branches of the manometer was noted. M. Regnault's experiments with this apparatus extended to a pressure of about 28 atmospheres, corresponding to a temperature of 230°·56 C. measured on the air thermometer.

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CHAP. III.—THE MECHANICAL THEORY OF HEAT.

An important and interesting inquiry relative to steam and its operation in the steam-engine, is that which traces the connection between the heat expended and the dynamical effect, or work, produced. The method of separate condensation, and the application of the force of expanding steam, changed to an important extent the accepted relations of heat to power, and added remarkably to the dynamical effect of the fuel; and though the steam-engine has been progressively improved by the continual elaboration of small economies, there is yet good reason to believe that the field of improvement is wide, and that the labourer in that field has the prospect of a good return. The inquiries of scientific men on the subject of the relation of heat to mechanical effect, have resulted in the establishment of the principle that heat and mechanical force are identical and convertible, and that the action of a given quantity of heat may be represented by a constant quantity of mechanical work performed. "Motion and force," says Professor Rankine, "being the only phenomena of which we thoroughly and exactly know the laws, and mechanics the only complete physical science, it has been the constant endeavour of natural philosophers, by conceiving the other phenomena of nature as modifications of motion and force, to reduce the other physical sciences to branches of mechanics. Newton expresses a wish for the extension of this kind of investigation. The theory of radiant heat and light having been reduced to a branch of mechanics by means of the hypo-

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thesis of undulations, it is the object of the hypothesis of molecular vortices"—oscillation or vibratory motion—" to reduce the theory of thermometric heat, and elasticity also, to a branch of mechanics, by so conceiving the molecular structure of matter that the laws of these phenomena shall be the consequences of those of motion and force. This hypothesis, like all others, is neither demonstrably true nor demonstrably false, but merely probable in proportion to the extent of the class of facts with which its consequences agree." It must, however, be remarked that, whether the hypothesis of molecular motion be probable or improbable, the theoretical and practical results arrived at in regard to the mechanical action of heat remain unaffected, being deduced from principles which have been established by experiment and demonstration. From these principles, Professor Rankine announced the specific heat of air before it was otherwise known,—the accuracy of his deductions having since been verified to within less than 1 per cent. by the experiments of Regnault. The best experiments, previous to those made by Regnault, in regard to the specific heat of air, were those of Delaroche and Berard, from which they deduced a specific heat of ·266; but, arguing from the mechanical theory of heat, Professor Rankine declared that this value must be erroneous, and that the specific heat of air could not exceed ·240. It has been found accordingly, by Regnault, since the statement was made, as the result of a hundred experiments, that the specific heat of air was ·238, and that it is constant for all pressures from one to ten atmospheres, or at least differs almost inappreciably. This coincidence of theoretical prediction with experimental evidence, it has been well observed, should have something like the same tendency in strengthening our belief of the theory upon which Professor Rankine's estimate was based, as the discovery of an unknown planet, previously indicated by Le Verrier and Adams, had in confirming our faith in the science of astronomy.

The principle of the dynamical or mechanical theory of heat, as already stated, is that, independently of the medium through which heat may be developed into mechanical action, the same quantity of heat converted is invariably resolved into the same total quantity of mechanical action. For the exact expression of this relation, of course, units of measure are established:—in terms of the English foot, as the measure of space; the pound avoirdupois, as the measure of weight, pressure, elasticity; and the degree of Fahrenheit's scale, as the measure of temperature and heat. Work done consists of the exertion of pressure through space, and the English unit of work is the exertion of 1 lb. of pressure through 1 foot, or the raising of 1 lb. weight through a vertical height of 1 foot: briefly, a foot-pound. The unit of heat is that which raises the temperature of 1 lb. of ordinary cold water by 1 degree Fahr. If 2 lb. of water be raised 1 degree, or 1 lb. be raised 2 degrees in temperature, the expenditure of heat is, equally in both cases, two units of heat. Similarly, if 1 lb. weight be raised through 1 foot, or 2 lb. weight be raised through 2 feet, the power expended, or work done, is equally in both cases two units of work, or two foot-pounds. From these definitions, then, the comparison lies between the unit of heat, on the one part, and the unit of work, or the foot-pound, on the other.

M. Clapeyron, in his treatise on the moving power of heat, and M. Noltzman, of Manheim, in 1845, who availed himself of the labours of M. Clapeyron and M. Carnot in the same field, grounding their investigations on the received laws of Boyle, or Marriotte, and Gay Lussac, which express the observed relations of heat, elasticity, and volume, in steam and other gaseous matter, concluded that the unit of heat was capable of raising a weight, between the limits of 626 lb. and 782 lb., 1 foot high; that is to say, that one unit of heat was equivalent to from 626 to 782 foot-pounds. By this mode of investigation, they suppose a given weight of steam, or gaseous matter, to be contained in a vertical cylinder formed of non-conducting material, in which is fitted an air-tight but freely-moving piston, which is pressed downwards by a weight equal to the elasticity of the gas. Now, the weight, initial temperature, pressure, and volume being known, a definite quantity of heat from without is supposed to be imparted to the vapour; and the result is partly an elevation of the temperature of the vapour, and partly a dilation or increase of volume, or, in other words, an exertion of pressure through space—the elasticity remaining the same. But the result may be represented entirely by dilation, so that there shall not be any final alteration of temperature; and for this purpose, it is only necessary to allow the vapour to dilate without any loss of its original or imparted heat until it re-acquires its initial temperature. In this case, the ultimate effect is purely dilatation, or motion against pressure; and the work done is represented by the product of that pressure into the space moved through.

Mr Joule, of Manchester, in 1843–47, proceeded, by entirely different, independent, and, in fact, purely experimental methods, to investigate the relation of heat and work:—1*st*, By observing the calorific effects of magneto-electricity. He caused to revolve a small compound electro-magnet, immersed in a glass vessel containing water, between the poles of a powerful magnet: heat was proved to be excited by the machine, by the change of temperature in the water surrounding it, and its mechanical effect was measured by the motion of such weights as by their descent were sufficient to keep the machine in motion at any assigned velocity. 2*d*, By observing the changes of temperature produced by the rarefaction and condensation of air. In this case, the mechanical force producing compression being known, the heat excited was measured by observing the changes of temperature of the water in which the condensing apparatus was immersed. 3*d*, By observing the heat evolved by the friction of fluids:—a brass paddle-wheel, in a copper can containing the fluid, was made to revolve by descending weights. Sperm oil and water yielded the same results. Mr Joule considered the third method the most likely to afford accurate results; and he arrived at the conclusion that one unit of heat was capable of raising 772 lb. 1 foot in height; or, that the mechanical equivalent of heat was expressible by 772 foot-pounds for 1 unit of heat,—known as "Joule's equivalent."

The following are the values of Joule's equivalent for different thermometric scales, and in English and French units:—

1 English thermal unit, or 1 degree of Fahrenheit in 1 pound of water	772 foot-pounds.
1 centigrade degree in 1 pound of water......... (or nearly 1390).	1389·6 „
1 French thermal unit, or 1 centigrade degree in a kilogramme of water	423·55 kilogram-metres.

The mechanical theory of heat rests upon a wide basis, and proofs in verification of the theory are constantly accumulating. When the weight of any liquid whatever is known, with the comparative weight of its vapour at different pressures, the latent heat at the different pressures is readily estimated from the theory; and this method of estimation agrees with the best experimental results, as may afterwards be shown; and when the latent heat is also known, the specific heat of the liquid can be determined by means of the same theory: in other words, the quantity of work, in foot-pounds, may be determined, which would, by agitating the liquid or by friction, be required to raise the temperature of any given quantity of the liquid by, say, one degree, altogether independently of Joule's experiments. The theory enables us to discover the utmost power it is possible to realize from the combination of any given weight of carbon and oxygen, or other elementary substances, with

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nearly as much precision as we can estimate the utmost quantity of work it is possible to obtain from a known weight of water falling through a given height. It is not difficult to comprehend, then, that the theory of the mechanical equivalent of heat proves of great practical utility.

According to the mechanical theory of heat, in its general form, heat, mechanical force, electricity, chemical affinity, light, sound, are but different manifestations of motion. Dulong and Gay Lussac proved, by their experiments on sound, that the greater the specific heat of a gas, the more rapid are its atomic vibrations. Elevation of temperature does not alter the rapidity, but increases the length of their vibrations, and in consequence produces "expansion" of the body. All gases and vapours are assumed to consist of numerous small atoms, moving or vibrating in all directions with great rapidity; but the average velocity of these vibrations can be estimated when the pressure and weight of any given volume of the gas is known, pressure being, as explained by Joule, the impact of those numerous small atoms striking in all directions, and against the sides of the vessel containing the gas. The greater the number of these atoms, or the greater their aggregate weight, in a given space, and the higher the velocity, the greater is the pressure. A double weight of a perfect gas, when confined in the same space, and vibrating with the same velocity—that is, having the same temperature—gives a double pressure; but the same weight of gas, confined in the same space, will, when the atoms vibrate with a double velocity, give a quadruple pressure. An increase or decrease of temperature is simply an increase or decrease of molecular motion. The truth of this hypothesis is very well established, as already intimated, by the numerous experimental facts with which it is in harmony.

When a gas is confined in a cylinder under a piston, so long as no motion is given to the piston, the atoms, in striking, will rebound from the piston after impact with the same velocity with which they approached it, and no motion will be lost by the atoms. But when the piston yields to the pressure, the atoms will not rebound from it with the same velocity with which they strike, but will return after each succeeding blow, with a velocity continually decreasing as the piston continues to recede, and the length of the vibrations will be diminished. The motion gained by the piston will, it is obvious, be precisely equivalent to the energy, heat, or molecular motion lost by the atoms of the gas. Vibratory motion, or heat, being converted into its equivalent of onward motion, or dynamical effect, the conversion of heat into power, or of power into heat, is thus simply a transference of motion; and it would be as reasonable to expect one billiard-ball to strike and give motion to another without losing any of its own motion, as to suppose that the piston of a steam-engine can be set in motion without a corresponding quantity of energy being lost by some other body.

In expanding air spontaneously to a double volume, delivering it, say into a vacuous space, it has been proved repeatedly that the air does not fall appreciably in temperature, no external work being performed; but, on the contrary, if the air, at a temperature, say of 230° Fahr., be expanded under pressure or resistance, as against the piston of a cylinder, giving motion to it, raising a weight, or otherwise doing work, by giving motion to some other body, the temperature will fall nearly 170° when the volume is doubled, that is, from 230° to about 60°; and, taking the initial pressure at 40 lb., the final pressure would be 15 lb. per square inch.

When a pound weight of air, in expanding, at any temperature or pressure, raises 130 lb. 1 foot high, it loses 1° in temperature; in other words, this pound of air would lose as much molecular energy as would equal the energy acquired by a weight of 1 lb. falling through a height of 130 feet. It must, however, be remarked, that but a small portion of this work, 130 foot-pounds, can be had as available work, as the heat which disappears does not depend on the amount of work or duty realised, but upon the total of the opposing forces, including all resistance from any external source whatever. When air is compressed, the atmosphere descends and follows the piston, assisting in the operation with its whole weight; and when air is expanded, the motion of the piston is, on the contrary, opposed by the whole weight of the atmosphere, which is again elevated. Although, therefore, in expanding air, the heat which disappears is in proportion to the total opposing force, it is much in excess of what can be rendered available; and, commonly, where air is compressed, the heat generated is much greater than that which is due to the work which is required to be expended, the weight of the atmosphere assisting in the operation.

Let a pound of water, at a temperature of 212° Fahr., be injected into a vacuous space or vessel, having 26·36 cubic feet of capacity—the volume of 1 pound of saturated steam at that temperature—and let it be evaporated into such steam, then 893·8 units of heat would be expended in the process. But, if a second pound of water, at 212°, be injected and evaporated at the same temperature, under a uniform pressure of 14·7 lb. per square inch due, to the temperature, the second pound must dislodge the first, by repelling that pressure, involving an amount of labour equal to 55,800 foot-pounds (that is, 14·7 lb. × 144 square inches × 26·36 cubic feet), and an additional expenditure of 72·3 units of heat (that is, 55,800 ÷ 772), making a total for the second pound of 965·1 units.

Similarly, when 1408 units of heat are expended in raising the temperature of air at constant pressure, 1000 of these units increase the velocity of the molecules, or produce a sensible increment of temperature; while the remaining 408 parts which disappear as the air expands, are directly expended in repelling the external pressure.

Again, if steam be permitted to flow from a boiler into a comparatively vacuous space, without giving motion to another body, the temperature of the steam entering this space would rise much higher than that of the steam in the boiler. Or, suppose two vessels, side by side, one of them vacuous, and the other filled with air at, say two atmospheres, a communication being opened between the vessels, the pressure would become equal in the two vessels; but the temperature would fall in one vessel and rise in the other; and although the air is expanded in this manner to a double volume, there would not on the whole be any appreciable loss of heat, for if the separate portions of air be mixed together, the resulting average temperature of the whole would be very nearly the same as at first. It has been proved experimentally, corroborative of this argument, that the quantity of heat required to raise the temperature of a given weight of air, to a given extent, was the same, irrespective of the density or volume of the air. Regnault and Joule found that, to raise the temperature of a pound weight of air, 1 cubic foot in volume, or 10 cubic feet, the same quantity of heat was expended.

In rising against the force of gravity, steam becomes colder, and partially condenses while ascending, in the effort of overcoming the resistance of gravity, by the conversion of heat into water. For instance, a column of steam weighing, on a square inch of base, 250·3 lb., that is, a pressure of 250·3 lb. per square inch, would, at a height of 275,000 feet, be reduced to a pressure of 1 lb. per square inch, and, in ascending to this height, the temperature would fall from 401° to 102° Fahr., while, at the same time, nearly 25 per cent. of the whole vapour would be precipitated in the form of water, if not supplied with heat while ascending.

If a body of compressed air be allowed to rush freely into the atmosphere, the temperature falls in the rapid part of the current, by the conversion of heat into motion, but the heat is almost all reproduced when the motion is quite subsided; and from recent experiments, it appears that nearly similar results are obtained from the emission of steam under pressure.

When water falls through a gaseous atmosphere, its motion is constantly retarded as it is brought into collision with the particles of that atmosphere; and by this collision it is partly heated and partly converted into vapour.

If a body of water descends freely through a height of 772 feet, it acquires from gravity a velocity of 223 feet per second; and if suddenly brought to rest when moving with this velocity, it would be violently agitated, and raised one degree in temperature. But suppose a water-wheel, 772 feet in diameter, into the buckets of which the water is quietly dropped, when the water descends to the foot of the fall, and is delivered gently into the tail-race, it is not sensibly heated. The greatest amount of work it is possible to obtain from water falling from one level to another lower level, is expressible by the weight of water multiplied by the height of the fall.

The objects of these illustrative exhibitions of the nature and reciprocal action of heat and motive power, with their relations, are,—first, to familiarise the reader with the doctrine of the mechanical equivalence of heat; second, to show that the nature and extent of the change of temperature of a gas while expanding, depends nearly altogether upon the circumstances under which the change of volume takes place.

CHAP. IV.—GENERAL RELATIONS OF GASEOUS BODIES.

Gases are divided into the two classes,—permanent gases, and vapours. The former were originally so called, under the impression that they existed permanently in the gaseous state, and could not possibly be reduced to the liquid form; while those which could be so reduced, and could be reconverted to the state of gas, were called vapours. It has, however, been shown by Sir Humphrey Davy and Mr Faraday, that by the conjoined effects of great pressure, and of a high degree of cold, most of the permanent gases may be liquefied. The under-mentioned still retained the gaseous state at the annexed temperatures and pressures:—

Hydrogen..........	at	−166° Fahr.	and	27	atmospheres.
Oxygen............	„	−166	„	27	„
Do................	„	−140	„	58·5	„
Nitrogen..........	„	−166	„	50	„
Nitric Oxide......	„	−166	„	50	„
Carbonic Oxide....	„	−166	„	40	„
Coal-gas..........	„	−166	„	32	„

Several of the liquefied gases are further capable of being reduced to the solid state. Thus, sulphurous acid becomes solidified at −105°; sulphuretted hydrogen at −122°; carbonic acid at −72°; ammonia at −103°. The difference, then, between the permanent gases and vapours, is merely one of degree, and depends upon the temperature at which the change from the fluid to the gaseous state occurs. Those which exist in the fluid state under ordinary temperatures and pressures are called vapours; those which require strong pressure and extremely low temperatures to reduce them to the liquid form, are called permanent gases.

Steam, as the elastic vapour of water, is amenable to the laws of gaseous fluids; and, according to these laws, the pressure, the density or the volume, and the temperature, bear fixed relations to each other. The influence of temperature on the expansion of permanent gases under constant pressures is such, that, for equal increments of temperature, the increments of volume by expansion are also equal, and they are nearly the same for different gases. The expansion of air by increase of temperature may be assumed to represent that of other gases; and, it may be added, the most exact measure of real temperature is to be found in the expansion of air, or any other perfect gas. By real or absolute temperature is signified the measure of the whole of the heat of a body; and at the absolute zero point of the scale, all gases would cease to have elasticity or molecular motion. As the expansion of air under constant pressure is found experimentally to be uniform for uniform increments of temperature, it is inferred, conversely, that it would contract uniformly, under uniform reduction of temperature, until, on arriving at a temperature 461° below zero of Fahrenheit's scale, or, exactly −461·2°, the air would be in a state of collapse, without appreciable elasticity. This point has, therefore, been adopted as that of absolute zero, standing at the foot of the natural scale of temperature. For example, let a volume of air, 673 cubic inches in bulk, at a temperature of 212° Fahr., be confined at a constant pressure in a cylinder, under a piston movable without friction. If the gas be cooled 10°, the piston will descend through 10 cubic inches; if cooled 100°, the piston will descend, and the air will contract, through 100 cubic inches; and so on, in the same ratio; so that, by lowering the temperature 673°, the air would not possess appreciable volume; and $673 - 212 = 461°$ below the artificial zero of Fahr., would, therefore, be arrived at as the point of absolute zero.

Again, if a given weight of air at 0° Fahr. be raised in temperature to 461° under a constant pressure, its volume will be doubled by expansion; and, if heated to $461 \times 2 =$ 922°, its volume will be trebled; in short, for every increment of one degree of temperature, its volume will be enlarged by equal increments uniformly $\frac{1}{461}$ part of the volume at 0°.

The following, then, are the established relations of the properties of permanent gases:—

With a constant temperature, the pressure varies simply as the density, or inversely as the volume. This is known as Boyle's or Marriotte's law.

With a constant pressure, expansion is uniform under a uniform accession of heat or rise of temperature, at the rate of $\frac{1}{461}$ part of the volume at 0° Fahr. for each degree of heat. If, then, 461° be added to the indicated temperature by Fahrenheit's scale, the sum, or absolute temperature, varies directly as the total volume, expanding or contracting, and inversely as the density. This is known as the law of Gay Lussac.

With a constant volume, or density, the increase of pressure is uniformly at the rate of $\frac{1}{461}$ part of the pressure at 0° Fahr. for each degree of temperature acquired. Adding 461° to the indicated temperature, the sum, or absolute temperature, varies directly as the total pressure.

In brief, 1*st*, the pressure varies inversely as the volume when the temperature is constant; 2*d*, the volume varies as the absolute temperature when the pressure is constant; 3*d*, the pressure varies as the absolute temperature when the volume is constant.

The foregoing enunciation of the relations of temperature, pressure, and density, should be qualified by the remark, that the more easily condensible gases, as they approach the liquefying point, become sensibly more compressible than air; and that they do not strictly conform to the relations of pressure and volume belonging to the permanent gases. It has been found that, as far as 100 atmospheres, oxygen, nitrogen, hydrogen, nitric oxide, and carbonic oxide, follow the same law of compression as atmospheric air, these being amongst the incondensible gases; and that sulphurous acid, ammoniac gas, carbonic acid, and protoxide of nitrogen—proved to be condensible—commence to be sensibly more compressible than air when they have been reduced to one-third or one-fourth of their

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original volume. Carbonic acid, for example, in place of following the simple ratio of the pressure and density for a constant temperature, increased in density in a greater ratio than the pressure, as indicated in the following table, showing, in the third column, the volume of carbonic acid and increasing pressures relative to that of air, which is expressed by unity:—

Table of the Compressibility of Carbonic Acid, as referred to Air. Temperature, 10° Centig., or 50° Fahr.

Pressures.	Theoretic Volumes.	Compressibility of Carbonic Acid.
Atmospheres.		Air=1·000
1	1000	1·000
2	500	1·000
4	250	1·000
5	200	·989
6·67	150	·980
10	100	·965
15·38	65	·934
20	50	·919
25	40	·880
33·3	30	·808
40	25	·739
45	...	liquefied.

The deviations from unity in the last column express the deviations from the law of Boyle, as applicable to dry air at a constant temperature; and they show that, under a pressure of 40 atmospheres, carbonic acid, near the condensing point, occupied rather less than three-fourths of the volume which would have been occupied by air under the same circumstances. This accelerated density, or incipient condensation, characteristic of carbonic acid and other condensible gases, in approaching the point of liquefaction, foretells the approaching change. It is, nevertheless, established that all gases, at some distance from the point of maximum density for the pressure, do virtually follow the law of Boyle, according to which the pressure and the density vary directly as each other when the temperature is constant; and, on such conditions, they rank as perfect gases.

CHAP. V.—GENERAL RELATIONS OF ORDINARY OR SATURATED STEAM.

The accelerated reduction of volume and increase of density, observable in the condensible gases, as they approach their condensing points, hold likewise with steam. Steam produced in an ordinary boiler, over water, is generated at its maximum density and pressure for the temperature, whatever this may be. In this condition of maximum density, steam is said to be saturated, being incapable of vaporizing or absorbing more water into its substance, or increasing its pressure, so long as the temperature remains the same. Nor, on the contrary, will steam be generated with less than the maximum constituent quantity of water which it is capable of appropriating from the liquid out of which it ascends. It stands both at the condensing point and at the generating point; so that a change in any one of the three elements of pressure, density, or temperature, is necessarily accompanied by a change of the two others. One density, one pressure, and one temperature, unalterably occur in conjunction: the same density is invariably accompanied by the same pressure and temperature.

If a part of the heat of saturated steam be withdrawn, the pressure will fall, and also the density, by the precipitation of a part of the steam in the liquid form.

If, while the temperature remains constant, the volume of steam over water be increased, then, as long as there is liquid in excess to supply fresh vapour to occupy the increased space opened for its reception, the density will not be diminished, but will, with the pressure, remain constant, —the maximum density and pressure due to the temperature being maintained.

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If, when all the liquid is evaporated, the fire or source of heat be removed, the pressure and density diminish when the volume is increased, as in permanent gases; and, if the volume be again reduced, the pressure and density increase until the latter returns to the maximum due to the temperature—that is to say, reaches the condensing point; and the effect of any further diminution of volume, or attempt to further increase the density at the same temperature, is simply attended by the precipitation of a portion of the vapour to the liquid state,—the density remaining the same.

On the contrary, if when all the liquid is evaporated, the application of heat be continued, the state of saturation ceases, the temperature and pressure are increased, whilst the density remains the same: the steam is said to be superheated, or surcharged with heat, and it becomes more perfectly gaseous. And were it, whilst in this condition, to be replaced in contact with water of the original temperature, it would evaporate a part of the water, transferring to it the surcharge of heat, and would resume its normal state of saturation.

Further, let the space for steam over the water remain unaltered, then, if the temperature is raised by addition of heat, the density of the vapour is increased by fresh vaporization, and the elastic force is consequently increased in a much more rapid ratio than it would be in a permanent gas by the same change of temperature. Conversely, if the temperature be lowered, a part of the vapour is condensed, the density is diminished, and the elastic force reduced more rapidly than in a permanent gas.

An account of the special results of M. Regnault's experiments, and of the investigations and deductions of himself and others based upon them, is given in detail in the following sections.

CHAP. VI.—RELATION OF THE PRESSURE AND TEMPERATURE OF SATURATED STEAM.

The admirable investigations of the constants relating to the economical employment of steam as a motive agency, conducted by M. Regnault, may be fairly considered as affording conclusive data of all the phenomena included within the range examined, until some new discovery in science, of a fundamental character, shall offer additional facilities of research. The direct methods of trial and observation may, in the meantime, be regarded as exhausted, and to have yielded the full measure of accuracy of which they are susceptible. It, therefore, only remained to give effect to the results obtained by reducing them to rules of calculation, of ready application, and the most simple of which the relations admit.

One of the most important of those relations is that subsisting between the temperature and the pressure, or elasticity of the steam in contact with the fluid from which it is generated. As yet this relation has only been expressed approximately, and by empirical formulas. The true law of connection has hitherto eluded analysis; and one is compelled to rely in most important calculations on rules which represent the law more or less distinctly, and usually over a very small portion of the curve graphically representing the pressures. There are many such rules, and some of them represent very exactly the data on which they are founded; but as these data are much less complete than those obtained from the elegant and extended researches of Regnault, it becomes necessary, even supposing the forms the most convenient, to lay aside the constants they contain, and to derive them anew from the more recent data.

There are two qualities required in a formula of this kind,—accuracy and simplicity. The first is obtainable by such a form of equation as that suggested by Laplace, which

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expresses the expansive force by a series arranged according to the ascending powers of the temperature. This suggestion was afterwards modified by Biot, whose form has been adopted, in the main, by Regnault, as the basis of his principal and most approved and exact formulas. The general form given by Regnault is the following:—

$$\text{Log F} = a\,\text{A}^{\theta} + b\,\text{B}^{\theta} + c\,\text{C}^{\theta} +$$

in which θ is a function of the thermometrical temperature; the other literal quantities are constants, to be determined from the series of experiments which the formula is intended to represent.

Egen's formula is also susceptible of accuracy. It is, in some measure, the inverse of that of Biot, and expresses the temperature by a series arranged according to the ascending powers of the logarithms of the elasticity.

Formulas, according to these models, may include any number of points of the curve of pressures, and may therefore be made to express any required degree of exactness. But such formulas become exceedingly unwieldy and inconvenient for the ordinary purposes of calculation; and they, moreover, do not admit of direct inversion. The formula of Dr Thomas Young, on which those of Creighton, Southern, Tredgold, Mellet, Coriolis, the Commission of the French Academy, the Committee of the Franklin Institute, and others, are founded, is comparatively simple in form; but it does not admit of very great exactness over any considerable extent of the curve. The expression in its most general form is

$$\text{F} = (a + bt)^{m}$$

This equation passes the curve through three given points, and when these are taken at no great distance apart, it may be employed to interpolate; but it cannot with safety be extended to any considerable distance beyond the assumed limits.

Another class of formulas is founded on that proposed by Professor Roche in 1828, from theoretical considerations. It expresses the elasticity by a constant number multiplied by a second constant raised to a power of which the exponent is a fraction, having the temperature in the nominator, and some function of the temperature in the denominator, thus —

$$\text{F} = a\,\text{A}^{\frac{t}{\gamma + t}}.$$

This form has been virtually adopted by August and Strehlke, Von Wrede, Magnus, Holtzmann, and Shortrede. It is greatly superior, as a formula of interpolation, to that of Dr Young in extent and accuracy, and to that of Biot in point of simplicity. It approaches more nearly to the double condition of accuracy and simplicity than any other expression which has yet been proposed; and, in fact, as a practical formula applicable to calculations relative to the steam-engine, leaves little to be regretted that it is not absolute. The most simple and convenient form to which this expression is reducible is, for the elastic force,

$$\text{Log F} = \text{A} - \frac{\text{B}}{t + \text{C}};$$

and the inverse formula for finding the temperature, when the pressure is given, is, accordingly,

$$t = \frac{\text{B}}{\text{A} - \log \text{F}} - \text{C}.$$

The late Mr W. M. Buchanan, of Glasgow, adopted this general equation as the basis of his formula, of which he published an account, in 1850, in the *Practical Mechanic's Journal*, and he tested it by a number of very careful determinations of the constants, from the graphic curve of pressures constructed by Regnault to represent the mean results of his experiments. He was led to conclude that no three points of that curve, which can be taken as data for the values of the constants, render the expression satisfactory throughout the entire range, experimentally represented. That range, however, extends over a space of 262° of the centigrade scale, equal to 471·6° of Fahrenheit's thermometer; namely, from 25·6° below 0° Fahr., at which the pressure is less than 0·006 lb. on the square inch of surface, to 446° Fahr., at which the pressure is over 400 lb. on the square inch. Both extremes of this range are at present much beyond the limits at which a practical formula is required for calculations relating to the steam-engine. The lower limit, especially, is obviously of no moment for such an object, however important it may be for other scientific purposes. Bearing in mind these considerations, Mr Buchanan adopted a temperature of 120° Fahr. as the lower limit of temperature at which it is practically necessary to consider the elasticity of steam as a motive-power, and he determined the constants from that limit to the higher extremity of the given curve, for the results obtained, both by the air and the mercurial thermometer. The values of these constants are arranged in the following statement:—

When the elasticity of the steam is expressed in atmospheres of 29·9212 inches of mercury, =14·68728 lb. on the square inch of surface	then	A=5·0324128 for the air thermometer. =4·8988483 for the mercurial do.
When the elasticity is expressed in atmospheres of 30 inches of mercury=14·726 lb. on the square inch	then	A=5·0312707 for the air thermometer. =4·8977061 for the mercurial do.
When the elasticity is expressed in inches of mercury of specific gravity 13·59596, which corresponds to the density at 32° Fahr.	then	A=6·5083919 for the air thermometer. =6·3748274 for the mercurial do.
When the elasticity is expressed in lbs. on the square inch	then	A=6·1993544 for the air thermometer. =6·0657899 for the mercurial do.

For the air thermometer	B=2938·16.
„ mercurial thermometer	B=2795·97.
„ air thermometer	C= 371·85.
„ mercurial thermometer	C= 358·74.

The formulas for p lb. pressure on the square inch, by the two modes of measuring the temperature are, therefore—

For the Air Thermometer.

$$\text{Log } p = 6{\cdot}1993544 - \frac{2938{\cdot}16}{t + 371{\cdot}85};$$

$$t = \frac{2938{\cdot}16}{6{\cdot}1993544 - \log p} - 371{\cdot}85.$$

For the Mercurial Thermometer.

$$\text{Log } p = 6{\cdot}0657899 - \frac{2795{\cdot}97}{t + 358{\cdot}74};$$

$$t = \frac{2795{\cdot}97}{6{\cdot}0657899 - \log p} - 358{\cdot}74.$$

Mr Buchanan observes, that "the indications by the air thermometer are greatly more to be relied upon than those of the mercurial. The air thermometer is not only more sensitive, but likewise admits of the employment of a relatively larger volume of the expanding fluid, compared with the volume of the glass envelope in which it is enclosed, The errors arising from the different expansibilities of different qualities of glass are, in consequence, much reduced relatively in amount; and, besides, the expansion of the fluid is very nearly uniform for equal increments of temperature. It is, however, the mercurial thermometer which is ordinarily employed in the measurement of temperatures, and accordingly it is of importance that the indications of the ordinary instrument should be represented by an appropriate formula. This formula, it is true, cannot possess

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more than an average approximation to the measurement by any particular instruments; for all thermometers made from different qualities of glass, and even when the usual fixed points are exactly and accurately determined, differ from one another at the higher temperatures. This is fully illustrated by the comparisons given by M. Regnault, in his memoir on the measurement of temperature, which has been justly characterized as one of the most elegant and successful examples we possess of the combination of experimental adaptation with inductive application of the results obtained. Let us take a single line of one of the many tables furnished; it compares four of the mercurial thermometers used with each other, and with the temperature indicated by the standard air thermometer. Take the temperature of 250° C. by the standard: in the medium having that temperature, the mercurial thermometer of

Choisy-le-Roi crystal, indicated	253·00 C.
Ordinary glass	250·05
Green glass	251·85
Swedish glass	251·44

At 100° higher, namely, 350° C., by the air thermometer, the first of these four thermometers gave 360·5°; and the second, 354°, as the temperature of the same medium. In this, it is to be remarked, that the deviations of the ordinary glass thermometer are the least; and this is true throughout the whole extent of the table,—a circumstance which ought to attract the attention, especially of the makers of these instruments. The wide differences thus shown to exist among thermometrical instruments of the very best description, render it little surprising that there should have existed very considerable discrepancies among the results obtained by different experimenters, in investigations involving the measurement of temperature. Both Regnault and Magnus have fortunately avoided this source of uncertainty in their researches relative to the elasticity of gaseous fluids, and accordingly their results agree with remarkable nearness."

The formulas employed by Regnault to connect the temperature with the pressure of steam in a state of saturation, chiefly constructed on the model of Biot's equation, though greatly more laborious, do not appear to be much, if in any degree, more exact than those constructed on Professor Roche's model. The wide range over which Buchanan's rules extend, based on Roche's model, and the great accuracy which they exhibit within the limits for which they are determined, seem to indicate that they contain at least the first terms of the absolute law. This supposition is further countenanced by the circumstance referred to by Mr Buchanan, that the same form expresses, better than any other, the tension of the vapours of some other liquids, as ether and alcohol; and he suggests that the formula ought to contain higher powers of the temperature than the first; that it ought to take some such form as the following:—

$$F=\frac{t}{x\,A^{a}+\beta t+\gamma t^{2}+}.$$

M. Bary applied the formula in this form, continued to the third power of t, to vapours.

Professor Rankine, of Glasgow, in 1849, published a formula for vapours in general, as follows:—

$$\operatorname{Log} p=a-\frac{b}{t}-\frac{c}{t^{2}},$$

in which log p represents the logarithm of the pressure of vapour at saturation; t, the absolute temperature; a, b, c, three constants, to be determined from three experimental data for each fluid. When the pressure is expressed in inches of mercury, and the temperature in degrees of Fahrenheit, the values of these constants, for steam, are as follows:—

$$a=6{\cdot}426421;\ \log b=3{\cdot}4403816;\ \log c=5{\cdot}5932626.$$

The inverse formula, for calculating the temperature from the pressure, is—

$$\frac{1}{t_{\prime}}=\sqrt{\frac{a-\log p}{c}+\frac{b^{2}}{4c^{2}}}-\frac{b}{2c};$$

in which $\frac{b}{2c}=0{\cdot}0035163$, $\frac{b^{2}}{4c^{2}}=0{\cdot}000012364$.

The operations of this formula are considerable, but in point of accuracy it is generally very satisfactory. Extending from $-22°$ to 446° of Fahrenheit's scale, it is the most exact of all the formulæ hitherto proposed for the same width of range. It is, however, much more tedious, especially in the inverse form, and is at least not more exact than Mr Buchanan's formula, between the same limits.

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CHAP. VII.—CONSTITUENT HEAT OF SATURATED STEAM.

The relation of the sensible temperature, measured by the thermometer, and the pressure of saturated steam, having been approximately determined and formulated, the next stage of the inquiry is the relation which the sensible temperature bears to the total heat of saturated steam. The total heat of steam comprises the latent heat, in addition to the sensible heat or temperature; that which is not directly measurable by the thermometer, and therefore called latent, together with that which is directly sensible to, and measurable by it. The total heat of steam would appear, at first sight, to be in some way related to, if not identical with, total or absolute temperature. The latter is, however, a speculative quantity, employed in the consideration of gaseous bodies, for the convenient expression of their known properties. The total heat of steam, according to the general acceptation, as defined by M. Regnault, is that quantity of heat which would be transferred to some other body in condensing the steam at the same temperature and pressure as those at which it was generated, and in cooling the condensed steam, or water, down to the freezing point. That is to say, conversely, if water be supplied at the freezing point of temperature, 0° centigrade, or 32° Fahrenheit, for evaporation into steam, the total quantity of heat applied to the water, and consumed in generating steam of any pressure and temperature from it, is said to be the total heat of the steam of the given pressure and temperature; and in general, whatever may be the actual temperature of the water from which the steam is generated, the total heat of the steam is reckoned from the freezing point. The adoption of the freezing-point as the zero for total heat, as well as for that of the sensible temperature in the case of the centigrade thermometer, is not done, of course, with any purpose of fixing an absolute datum for total constituent heat; but for convenience, being situated sufficiently low in the scale of temperature to underlie all the ordinary calculations about steam.

It was determined experimentally by Regnault, that the latent heat of saturated steam, at 0° C., was 606·5° C.; so that the latent heat of 1 lb. of steam, at 0° C., would raise the temperature of 606·5 lb. of cold water through 1°. The total heat of steam at 0° C. is the same as the latent heat, namely, 606·5° C.; and it was found that the total heat of saturated steam increased uniformly between the temperatures of 0° and 230° C., by ·305°, with each increment of 1° of temperature. The specific heat of ordinary steam is thus ·305°, that of water being $=1$. The total heat H of saturated steam of any temperature t, in centigrade degrees, is therefore expressed by the equation—

$$H=606{\cdot}5+{\cdot}305\,t.$$

From this equation it appears, that, whilst the sensible heat or temperature rises 1°, the total heat increases only ·305°, or less than a third of a degree. The latent heat

Constituent Heat of Saturated Steam.

must, therefore, necessarily be diminished as the temperature rises, other circumstances being the same, by as much as $\cdot 305°$ falls short of $1°$, or $1 - \cdot 305 = \cdot 695°$ for each degree of temperature; and the decreasing latent heat would be expressed by $606 \cdot 5° - \cdot 695° t$. There is one slight disturbing element, however,—the specific heat of water, which is not constant for all temperatures, but is slightly increased by a rise of temperature; and by as much as the specific heat of the water is increased, the latent heat of the steam is still further diminished, and the true rate of reduction is expressed by a higher fraction than $\cdot 695\, t$. In fact, if the specific heat of water, at temperatures between 0° and 30° C., be represented by an average of unity, it will be equal to 1·005 between 30° and 120°, and 1·013 between 120° and 190° C., or 374° Fahr. M. Regnault embodies this slight rate of increase in the formula, $C = 1 + \cdot 00004\ t + \cdot 0000009\ t^2$, in which C is the specific heat of water at any temperature t, that at 0° C., the freezing-point, being = 1. The introduction of this element into a general formula for the latent heat of steam, would complicate it too much for general use; and for present purposes, the equation employed by Clausius is preferred, namely,

$$L = 607 - \cdot 708\, t,$$

in which L is the latent heat due to the temperature t; and it may be noted that the co-efficient of t is slightly increased above that which would be due to a constant specific heat of water, as the deduction due to a slightly increasing specific heat. That the results afforded by the simpler equation are sufficiently near correctness, appears by the following comparative instances of its application, at different temperatures, by Fahrenheit's scale, as against the use of Regnault's correct but more complicated process:—

	100°	200°	212°	300°	400° F.
By Clausius,	L=1044·4	973·6	965·1	902·8	832
By Regnault,	L=1044·47	974	965·7	902·9	829·84

In estimating the latent heat of steam at 100° C., or 212° Fahr., Regnault found, that on account of the slight variation of the specific heat of water, 100·5 centigrade units, or 180·9 Fahrenheit units, of heat, were required to raise the unit of water from 0° to 100° C., or through 180° Fahr.; and he found that the total heat of steam, at 100° C., was 636·67° C. From this deduct 100·5°, and the difference, $636 \cdot 67 - 100 \cdot 5 = 536 \cdot 17°$ C., represents the true latent heat of steam at 100° C. But as, in the compilation of his tables, Regnault started with the integral number 637°, the latent heat of saturated steam, at 100° C., or 212° Fahr., is estimated by him at 536·5° C. = 965·7° Fahr.

To modify the formula for the total heat of steam, in terms of Fahrenheit degrees, $606 \cdot 5°\ C. \times 9 \div 5 = 1091 \cdot 7°$ Fahr., is the total heat at 32° Fahr.; and as t represents the indicated temperature, the total heat would be expressed by $1091 \cdot 7 + \cdot 305\ (t - 32)$, or, in a more general form, by $(1123 \cdot 7 - 32) + (\cdot 305t - 9 \cdot 76) = (1113 \cdot 94 - 32) + \cdot 305t$. The first element in this expression should be reduced to 1113·4, in order to produce exact conformity with the observed total heat at 212° Fahr., Regnault's starting-point; and the formula for the total heat, in terms of Fahrenheit degrees, becomes,

$$H = (1113 \cdot 4 - 32) + \cdot 305t;\ \text{or},$$
$$H = 1081 \cdot 4 + \cdot 305t.$$

By this equation, the total heat of steam generated at 212° Fahr. is equal to $1113 \cdot 4 - 32 + (\cdot 305 \times 212) = 1146°$ Fahr.; and this represents what would be consumption of heat in generating the steam, if the water were supplied at 32° Fahr. By means of the same form of equation, the total expenditure of heat consumed in raising steam from water supplied at ordinary temperatures may be calculated, by substituting for 32 in the formula, the initial temperature of the water supplied for evaporation, subject to an allowance, if deemed sufficiently important, for the slight increase of specific heat of the water of higher temperature. Thus, when the water is supplied at 62° Fahr., the average temperature of cold water, the extra specific heat may be neglected, and the heat expended in generating steam from the water is expressed by the equation,

$$H_1 = (1113 \cdot 4 - 62) + \cdot 305t;\ \text{or}$$
$$H_1 = 1051 \cdot 4 + \cdot 305t.$$

If, as in condensing engines, the water be supplied at, say 100° Fahr., the heat expended in generating steam from it, again neglecting the specific heat, is expressed as follows:—

$$H_2 = (1113 \cdot 4 - 100) + \cdot 305t;\ \text{or},$$
$$H_2 = 1013 \cdot 4 + \cdot 305t.$$

Again, if the water be supplied at a boiling temperature, 212° Fahr., the specific heat of the water at 212°, as already noted, would be ·9 unit, or degree, of heat in excess of that at 32°, and $212 + \cdot 9 = 212 \cdot 9°$ should be substituted. Hence, for an initial temperature of 212° Fahr., the expenditure of heat in generating steam would be

$$H_3 = (1113 \cdot 4 - 212 \cdot 9) + \cdot 305t;\ \text{or},$$
$$H_3 = 900 \cdot 5 + \cdot 305t.$$

To convert Clausius's formula for the latent heat of steam, namely, $L = 607 - \cdot 708t$, into Fahrenheit's measure, $607°\ C. \times 9 \div 5 = 1092 \cdot 6°$ Fahr., and for $t°$ C. substitute $(t - 32)$ Fahr., then $L = 1092 \cdot 6° - \cdot 708\ (t - 32)$ Fahr., or finally, by the Fahrenheit scale,

$$L = 1115 \cdot 2 - \cdot 708t.$$

It is convenient to bear in mind that the same figures which express in degrees the relations of the constituent heat of steam, as ratios simply, not as absolute quantities, express also positive values—in units of heat—when applied to 1 pound-weight of steam, in accordance with the definition of the heat-unit, or the thermal unit. Now, to trace the appropriation of all the heat which contributes to the formation of a pound of steam, in terms of thermal units, as well as of dynamic units or foot-pounds, take 1 pound of water at 32° Fahr., to be converted into saturated steam at 212°. The first instalment of heat is provided to elevate the temperature to 212°, through 180°; in other words, to increase the molecular velocity and slightly expand the liquid, which appropriates 180·9 units of heat, equivalent to $180 \cdot 9 \times 772 = 139655$ foot-pounds. Secondly, heat is absorbed in overcoming the molecular attraction, and separating the particles; that is, in the formation of steam, appropriating 892·8 units of heat = 689,242 foot-pounds. Thirdly, in repelling the incumbent pressure, whether of the atmosphere, or of the neighbouring steam; that is, to raise a load of 14·7 lb. per square inch, or 2116·8 lb. on a square foot, through a cubic space of 26·36 cubic feet, which is the volume of 1 pound of saturated steam: equal to 55,815 foot-pounds, or 72·3 units of heat. Strictly, there is the initial volume of the original pound of water to be deducted from this total volume; but it is relatively small, and need not be further considered. The second of the above proportions of heat is formed by subtracting the sum of the first and third, which are both arrived at by direct observation, from the total heat. The first is the sensible heat, and the second and third together constitute the latent heat. With respect to the third constituent proportion of heat, it is simply an expression of the necessary mechanical labour of disengaging 26·36 cubic feet of steam, and forcing its way into space against a pressure of 2116·8 lb. per square foot; and these quantities being multiplied together, and divided by 772, are equivalent to 72·3 units of heat.

The proportions of the heat expended in generating saturated steam at 212° Fahr., and at 14·7 lb. pressure per square inch, from water supplied at 32°, may be exhibited thus:—

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	Units of Heat.	Mechanical Equivalent in foot-pounds.
The Sensible Heat:—		
1. To raise the temperature of the water from 32° to 212°, through 180°,................................	180·9 or	139,655
The Latent Heat:—		
2. In the formation of steam,.........	892·8 „	689,242
3. In resisting the incumbent pressure of 14·7 lb. per square inch, or 2116·8 lb. per square foot ...	72·3 „	55,815
Latent heat	965·1 or	745,057
Total heat	1146·0 or	884,712

Supposing, however, that 1 lb. of water, at 32° Fahr., were injected into a vacuous space or vessel, having 26·36 cubic feet of capacity. If heat were applied to evaporate this water into steam of 212°, and 14·7 lb. per square inch pressure, so as to fill the whole space with saturated steam, the expenditure of heat would consist only of the sensible heat, to raise the temperature of the water 180·9 units, *plus* the latent heat for the formation of the steam, 892·8 units, = 1073·7 units, as in this case there would be no incumbent pressure to resist, and no extraneous work. But, again, let a second pound of water be injected into the same vessel, already full of steam, to be evaporated into steam of 14·7 lb. pressure per square inch, so that the vapour of the second pound of water must expel the first, a uniform pressure of 14·7 lb. per square inch being maintained within the vessel. The expenditure of heat in the generation of the second pound will be 72·3 units in excess of that required for the first pound, being the additional quantity required to repel the incumbent pressure; and the total expenditure will be 1146 units. The 72·3 units excess of heat expended on the second pound of steam disappears, or rather it does not appear as heat, but is transformed into the work of expelling the first pound of steam; and, after its production, the second pound contains just the same quantity of heat as the first, namely, 1073·7 units, which may be proved by condensing them both into water of 32° Fahr.

The latent heat of steam, then, is not, as is sometimes supposed, an expression of the total work or energy in the steam; but is the work expended in overcoming the attraction of the particles, forcing them asunder, together with the work expended in repelling the external pressure under which the steam is generated. As the temperature rises, the centrifugal velocity, or vibratory motion of the minute particles is accelerated, the liquid expands, and the attraction of the particles is consequently diminished. Hence that part of the latent heat, or work, expended in effecting an entire separation of the particles, diminishes as the temperature rises. When water is evaporated at a low temperature, it is obvious that the particles are held together by a greater force than if it were evaporated at a higher temperature, after heat has been expended in accelerating the velocity of the particles, and expanding the liquid; and less work is expended in effecting their separation. At high temperatures the particles are already in part separated; they have a less hold on each other, and consequently an entire separation is more easily completed at higher than at lower temperatures. On the contrary, the second, but inferior portion of latent heat expended in repelling the external resistance—the product of increasing pressure into diminishing volume—increases slowly as the temperature rises; but the increase in this respect is less than the decrease in respect of the chief duty of the latent heat. In this manner it is to be explained, that though the total constituent heat of steam slowly increases as the temperature rises, in consequence of the comparative rapidity with which the sensible heat increases, the latent heat slowly diminishes as the temperature is elevated.

CHAP. VIII.—THE DENSITY OF SATURATED STEAM.

Density of Saturated Steam.

On the principle of the mechanical equivalence of heat, according to which heat, and work or duty performed, are convertible into and representative of each other, the investigation of the properties of steam may be conveniently conducted in terms of one form of expression or the other —heat, or dynamic effect—as the nature of the experimental evidence may demand. The density of saturated steam is one of its properties which has not yet been accurately determined by direct experiment; nor, of course, has the relative volume, which is inversely as the density. The density of steam is expressed by the weight of a given constant volume—say one cubic foot; and the relative volume by the number of volumes of steam produced by one volume of water—hence called relative. The density and the relative volume are, however, most accurately determinable by means of the pressure, temperature, and latent heat of steam, all of which have been subjects of careful and comprehensive experiment. When steam is freely generated in contact with water in a boiler, the actual process of generation consists, first, in heating the water to the temperature due to the pressure under which the steam is generated; second, in the absorption of a large quantity of heat which becomes latent—not affecting the thermometer—and is replaced physically by a quantity of steam of the same temperature—the sensible heat of the water continuing sensible in the steam. It is properly argued, then, that the specific function of converting the water into steam, of changing a non-elastic into an elastic substance, of thus developing a reservoir of motive-power where none existed before, is performed by the latent heat; and that, inasmuch as the process is just the conversion or change of form, of heat into elastic force, the force or power so manifested is simply commensurate with the latent heat; and if the latent heat, the amount of which is known experimentally, be converted into foot-pounds, in terms of Joule's equivalent, it will constitute one side of an equation, which will show on the other side the dynamic expression of the relative temperature and pressure, which also are directly known by experiment.

Suppose 1 pound of water in contact with other water, to be converted into 1 pound of steam within a boiler, and that the process of heating and conversion be commenced at the bottom of the scale of absolute temperature, at 461° below zero Fahrenheit. Whether it be possible or not, it is at least conceivable that the whole of the given weight of water may be in a state of vapour at 1° absolute temperature, of extreme tenuity, indefinitely large in volume, and indefinitely low in pressure; let it be supposed that this 1 pound of steam occupies the entire capacity of the boiler, and let the temperature be raised to 2°; another portion of vapour would be generated, occupying part of the capacity of the boiler, and forcing the prior steam into smaller compass, and thus increasing its density. If the temperature be thus continually elevated by degrees, the particular pound of steam under consideration would be continually reduced into smaller bulk, and its density would be increased, and likewise the pressure. It may properly be conceived, therefore, to undergo a process of compression from its conception to maturity—the increments of pressure accumulating with the increments of density and pressure. Now, the work or dynamic force accumulated in the given pound of steam, in virtue of the successive compression to which it may be supposed to have been subjected, is the same in quantity for each degree of temperature:—it is equal, in fact, to the product of the final increment of pressure multiplied into the final volume of the steam. Or—regarding the problem in another way—a pound of water is converted into a pound of steam, generating and occupying a certain volume, and this volume is consummated with a

Density of Saturated Steam.

final increment of pressure for the final degree of temperature.

This final increment of pressure, then, represents, for this particular volume, one degree of temperature; and if multiplied into the volume, is an expression of the action for one degree of temperature. If further multiplied by the absolute temperature in degrees, the resulting product expresses the whole of the latent heat of evaporation inherent in the given weight of steam.

In strict argument, this mode of estimation, in terms of the whole volume of the steam, gives a result slightly in excess of the literal result, as the volume actually generated is not the whole final volume, but only the excess of this above the volume of the water from which it is generated.

To vary the form of the argument, suppose the final volume of the given pound-weight of steam to be erected into a vertical column on 1 square foot of base, the column would of course weigh 1 pound; and if the height be multiplied by the final increment of pressure in lbs. per square foot for one degree of temperature, the product would express the height of a vertical column of the steam on 1 square foot of base, equal in weight to the final increment of pressure. If the weight be again multiplied by the absolute temperature, the ultimate product will express the latent heat of 1 pound weight of steam in "feet of fall" of 1 pound, that is, foot-pounds; and, further, dividing by 772, Joule's equivalent, the quotient will be the equivalent value of the latent heat in units or degrees of Fahrenheit's scale.

This form of reasoning, no doubt, contains a principle of hypothetical origin, according to which the actual heat present in a substance is simply proportional to its temperature, measured from a certain point of absolute cold, and multiplied by a specific constant; and "although," as Professor Rankine observes, "existing experimental data may not be adequate to verify this principle precisely, they are still sufficient to prove, that it is near enough to the truth for all purposes connected with thermo-dynamic engines, and to afford a strong probability that it is an exact physical law."

Let g = the increment of pressure for the final degree of temperature in lbs. on the square foot; 772 foot-pounds = the mechanical equivalent of one unit of heat, or so much heat as would raise the temperature of 1 pound of cold water 1°; L = the latent heat of 1 pound of water in units, which is of course identical with the latent heat in degrees deduced from the temperature; T = the absolute temperature; V = the volume of 1 lb. of steam in cubic feet, and v the volume of the water from which it is generated; then $V-v$ = the volume generated, and the contemplated equation would be as follows:—

$$772L = Tg\,(V-v);$$

or, for simplicity, let the volume of the water be neglected, as it is not practically important, then the equation would be—

$$772L = TgV.$$

From this equation, it follows that the latent heat of one pound of steam is

$$L = \frac{TgV}{772} \text{ units of heat; or,}$$

$$L = TgV \text{ foot-pounds.}$$

Consequently, also, the latent heat l, of one cubic foot of steam, dividing the above quantities by V, is

$$l = \frac{Tg}{772} \text{ units of heat; or,}$$

$$l = Tg \text{ foot-pounds.}$$

The volume of 1 lb. of steam in cubic feet, L being expressed in units of heat, is

$$V = \frac{772\,L}{T\,g} \text{ cubic feet.}$$

As the weight of 1 cubic foot of cold water is 62·3 lbs., it follows that 62·3V is the volume, in cubic feet, of the steam generated from 1 cubic foot of water. If n be the relative volume, then $n = 62{\cdot}3V$, and $V = n \div 62{\cdot}3$; and, by substitution,

$$\frac{n}{62{\cdot}3} = \frac{772\,L}{Tg};$$

from which the relative volume of the steam is

$$n = \frac{772L}{Tg \div 62{\cdot}3};$$

also, conversely, the latent heat, in Fahrenheit degrees, in terms of the relative volume, is

$$L = \frac{nTg}{772 \times 62{\cdot}3}.$$

For illustration, let the temperature be raised from $211\frac{1}{2}$ to $212\frac{1}{2}$°, through one degree, the pressure will rise from 2094 lb. to 2136 lb. per square foot, making the increment of pressure $g = 42$ lb. per square foot. The mean temperature is 212°, and the absolute temperature $T = 461 + 212 = 673°$. The latent heat Tg in foot-pounds, of 1 cubic foot of steam at 212°, and a pressure of 14·7 lb. per square inch, or 2116·8 lb. per square foot, is, therefore, $673 \times 42 = 28{,}266$ foot-pounds. To determine next the value of V, the volume of 1 lb. of steam at 212°, and at atmospheric pressure, let the steam be gaseous, then, by the equation for gaseous steam (which will be afterwards explained), $V = 85{\cdot}4\,T \div P = 85{\cdot}4 \times 673 \div 2116{\cdot}8 = 27{\cdot}16$ cubic feet; and substituting numerical values, we have for the latent heat of 1 lb. of gaseous steam at 212°, and atmospheric pressure,

$$L = \frac{TgV}{772} = \frac{673 \times 42 \times 27{\cdot}16}{772} = 994{\cdot}4,$$

which is precisely the latent heat of gaseous steam at 212°, as deduced by Mr Brownlee, in terms of Regnault's constant for the specific heat of gaseous steam, namely, ·475.

According to the preceding equations, the volume of 1 lb. of saturated steam at 212°, is

$$V = \frac{772\,L}{Tg} = \frac{772 \times 965{\cdot}1}{673 \times 42} = 26{\cdot}36 \text{ cubic feet;}$$

and the relative volume of the same steam is

$$n = \frac{772 \times 965{\cdot}1}{673 \times 42 \div 62{\cdot}3} = 1642 \text{ volumes,}$$

which has been, but erroneously, considered to be 1700 volumes.

The density or weight of 1 cubic foot of saturated steam is readily deducible from the equation for the volume in cubic feet of 1 pound of steam, in which $V = 772L \div Tg$; as the weight of a cubic foot is simply the inverse of this equation. Thus, the density D, or the weight in pounds of 1 cubic foot $= \frac{1}{V}$, or

$$D = \frac{Tg}{772\,L}.$$

Mr James Brownlee has deduced a simple expression for the density of saturated steam in terms of the total pressure, thus—

$$D = \frac{p^{\cdot 941}}{330{\cdot}36}; \text{ or,}$$

$$\text{Log } D = {\cdot}941 \log p - 2{\cdot}519;$$

in which D is the weight of 1 cubic foot of steam, of the pressure p Fahr. The results presented by means of this formula are very accurate; they do not differ from those

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obtained in terms of the temperature and latent heat of steam for pressures from 1 lb. to 250 lb. per square inch by more than $\frac{1}{7}$th per cent. The volume in cubic feet of 1 pound of saturated steam is of course expressed by the inverse of the weight in pounds of a cubic foot of the steam,

thus $V=\frac{1}{D}$, consequently

$$V=\frac{330{\cdot}36}{p^{\cdot 941}}\text{; or,}$$

$$\text{Log } V=2{\cdot}519-{\cdot}941 \log p.$$

Again, the relative volume of the steam is expressed by the ratio of 62·3 lb., the weight of a cubic foot of water, to D, the weight of a cubic foot of steam; hence, $62{\cdot}3 \div \frac{p^{\cdot 941}}{330{\cdot}36}=62{\cdot}3\times 330{\cdot}36\div p^{\cdot 941}$, = the relative volume. Putting n = the relative volume.

$$n=\frac{20559}{p^{\cdot 941}}\text{; or,}$$

$$\text{Log } n=4{\cdot}3135-({\cdot}941\times \log p);$$

from which it appears that the relative volume of saturated steam of 14·7 lb. pressure per square inch, and 212° temperature, is 1642, the same as was found before in terms of the temperature and latent heat.

CHAP. IX.—GASEOUS STEAM.

If ordinary or saturated steam be superheated or "surcharged" with heat, it advances from the state of saturation into that of gaseity. The transition into the gaseous state involves a considerable elevation of temperature, by amounts which increase with the pressures; and steam, when thus sufficiently elevated in temperature above the saturation-point due to its density, is known as gaseous steam, distinctively from ordinary, or, as it may be called, imperfectly gaseous steam.

Regnault found, throughout the whole range of his observations, that the specific density of gaseous steam at all temperatures was ·622; that is to say, the weights of equal volumes of air and sufficiently superheated or gaseous steam, having the same pressures and temperatures, were as 1 to ·622, and that therefore the steam so treated was gaseous, as, the specific density being constant, the air and the gaseous steam, when taken at the same temperature, must expand alike when equally raised in temperature.

Confirmatory of Regnault's specific density of gaseous steam, the chemical union of oxygen and hydrogen, in the proportions to form steam, may be referred to. Two cubic feet of hydrogen and one of oxygen combining, will form two cubic feet of gaseous steam at the same temperature. The specific density of hydrogen is = ·06926, and that of oxygen = 1·10563, and the density of the product is in the combined ratio of the densities and the uniting volumes.

Hydrogen, 2 volumes,	× ·06926	=	·13852
Oxygen, 1 do.	× 1·10563	=	1·10563
Gaseous steam, 2 volumes..........			1·24415 ÷ 2
Specific density......................		=	·622

being the same as was determined by Regnault from direct observation.

In accordance with the relations of perfect gases, the weight of a cubic foot of air, expressive of the density, D, at any pressure per square inch, p, and temperature, $t°$, Fahrenheit, is expressed by the equation,

$$D=\frac{144\,p}{53{\cdot}15\,(t+461)},$$

in which $144\,p$ expresses the pressure per square foot, $t+461$ the absolute temperature, and 53·15 a constant determined for air. The same form will express the weight of steam by a modification of the constant in terms of the specific density; thus, for gaseous steam, $53{\cdot}15\div{\cdot}622=85{\cdot}4$ is the appropriate constant, and the weight of a cubic foot of gaseous steam is expressed by the equation,

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$$D=\frac{144\,p}{85{\cdot}4\,(t+461)}=\frac{P}{85{\cdot}4\,T},$$

in which $P=144\,p$, and $T=t+461$.

As the pressure, volume, and temperature of gaseous steam, and other gases, vary with each other in simple ratios—the pressure and the volume inversely with each other, and both of them directly with the absolute temperature—their mutual relation for any given constant weight of gas is such, that the pressure multiplied by the volume is equal to the absolute temperature multiplied by a constant number. For gaseous steam, as the weight in pounds of 1 cubic foot is equal to $P\div 85{\cdot}4\,T$; then, conversely, the volume in cubic feet of 1 pound of steam is $85{\cdot}4T\div P$, and, generally, $PV=85{\cdot}4T$, for gaseous steam. For air, and a few other gases, the following are the general equations for a given weight, 1 pound of gas:—

Constants for One Pound Weight of Gas.

		Specific Density.
Air........................	PV = T × 53.15	1·000
Gaseous steam.........	PV = T × 85·4	·622
Oxygen gas	PV = T × 48·07	1·106
Hydrogen gas	PV = T × 767·4	·069
Sulphuric ether	PV = T × 20·8	2·556
Alcohol..................	PV = T × 33·45	1·589
Chloroform..............	PV = T × 10 0	5·300

In order to find the total heat of steam, it may be observed, that from some experiments made by Regnault, it appeared that ordinary steam is nearly gaseous at temperatures below 60° Fahr. Mr Brownlee has adopted a fundamental temperature of 40° Fahr. as that at which the saturated and the gaseous steams become identical in constitution. For gaseous steam, Regnault found the specific heat to be ·475°: that is, that the total heat of gaseous steam increases uniformly ·475° for each degree of sensible temperature; and it follows that an equation on the model of that for saturated steam may be found to express the total heat of gaseous steam. Proceeding on this basis, Mr Brownlee finds, by the formula for saturated steam, that the total heat of steam at 40° Fahr., and at the pressure due to saturation, is $1113{\cdot}4-32+({\cdot}305\times 40)=1093{\cdot}6°$ F.; and he substitutes for ·305 the gaseous constant ·475, and adjusts also the first quantity in the expression, reducing it to 1106·6,—by as much, in fact, as the constant ·475 adds to the first side of the equation. The expression, then, becomes $1106{\cdot}6-32+({\cdot}475\times 40)=1093{\cdot}6°$ F., showing the same total heat, 1093·6° Fahr., regarded as gaseous steam, as was found by the formula appropriate for saturated steam. The general formula for the total heat of gaseous steam, putting t for the temperature in Fahrenheit degrees, is, then,

$$H=1106{\cdot}6-32+{\cdot}475t\text{; or,}$$

$$H=1074{\cdot}6+{\cdot}475t.$$

To raise the temperature of the vapour generated at 40° to 212° through 172°, the pressure remaining the same, the additional heat is measured by ${\cdot}475\times 172=81{\cdot}7°$, and $1093{\cdot}6+81{\cdot}7=1175{\cdot}3°$, the total heat. Or, employing the above equation in the calculation, ${\cdot}475\times 212=100{\cdot}7$, and $H=1074{\cdot}6+100{\cdot}7=1175{\cdot}3°$, as before.

As already shown for saturated steam, the foregoing equation for the total heat of gaseous steam may be employed to find the actual expenditure of heat in raising gaseous steam from water of any temperature higher than 32° Fahr. The latent heat of this steam may be estimated from the total heat by deducting 180·9°, the heat necessary to raise the temperature of water from 32° to 212°; thus, $1175{\cdot}3-180{\cdot}9=994{\cdot}4°$, is the latent heat of any gaseous steam at 212°.

Table of the Properties of Saturated Steam.

As for saturated steam, so also for gaseous steam, the latent heat diminishes as the temperature rises, but not so rapidly in the latter as in the former, as the specific heat is greater; that is to say, the increment of total heat, ·475°, for each degree of sensible temperature of gaseous steam, is greater than the increment, ·305°, for saturated steam; and therefore the difference, 1 – ·475 = ·525°, being the reduction of latent heat for each degree of temperature for gaseous steam, is less than the difference, 1 – ·305 = ·695°, for saturated steam.

The actual expenditure of heat in generating gaseous steam from water of higher temperature than 32° Fahr., may be found by substituting the temperature for 32 in the last formula; as follows, for the common temperature 62° Fahr.:—

$$H_1 = 1106{\cdot}6 - 62 + {\cdot}475t;\ \text{or,}$$
$$H_1 = 1044{\cdot}6 + {\cdot}475t.$$

For a temperature of 100° Fahr. the formula is—

$$H_2 = 1106{\cdot}6 - 100 + {\cdot}475t;\ \text{or,}$$
$$H_2 = 1006{\cdot}6 + {\cdot}475t.$$

For a temperature of 212°, with the specific heat of water 212·9°, the formula is—

$$H_3 = 1106{\cdot}6 - 212{\cdot}9 + {\cdot}475t;\ \text{or,}$$
$$H_3 = 893{\cdot}7 + {\cdot}475t.$$

Table of the Properties of Saturated Steam.

TABLE OF THE PROPERTIES OF SATURATED STEAM.

The appended table of the properties of saturated steam has been calculated by means of the formulas in this article. The first column contains the ascending total pressures in pounds per square inch. The second column, of temperatures, was calculated from the pressures by the formula—

$$t = \frac{2938{\cdot}16}{6{\cdot}1993544 - \log. p} - 371{\cdot}85;$$

the third column, of total heat, was calculated by the formula $H = 1081{\cdot}4 + {\cdot}305\,t$; the fourth column, of latent heat, by the formula $L = 1115{\cdot}2 - {\cdot}708\,t$; the fifth column, of density, by the formula $\text{Log } D = {\cdot}941 \log. p - 2{\cdot}519$; the sixth column, of the volume of 1 lb. of steam, by the formula $\text{Log } V = 2{\cdot}519 - {\cdot}941 \log. p$; and the seventh column, of relative volume, by the formula $\text{Log } n = 4{\cdot}3135 - ({\cdot}941 \times \log p.)$

Table of the Properties of Saturated Steam.

Total pressure per square inch.	Temperature in Fahrenheit degrees.	Total Heat in Fahrenheit degrees from 32 degrees.	Latent Heat. Fahrenheit degrees.	Density or weight of one cubic foot.	Volume of one pound of Steam.	Relation Volume, or cubic feet of Steam from one cubic foot of Water.	Total pressure per square inch.	Temperature in Fahrenheit degrees.	Total Heat in Fahrenheit degrees from 32 degrees.	Latent Heat. Fahrenheit degrees.	Density or weight of one cubic foot.	Volume of one pound of Steam.	Relation Volume, or cubic feet of Steam from one cubic foot of Water.
Lb.	Fahr.	Fahr.	Fahr.	Lb.	Cubic Feet	Rel. Vol.	Lb.	Fahr.	Fahr.	Fahr.	Lb.	Cubic Feet	Rel. Vol.
1	102·1	1112·5	1042·9	·0030	330·36	20582	48	278·4	1166·3	918·1	·1156	8·65	539
2	126·3	1119·7	1025·8	·0058	172·08	10721	49	279·7	1166·7	917·2	·1179	8·48	529
3	141·6	1124·6	1015·0	·0085	117·52	7322	50	281·0	1167·1	916·3	·1202	8·31	518
4	153·1	1128·1	1006·8	·0112	89·62	5583	51	282·3	1167·5	915·4	·1224	8·17	509
5	162·3	1130·9	1000·3	·0138	72·66	4527	52	283·5	1167·9	914·5	·1246	8·04	500
6	170·2	1133·3	994·7	·0163	61·21	3813	53	284·7	1168·3	913·6	·1269	7·88	491
7	176·9	1135·3	990·0	·0189	52·94	3298	54	285·9	1168·6	912·8	·1291	7·74	482
8	182·9	1137·2	985·7	·0214	46·69	2909	55	287·1	1169·0	912·0	·1314	7·61	474
9	188·3	1138·8	981·9	·0239	41·79	2604	56	288·2	1169·3	911·2	·1336	7·48	466
10	193·3	1140·3	978·4	·0264	37·84	2358	57	289·3	1169·7	910·4	·1364	7·36	458
11	197·8	1141·7	975·2	·0289	34·63	2157	58	290·4	1170·0	909·6	·1380	7·24	451
12	202·0	1143·0	972·2	·0314	31·88	1986	59	291·6	1170·4	908·8	·1403	7·12	444
13	205·9	1144·2	969·4	·0338	29·57	1842	60	292·7	1170·7	908·0	·1425	7·01	437
14	209·6	1145·3	966·8	·0362	27·61	1720	61	293·8	1171·1	907·2	·1447	6·90	430
14·7	212·0	1146·1	965·2	·0380	26·36	1642	62	294·8	1171·4	906·4	·1469	6·81	424
15	213·1	1146·4	964·3	·0387	25·85	1610	63	295·9	1171·7	905·6	·1493	6·70	417
16	216·3	1147·4	962·1	·0411	24·32	1515	64	296·9	1172·0	904·9	·1516	6·60	411
17	219·6	1148·3	959·8	·0435	22·96	1431	65	298·0	1172·3	904·2	·1538	6·49	405
18	222·4	1149·2	957·7	·0459	21·78	1357	66	299·0	1172·6	903·5	·1560	6·41	399
19	225·3	1150·1	955·7	·0483	20·70	1290	67	300·0	1172·9	902·8	·1583	6·32	393
20	228·0	1150·9	952·8	·0507	19·72	1229	68	300·9	1173·2	902·1	·1605	6·23	388
21	230·6	1151·7	951·3	·0531	18·84	1174	69	301·9	1173·5	901·4	·1627	6·15	383
22	233·1	1152·5	949·9	·0555	18·03	1123	70	302·9	1173·8	900·8	·1648	6·07	378
23	235·5	1153·2	948·5	·0580	17·26	1075	71	303·9	1174·1	900·3	·1670	5·99	373
24	237·8	1153·9	946·9	·0601	16·64	1036	72	304·8	1174·3	899·6	·1692	5·91	368
25	240·1	1154·6	945·3	·0625	15·99	996	73	305·7	1174·6	898·9	·1714	5·83	363
26	242·3	1155·3	943·7	·0650	15·38	958	74	306·6	1174·9	898·2	·1736	5·76	359
27	244·4	1155·8	942·2	·0673	14·86	926	75	307·5	1175·2	897·5	·1759	5·68	353
28	246·4	1156·4	940·8	·0696	14·37	895	76	308·4	1175·4	896·8	·1782	5·61	349
29	248·4	1157·1	939·4	·0719	13·90	866	77	309·3	1175·7	896·1	·1804	5·54	345
30	250·4	1157·8	937·9	·0743	13·46	838	78	310·2	1176·0	895·5	·1826	5·48	341
31	252·2	1158·4	936·7	·0766	13·05	813	79	311·1	1176·3	894·9	·1848	5·41	337
32	254·1	1158·9	935·3	·0789	12·67	789	80	312·0	1176·5	894·3	·1869	5·35	333
33	255·9	1159·5	934·0	·0812	12·31	767	81	312·8	1176·8	893·7	·1891	5·29	329
34	257·6	1160·0	932·8	·0835	11·97	746	82	313·6	1177·1	893·1	·1913	5·23	325
35	259·3	1160·5	931·6	·0858	11·65	726	83	314·5	1177·4	892·5	·1935	5·17	321
36	260·9	1161·0	930·5	·0881	11·34	707	84	315·3	1177·6	892·0	·1957	5·11	318
37	262·6	1161·5	929·3	·0905	11·04	688	85	316·1	1177·9	891·4	·1980	5·05	314
38	264·2	1162·0	928·2	·0929	10·76	671	86	316·9	1178·1	890·8	·2002	5·00	311
39	265·8	1162·5	927·1	·0952	10·51	655	87	317·8	1178·4	890·2	·2024	4·94	308
40	267·3	1162·9	926·0	·0974	10·27	640	88	318·6	1178·6	889·6	·2044	4·89	305
41	268·7	1163·4	924·9	·0996	10·03	625	89	319·4	1178·9	889·0	·2067	4·84	301
42	270·2	1163·8	923·9	·1020	9·81	611	90	320·2	1179·1	888·5	·2089	4·79	298
43	271·6	1164·2	922·9	·1042	9·59	598	91	321·0	1179·3	887·9	·2111	4·74	295
44	273·0	1164·6	921·9	·1065	9·39	585	92	321·7	1179·5	887·3	·2133	4·69	292
45	274·4	1165·1	920·9	·1089	9·18	572	93	322·5	1179·8	886·8	·2155	4·64	289
46	275·8	1165·5	919·9	·1111	9·00	561	94	323·3	1180·0	886·3	·2176	4·60	286
47	277·1	1165·9	919·0	·1133	8·82	550	95	324·1	1180·3	885·8	·2198	4·55	283

Properties of Saturated Steam.

Table of the Properties of Saturated Steam—(Continued.)

Total pressure per square inch.	Temperature in Fahrenheit degrees.	Total Heat in Fahrenheit degrees from 32 degrees.	Latent Heat. Fahrenheit degrees.	Density or weight of one cubic foot.	Volume of one pound of Steam.	Relation Volume, or cubic feet of Steam from one cubic foot of Water.	Total pressure per square inch.	Temperature in Fahrenheit degrees.	Total Heat in Fahrenheit degrees from 32 degrees.	Latent Heat. Fahrenheit degrees.	Density or weight of one cubic foot.	Volume of one pound of Steam.	Relation Volume, or cubic feet of Steam from one cubic foot of Water.
Lb.	Fahr.	Fahr.	Fahr.	Lb.	Cubic Feet	Rel. Vol.	Lb.	Fahr.	Fahr.	Fahr.	Lb.	Cubic Feet	Rel. Vol.
96	324·8	1180·5	885·2	·2219	4·51	281	134	349·5	1188·0	867·8	·3040	3·29	205
97	325·6	1180·8	884·6	·2241	4·46	278	135	350·1	1188·2	867·4	·3060	3·27	203
98	326·3	1181·0	884·1	·2263	4·42	275	136	350·6	1188·3	867·0	·3080	3·25	202
99	327·1	1181·2	883·6	·2285	4·37	272	137	351·2	1188·5	866·6	·3101	3·22	200
100	327·9	1181·4	883·1	·2307	4·33	270	138	351·8	1188·7	866·2	3121	3·20	199
101	328·5	1181·6	882·6	·2329	4·29	267	139	352·4	1188·9	865·8	·3142	3·18	198
102	329·1	1181·8	882·1	·2351	4·25	265	140	352·9	1189·0	865·4	·3162	3·16	197
103	329·9	1182·0	881·6	·2373	4·21	262	141	353·5	1189·2	865·0	·3184	3·14	195
104	330·6	1182·2	881·1	·2393	4·18	260	142	354·0	1189·4	864·6	·3206	3·12	194
105	331·3	1182·4	880·7	·2414	4·14	257	143	354·5	1189·6	864·2	·3228	3·10	193
106	331·9	1182·6	880·2	·2435	4·11	255	144	355·0	1189·7	863·9	·3250	3·08	192
107	332·6	1182·8	879·7	·2456	4·07	253	145	355·6	1189·9	863·5	·3273	3·06	190
108	333·3	1183·0	879·2	·2477	4·04	251	146	356·1	1190·0	863·1	·3294	3·04	189
109	334·0	1183·3	878·7	·2499	4·00	249	147	356·7	1190·2	862·7	·3315	3·02	188
110	334·6	1183·5	878·3	·2521	3·97	247	148	357·2	1190·3	862·3	·3336	3·00	187
111	335·3	1183·7	877·8	·2543	3·93	245	149	357·8	1190·5	861·9	·3357	2·98	186
112	336·0	1183·9	877·3	·2564	3·90	243	150	358·3	1190·7	861·5	·3377	2·96	184
113	336·7	1184·1	876·8	·2586	3·86	241	155	361·0	1191·5	859·7	·3484	2·87	179
114	337·4	1184·3	876·3	·2607	3·83	239	160	363·4	1192·2	857·9	·3590	2·79	174
115	338·0	1184·5	875·9	·2628	3·80	237	165	366·0	1132·9	856·2	·3695	2·71	169
116	338·6	1184·7	875·5	·2649	3·77	235	170	368·2	1193·7	854·5	·3798	2·63	164
117	339·3	1184·9	875·0	·2652	3·74	233	175	370·8	1194·4	852·9	·3899	2·56	159
118	339·9	1185·1	874·5	·2674	3·71	231	180	372·9	1195·1	851·3	·4009	2·49	155
119	340·5	1185·3	874·1	·2696	3·68	229	185	375·3	1195·8	849·6	·4117	2·43	151
120	341·1	1185·4	873·7	·2738	3·65	227	190	377·5	1196·5	848·0	·4222	2·37	148
121	341·8	1185·6	873·2	·2759	3·62	225	195	379·7	1197·2	846·5	·4327	2·31	144
122	342·4	1185·8	872·8	·2780	3·59	224	200	381·7	1197·8	845·0	·4431	2·26	141
123	343·0	1186·0	872·3	·2801	3·56	222	210	386·0	1199·1	841·9	·4634	2·16	135
124	343·6	1186·2	871·9	·2822	3·54	221	220	389·9	1200·3	839·2	·4842	2·06	129
125	344·2	1186·4	871·5	·2845	3·51	219	230	393·8	1201·5	836·4	·5052	1·98	123
126	344·8	1186·6	871·1	·2867	3·49	217	240	397·5	1202·6	833·8	·5248	1·90	119
127	345·4	1186·8	870·7	·2889	3·46	215	250	401·1	1203·7	831·2	·5464	1·83	114
128	346·0	1186·9	870·2	·2911	3·44	214	260	404·5	1204·8	828·8	·5669	1·76	110
129	346·6	1187·1	869·8	·2933	3·41	212	270	407·9	1205·8	826·4	·5868	1·70	106
130	347·2	1187·3	869·4	·2955	3·38	211	280	411·2	1206·8	824·1	·6081	1·64	102
131	347·8	1187·5	869·0	·2977	3·35	209	290	414·4	1207·8	821·8	·6273	1·59	99
132	348·3	1187·6	868·6	·2999	3·33	208	300	417·5	1208·7	819·6	·6486	1·54	96
133	348·9	1187·8	868·2	·3020	3·31	206							

Mr William Fairbairn and Mr Thomas Tate read a paper at the meeting of the British Association for the advancement of science in September 1859, containing some approximate results of experiments undertaken by them, for the purpose of determining the law of the density of steam and other condensable vapours, and of testing the deductions from the dynamic theory of heat of Professor Rankine and others, with respect to that subject. The new feature of the experiments consists in the use of the "saturation-guage," to aid in determining with precision the point of saturation of steam. Suppose two globes, called A and B, to be connected by a syphon tube, containing mercury, and the whole to be immersed in a bath, in which they can be raised to any required temperature. If an absolute vacuum be created in each globe, and 20 grains of water be introduced into A, and 30 or 40 grains into B; then, if the temperature be slowly and uniformly raised around the globes, the water within them will be gradually evaporated, and filled with steam of a density increasing with the temperature, until the whole of the water in A is converted into steam, when instantly the line of the mercury, heretofore undisturbed, will rise towards the globe A. The disturbance of level thus occasioned constitutes the saturation-test; it is caused by the change of the steam in A, from the condition of saturation to that of superheating, whilst that in B, which contains a surplus of water, must necessarily continue in the state of saturation, and there is no longer an equilibrium of pressure. The volume of the steam in A is known, and the temperature in the bath at the instant of the disturbance of the mercury is that of saturation. The following is a selection of temperatures and relative volumes of saturated steam approximately reduced from the experiments, with the corresponding volumes reckoned from the foregoing table of the properties of saturated steam:—

Temperature.	Relative Volume by Experiment.	Relative Volume by the Formula.	Difference by Experiment.
244°	896	935	−39
245	890	917	−27
257	751	753	− 2
262	684	695	−11
268	633	632	+ 1
270	604	613	− 9
283	490	504	−14

The nearness of the experimental results to those theoretically established is very remarkable. The differences, as Professor Rankine suggests, may arise from a difference in the value assumed for the volume of water.

The reader is referred to the end of the article STEAM-ENGINE for a list of references to works on steam. The first chapter of this article, it should be stated, is abridged from the article on STEAM in the previous edition of the *Encyclopædia Britannica*. (D. K. C.)

STEAM-ENGINE.

PART I.—HISTORY AND DESCRIPTIVE ACCOUNT OF THE STEAM-ENGINE.

SECTION I.

History and Descriptive Account.

It appears highly probable that the ancients knew more of the phenomena of steam than has been generally admitted; and one evident cause of this mistake is, that no specific term equivalent to the word steam was generally used by them; and water, when heated, was said to be converted into air. Hero of Alexandria, in his *Pneumatics*, written more than 120 years before the Christian era, collected the science and inventions of the ancients, along with some of his own, into a systematic treatise. His book commences with a lucid dissertation on the properties of air as a medium for the communication of pressure and motion, and especially upon the nature and effects of a vacuum, subjects to be thoroughly understood by all who would master the theory of the steam-engine.

The following description of the manner in which the force of steam issuing from a boiler may be applied to support a weight is given in the *Pneumatics*:—"A boiler (fig. 1) perforated on the top is placed on the fire. From the perforation there proceeds a tube on whose extremity is fixed a hollow hemisphere perforated in like manner. If then we place a light ball in the hemispherical cup, it will follow that the vapour rising up from the boiler through the tube will support the sphere, and it will appear to dance."

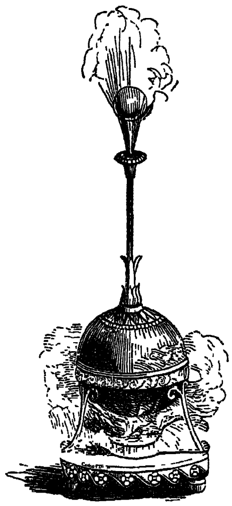


Fig. 1.

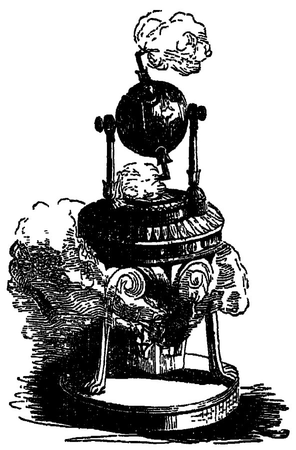


Fig. 2.

There is another apparatus in the *Pneumatics* for producing a revolving motion by the action of steam from a boiler, issuing through a couple of bent arms, from orifices at their extremities (fig. 2); the arms being free to revolve horizontally, do so in obedience to the action of the escaping jets of steam.

The same apparatus, on similar principles, is next applied by Hero to the construction of a machine still more curious. The agent mentioned in this case is rarified air, although the action is of precisely the same nature. Here the science of the philosopher appears to have been degraded to assist the priesthood in deceiving the populace by the resemblance of miraculous interference. "A fire having been kindled upon an altar, living figures will appear to lead a choral dance, even although the altar itself be of transparent glass or horn. Through the epipyrus a pipe is to be let down to the base of the altar, where it is to revolve on an iron pin, the other end being passed through a tubular fitting attached to the epipyrus. And this pipe is to have other little cross-pipes attached to it, and perforated (fig. 3), so as to communicate with it (which

History and Descriptive Account.

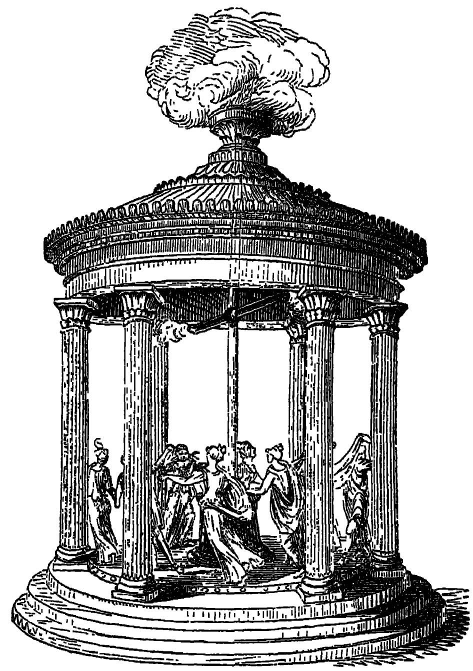


Fig. 3.

are to radiate opposite to one another around it), and turned alternately in opposite directions in the ends. There shall likewise be a drum attached to it, upon which the figures of the dance are to be set. Then by the action of the kindled fire, the air, being warmed, will proceed into the pipe, and from its being driven out through the bent tubes in the base of the altar, will turn round the pipe and its drum."

There is considerable reason to suppose that, to their knowledge of the elements of machinery, the Egyptians added some acquaintance with the power of steam, applied however, only to the degraded service of superstition. The statue of Memnon is said to have emitted sounds which Pausanias compares to those produced by the snapping of the strings of a harp. Strabo expressly states that he heard them; and Philostratus states, that when the sun shone strongly on the statue, sounds issued from its mouth similar to those of a stringed instrument.

The Romans appear to have done little for the mechanical arts, and nothing for the improvement of steam apparatus. It was not until the dawn of knowledge succeeded the darkness of the middle ages, that the light reflected from the works of Hero and the older mechanicians, rekindled the flame of mechanical invention. The works of Archimedes and of Hero were read with great avidity, and formed some of the most popular productions of the young art of printing.

Giambattista Della Porta, an Italian, was one of the ablest expositors of the principles of pneumatics. In his work published at Naples in 1601, he describes a beautiful and simple expedient designed for determining the philosophical question, How much aqueous vapour is formed by a given quantity of water? And it shows an acquaintance with the fact, that water heated by fire is converted into

History and Descriptive Account.

aqueous air, with sufficient force to raise water above its level and form a running stream.

Salomon de Caus, a French engineer, published at Frankfort, in 1615, some account of his works, constructed for the gratification of "gentille curiosité," in which he states that the violence with which water is dissolved into air by means of fire is very great, and that a ball of copper containing water, if placed in a fire, would certainly burst. He afterwards shows how a jet of water may be made to rise above its level, and play in the air by means of fire; a copper ball A (fig. 4) has an orifice D, at which water is poured in, and it is then closed with a stop-cock. Another tube BC is closely fitted to the same ball, but passes down near to the bottom, where it is open in the water: the pipe terminates above in an orifice for a small jet of water, which is regulated by a stop-cock. In fact, the apparatus is precisely that which Hero uses for raising a jet of water, but without the aid of heat, when he forces air above the water, till it raises a jet of water by its pressure. Of course the heat produces the same elastic force in De Caus's machine as the compression of air does in Hero.

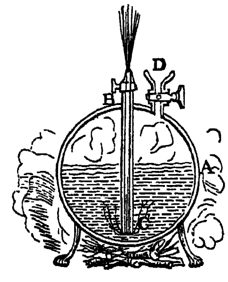


Fig. 4.

The direct emission of steam from an orifice of the boiler, which had been used by Hero to sustain the ball in the air, was applied by Branca, an Italian architect and engineer, to impress a revolving motion on the vanes of a wheel like a common mill-wheel, and this communicating with a series of toothed wheels gave motion to a series of pestles in mortars. This and many other machines were published by him at Rome in 1629. This period appears to have teemed with curiosities of mechanical invention:—Perpetual motions were very common; wings for enabling men to fly in the air, mechanical chariots for a similar purpose, conveyances to the moon, and engines for making continual and cheap music by mills or by fire, for rocking of cradles and turning of spits, were favourite subjects of design; and many of these curious contrivances, without serving any definite purpose, form elegant and curious pieces of apparatus.

The Marquis of Worcester invented and constructed the first actual steam-engine, announced in the *Century of Inventions* in 1663; none of the contrivances before his time were provided with means to make their action continuous. The instrument of De Caus had merely the power of emptying itself of the boiling-water with which it was filled; the engine of Worcester was provided with two vessels to act successively and continuously, in raising water. "Having found a way to make my vessels so that they are straightened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain, 40 feet high. One vessel of water rarified by fire driveth up 40 of cold water; and a man that attends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively." The Marquis enumerates many important practical uses to which his engine might be applied, and many of them it certainly would have been competent to compass. Lord Worcester's "Water-commanding Engine" was the first machine moved by fire of efficacy and permanence: he actually erected one of his engines of about 2-horse power on the banks of the Thames, at Vauxhall, and it was employed in supplying the town with water. Not that any great merit is to be attached even to that contrivance, for it is deducible without any violent stretch of the imagination from the schemes of Hero; and there is no doubt, as Mr Bourne suggests, that the ancients would have realized an effectual steam-engine, if they only had possessed mines that required to be drained, and coal to bestow on such a purpose.

The next forward step of invention was the accomplishment of a vacuum by the agency of steam, by Captain Thomas Savery, who exhibited a model of his engine to the Royal Society in 1669. The Marquis's engine appears to have been placed on or below the level of the water to be raised, and, his vessels being filled, their contents were raised by the elastic force only of the steam; Savery, on the other hand, erected his engine at a height of nearly 30 feet above the level of the water. A large close vessel was filled with steam; this steam was reconverted, by cooling the outside of the vessel, into water, leaving the large space it had formerly occupied vacuous; into this vacuum water was raised, as into the vacuum of a common sucking-pump, by atmospheric pressure, and so within the limit of atmospheric pressure, raised 28 or 30 feet. After this was accomplished, the water was further raised by the elastic force of the steam, just as in the engine of the Marquis of Worcester. But the improvement was great, and led to the general use of steam as a means of raising water. Fig. 5 represents this engine as applied to draw water from deep mines. It is placed under ground, on a platform from 20 to 30 feet above the level of the water at A. The chimney ascends in the shaft of the mine along with a pipe, through which the water is forced to the surface. The engine consisted of two boilers, in which the necessary steam was generated, and two receivers with valves. The process of pumping was effected by admitting steam into one of the receivers *a*, and then cutting off the connection with the boiler. The steam was suddenly condensed by means of a jet of cold water, which, forming a vacuum, the water to be lifted rushed up the pipe *b*, to refill the receiver. Steam was then admitted from the boiler to press upon the water in the receiver, and all connection with *b* being cut off by a valve, the water was forced up the pipe *c*, and discharged into the trough *d*. The steam in the receiver *a*, being again condensed, the process was repeated; and thus by the alternate action of two receivers, a continuous stream was maintained.

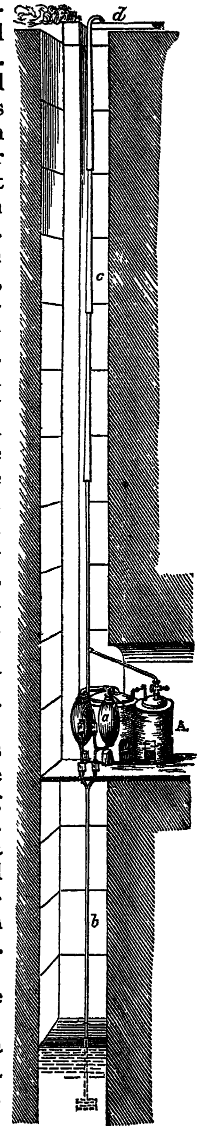


Fig. 5.

One of the first uses of Savery's engine, proposed by himself, was to raise water to fall on a mill-wheel, turning machinery as by a common fall of water. Several engines were erected by a Mr Joshua Rigley at Manchester, and throughout Lancashire, to impel the machinery of some of the earliest cotton mills and manufactories of the district. One was erected at St Pancras, London, at the manufactory of a Mr Kier, where it long continued to turn lathes, &c.

Dr Denis Papin, in 1690, proposed a scheme for producing a vacuum under a piston,—first of all by gunpowder, and afterwards by steam. He had a cylinder A B C D (fig. 6), containing a piston P, below which he placed a fire, and so as to generate steam from a little water in the bottom of the cylinder. This steam raised the piston, which was secured in its elevated position by a catch; then the fire was removed, the steam

condensed, and the piston was released and forced down by the pressure of the atmosphere. This plan, though crude, contained the earliest suggestion of a vacuum under a piston by the agency of steam.

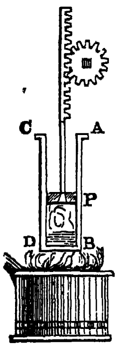


Fig. 6.

But Papin halted there. His proposed modes of procuring a vacuum by removing the fire was a step in retrogression from Savery's practice, which was to pour water over the receiver, and operate by surface condensation. In Savery's engine, however, there was the waste of steam consumed in re-heating the receivers and the upper stratum of water, every time it was admitted for the purpose of forcing up the water. It was reserved for Newcomen and Cawley of Dartford to combine the good points of Savery and Papin:—a separate boiler and furnace, and a separate cylinder and piston, with a distinct water-pump connected with the piston through the medium of a beam; a means of rapid condensation by injecting water into the cylinder in direct contact with the steam to be condensed, and a system of self-acting valves, which were opened and closed by the reciprocations of the beam, without the usual agency of an attendant. The history of the discovery of the two last-named features is thus concisely given by Dr Desaguliers:—"They were surprised to see the engine go several strokes and very quick together, when after a search they found a hole in the piston which let the cold water in to condense the steam in the inside of the cylinder, whereas before they had always done it on the outside. They used before to work with a buoy in the cylinder enclosed in a pipe, which buoy rose when the steam was strong, and opened the injection-pipe and made a stroke, whereby they were capable of only giving six, eight, or ten strokes in a minute, till a boy named Humphrey Potter, who attended the engine, added what he called a *scoggan*, by which the beam of the engine always opened and shut its own valves, and then it would go (entirely without the attendance of a man) fifteen or sixteen strokes in a minute. But this being perplexed with catches and strings, Mr Henry Beighton, in an engine he had built at Newcastle-on-Tyne in 1788, took them all away, the beam itself supplying all much better." Thus, for more than half a century, the engine remained in general use without any material change.

Newcomen, Potter, and Beighton had rendered the atmospheric steam-engine an independent self-acting mechanical power of so great perfection in its principle of action, and its minor details, as to be very generally introduced as a substitute for the power of animals in draining mines and collieries, and to confer very great advantages in those important and primary sources of national industry and wealth. The saving of money from this change was so great as to be continually opening up new avenues of mining enterprize, by the rapid progress of which the capabilities of the engine were soon put to the severest trial. The cylinders, which had been originally of 12 and 16 inches diameter, were gradually increased to 60 inches. Along with this dimension, the other parts required to be increased in a still higher proportion; and at last the structure became so gigantic as to demand an amount of science and practical skill which was rare in that period. The man suited to the emergency at last arose in the father of civil engineering, the justly celebrated Smeaton, who brought to bear on this subject endowments and accomplishments seldom united. He conferred upon the atmospheric steam-engine all the extent and variety of application of which it was capable, and all the perfection of proportion and execution which the state of the mechanical arts could then afford. The most magnificent of Smeaton's works in this department is his great Chasewater engine, of which the details are also given in his reports, and which abound in ingenious contrivances and judicious arrangement. This engine was of 150 horse-power, turning out 880 hogsheads of water per hour, by the heat of $16\frac{1}{2}$ bushels of coal. The cylinder A B, fig. 7, is 72 inches in diameter, the stroke 10 feet 6 inches. The great lever or beam of the engine D D consists of twenty large bulks of timber, the four nearest the centre being each a foot square, and the whole firmly joggled together with heart of oak, and bolted with iron, forming a very elegant but ponderous beam. The beams F F upon which the cylinder rests are kept in their place by being entered into the side-walls of the house, and are joggled and framed together similarly to the great lever; G is the boiler, H the furnace, I B the steam-pipe, J the injection-pipe, K the injection cistern, fed by a pump L, which is wrought by the great lever, M the waste-pipe for the condensed steam. On the left edge of the figure is the spear or rod of the great

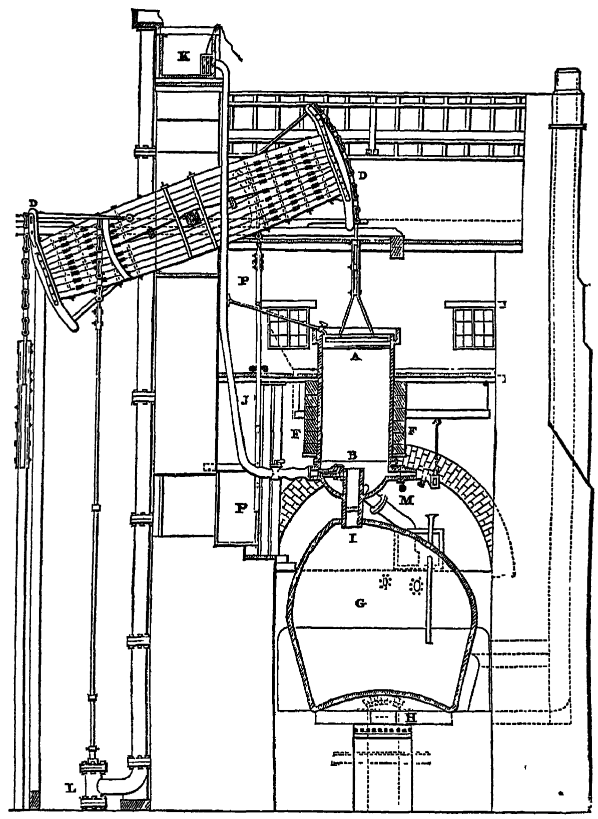


Fig. 7.

draining-pump, wrought by the engine; P P is the plug-tree, suspended from the main beam and carrying plugs, which in their upward and downward progress act on the levers which open and shut the regulator and injection-cocks. The date of this engine is 1775. Its working gear, which is very simple and good, is represented on a larger scale in fig. 8, for those who are conscientious enough to study it.

A collateral scintillation of invention was exhibited by Jacob Leupold in 1725, who inverted the ordinary Newcomen's engine, causing the engine to do its work against the atmosphere. He introduced comparatively high pressure steam below a piston, and raised it against the pressure of the atmosphere, plus the active resistance of the column of water forced up by a pump. His machine (figs. 9 and 10) was a true water-pumping high-pressure steam-engine, and might be efficiently used without any alteration at the present day, only the modern machines do the work with less fuel. Two pumps T V for raising water are directly worked by steam by connecting the handles G H of these

pumps with the pistons of two high-pressure cylinders C D in such a manner that, when the pistons are raised by the

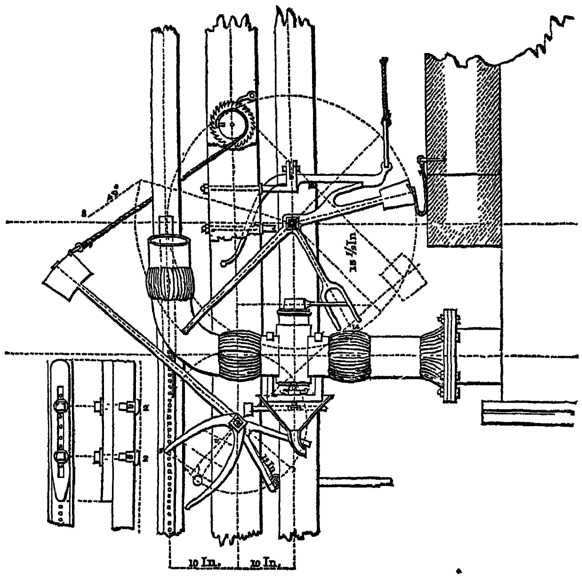
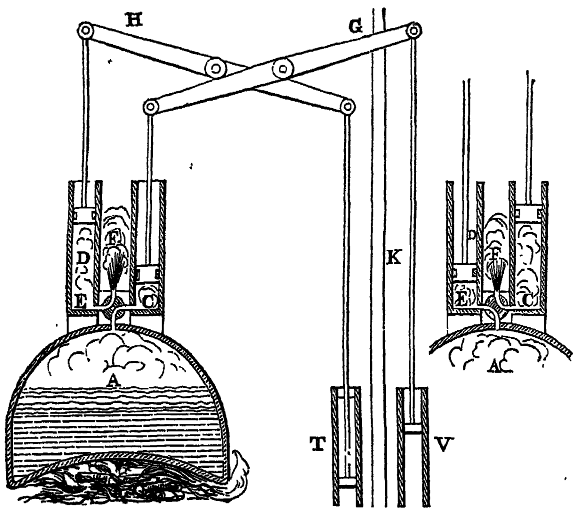


Fig. 8.

steam, the water is forced up in the pump-pipe K. In fig. 9, at A C, the steam is entering the cylinder C, and push-



Figs. 9 and 10.

ing up the end of the lever G, so as to force the water; and in fig. 10 the steam is shown entering the cylinder D to work it. This change is effected by turning round the disc A F into the position which reverses the passages. Thus, while the steam is entering the cylinder C (fig. 9) through A C, the steam from the cylinder D is escaping through E F into the open air; and in fig. 10 the steam is passing into the cylinder D through A E, and out of the cylinder C through C F. The action of this four-way stop-cock is very simple and beautiful, and deserves to be carefully studied. By continually turning it in one direction, communications are simultaneously effected between the boiler and each of the cylinders alternately, and between each cylinder and the open air.

Hitherto the fire-engine, even in Smeaton's hands, was so imperfect, that it wasted a large quantity of fuel and of steam in doing what was useless, viz., heating the cylinder, which was cooled alternately in each stroke by the cold water injected into it. In Long Benton colliery engine, out of 63 cubic feet of steam 32 were thus wasted, and the remaining 31 feet alone performed useful work. There remained, therefore, one-half of the power of the steam and expense of the fuel to be saved by future improvements, provided the useless heating and cooling of the cylinder could be avoided. The vacuum formed below the cylinder was also far from being perfect. In this state James Watt found the atmospheric fire-engine in the hands of Smeaton, and produced from it the pure steam-engine, which he left to us in its present state of high improvement. He was the man who turned the scale of expense in favour of the fire-engine, when it was a more costly power than horses, except when fuel was extremely cheap. In his hands it ceased to be an atmospheric engine, and became wholly a steam-engine, capable of being applied to any purpose, on a much larger scale, and at much less expense than the power of horses. He reflected that, "in order to make the best use of the steam, it was necessary, first, that the cylinder should be maintained always as hot as the steam which entered it; and secondly, that when the steam was condensed, the water of which it was composed, and the injection itself, should be cooled down to 100°, or lower where that was possible." The means of accomplishing these objects occurred to Mr Watt in 1765:—The separate condenser, distinct from but in connection with the steam-cylinder, into which the steam from the cylinder would flow, and in which all the operations of condensation could be performed by surrounding it with cold water, or by injection, or both. The water which would necessarily accumulate in the condenser, Mr Watt proposed to remove by means of a pump. "It next occurred to me," says Mr Watt, "that the mouth of the cylinder, being open, the air which entered to act on the piston would cool the cylinder, and condense some steam on again filling it. I therefore proposed to put an air-tight cover upon the cylinder, with a hole and stuffing-box for the piston rod to slide through, and to admit steam above the piston to act upon it instead of the atmosphere. There still remained another source of the destruction of steam, the cooling of the cylinder by the external air, which would produce an internal condensation whenever steam entered it, and which would be repeated every stroke. This I proposed to remedy by an external cylinder containing steam, surrounded by another of wood, or of some other substance which would conduct heat slowly.

"When once the idea of the separate condensation was started, all these improvements followed as corollaries in quick succession; so that, in the course of one or two days, the invention was thus far complete in my mind, and I immediately set about an experiment to verify it practically. I took a large brass syringe A, $1\frac{3}{4}$ inches diameter and 10 inches long, made a cover and bottom to it of tin-plate, with a pipe S to convey steam to both ends of the cylinder from the boiler; another pipe E to convey steam from the upper end to the condenser (for to save apparatus I inverted the cylinder). I drilled a hole longitudinally through the axis of the stem of P the piston, and fixed a valve at its lower end, to permit the water which was produced by the condensed steam on first filling the cylinder to issue. The condenser used upon this occasion consisted of two pipes *a b*, *c d* of thin tin-plate, 10 or 12 inches long and about $\frac{1}{6}$th-inch diameter, standing perpendicular and communicating at top with a short horizontal pipe *h* of large diameter, having an aperture on its upper side which was shut by a valve opening upwards. These pipes were joined at bottom to another perpendicular pipe *p* of about an inch diameter, which served for the air and water pump, and both the condensing pipes and the air-pump were placed in a small cistern C filled with cold water.

"The steam-pipe was adjusted to a small boiler B.

When steam was produced it was admitted into the cylinder, and soon issued through the perforation of the

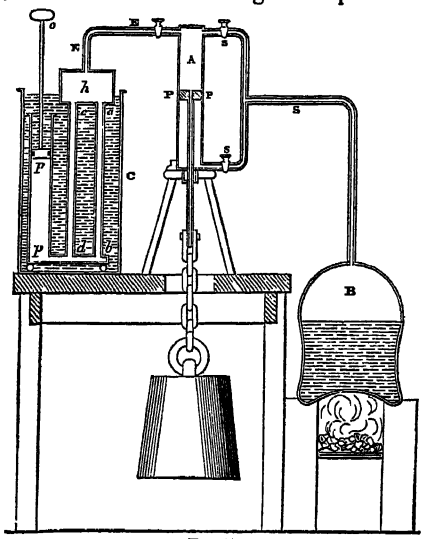


Fig. 11.

rod, and at the valve of the condenser. When it was judged that the air was expelled, the steam-cock was shut, and the air-pump piston-rod was drawn up, which leaving the small pipes of the condenser in a state of vacuum, the steam entered them and was condensed. The piston of the cylinder immediately arose, and lifted a weight of about 18 lbs. which was hung to the lower end of the piston-rod. The exhaustion-cock was shut, the steam was re-admitted into the cylinder, and the operation was repeated; the quantity of steam consumed, and the weights it could raise were observed; and excepting the non-application of the steam case and external covering, the invention was complete in so far as regarded the savings of steam and fuel. A large model with an outer cylinder and wooden case (fig. 12) was immediately constructed, and the experiments made with it served to verify the expectations I had formed, and to place the advantage of the invention beyond the reach of doubt." Mr Watt patented his inventions in the steam-engine in 1768.

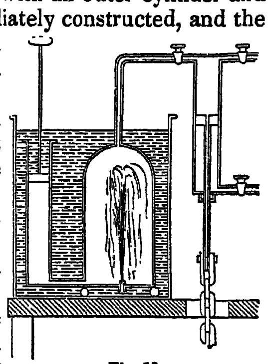


Fig. 12.

In recapitulation, it appears that the invention of the steam-engine as a useful and permanent machine originated with the Marquis of Worcester, that he employed high-pressed steam in close vessels pressing directly upon water contained in them, and forcing it to considerable elevations above the level of the engine. Second, Captain Savery created a vacuum within the vessels by means of cold water applied externally, so as to lift the water from below the level of the engine, as well as to force it above the level. Third, Papin proposed the use of a cylinder and piston separate and distinct from but connected with the work to be done, but showed no practicable application of the proposal. Fourth, Newcomen and Cawley successfully embodied Papin's idea of the independent cylinder and piston connected by a beam to the pumps for raising water, and they greatly accelerated the action and increased the efficiency of the machine by internal condensation, or the injection of cold water within the cylinder. Fifth, James Watt added the separate condenser—a chamber distinct from but auxiliary to the working cylinder, in which internal condensation was effected without necessarily cooling the cylinder and wasting steam in re-heating it, which was unavoidable in Newcomen's engine. We have, then, the boiler or generator, with its appendages; the cylinder or applicator, with its appendages; and the refrigerator or condenser, with its appendages—the function to be discharged by the first of these being altogether the reverse of the last; the first producing steam by heat from water, the last producing water from steam by cooling. Papin's scheme was possible but impracticable; Newcomen's system was practicable but wasteful; Watt's system was practical, economical, and complete.

Mr Watt's first engines are in general form represented by fig. 13, in which A represents the cylinder of his earlier

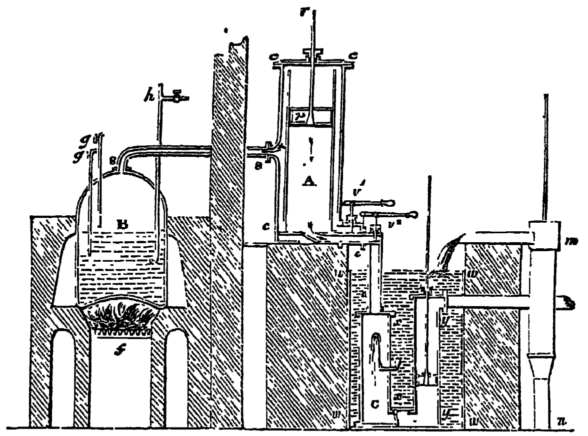


Fig. 13.

engine, B the boiler, and C the condenser, each with its various appendages. The appendages of the boiler B are, of course *f*, the furnace; *g g* small pipes for showing the height of the water in the boiler; *h* a pipe for supplying the boiler with water as it passes off in the form of steam; *s s* a pipe for conveying the steam to the cylinder. The appendages of the cylinder are—*p* the piston, fitting accurately the inside of the cylinder, and surrounded with hemp-packing, soaked with tallow and oil, so as to be steam-tight; the jacket or casing *c c c c*, which prevents the cold air of the atmosphere from entering into and cooling the cylinder at the expense of afterwards heating it by the steam; and instead of allowing such air to enter at the top of the cylinder A and press down the piston, as in Newcomen's engine, the hot steam is substituted, which, being of an elasticity equal to the force of the atmosphere, presses it towards the bottom of the cylinder. On this being accomplished, the handle of the valve v^1 is raised so as to admit the steam below as well as above the piston, which equilibrium of upward and downward pressure allows the piston again to rise, in consequence of a counter weight connected with the top of the piston-rod *r*, and this opening, of what is called the steam-valve v^1, continues until the piston again reaches the top of the cylinder, when it is closed. The eduction valve v^2, which is at that moment opened, permits the steam to escape suddenly into the condenser, when it becomes water, and leaves the space below the cylinder vacuous, so as to give free space for the piston to be carried down into the cylinder by the pressure of the steam upon the top of the piston. These, the casing, piston, piston-rod, steam-valve, eduction-valve, and communicating passages are appendages of the second great member of the machine, viz., the cylinder, by which the power of the steam is applied to give the required motion to whatever solid machinery may be placed in connection with the piston-rod. The appendages of the condenser C of Mr Watt are as follows:—First of all, a large cistern *w* of cold water is provided, and furnished continually with fresh supplies of cold water either from a

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running stream or by means of a pump in or wrought by the engine itself; in this is placed the condensing chamber *c x x*, wholly surrounded by cold water, but perfectly empty, excepting that a small jet of cold water from the exterior is admitted through a regulated aperture to play in the inside, by which injection it has always been observed that the condensation of the steam is more efficient than when a casing of metal intervenes between the cold water and the steam. The eduction-pipe *e e e* conducts the steam out of the cylinder by the valve v^2 into the condenser *x x*, where it is reduced back into the water from which it had been originally generated. Now, it must be obvious on a little consideration, that the water which is injected into the condenser must rapidly accumulate there, becoming at the same time warmed by mixing with the steam, and so would impede the progress of condensation by ultimately filling up the interior of the condensing chamber, which should be kept vacuous; and further, that the steam itself, becoming reconverted into water, would soon accumulate in the condenser and choke it up. Hence a principal appendage of the condenser is a large pump, which is essential to its long-continued efficient action, and which withdraws a portion of the accumulated warm water from the interior of the condenser, and keeps it vacuous; and because there is generally air in the water, and because, also, air is very apt to insinuate itself by many chinks or crevices into the condenser, this clearing pump must be capable of pumping out air as well as water. This appendage of the condenser, represented in the preceding figure by *y y*, is generally termed the "air-pump," a name which but imperfectly expresses its functions.

Fire being placed under the boiler, its heat, communicated to the water, rapidly expands that water, and rarifies it into steam, by the addition of more than five times the heat which would raise its temperature from the freezing to the boiling point. This combination of heat and water, forming the steam, rushes along the steam-pipe into the cylinder casing, and is admitted into the interior of the machine, filling all its chambers and pipes with steam; but that portion of the steam which is in communication with the condenser, being instantly chilled by the jet of cold water and the cold sides of the vessels in the cold well, is condensed, and then the valve v^2 being closed so as to admit no more steam into the condenser, and the valve v^1 being closed so as to admit no more steam into the lower part of the cylinder below the piston, there remains the elastic force of the steam above pressing it towards the bottom of the cylinder with a force proportioned to the pressure of the steam and the extent of the cylinder. Thus, a moving power is generated in the cylinder by the steam which may be conveyed through the piston-rod *r*, and applied through various mechanism of application to the performance of the required work. The steam which has thus pressed down the piston is now admitted below to neutralize the force of that which remains; and having thus done its duty, is again annihilated by the opening of the communication into the condenser, into which it rushes; and being almost instantly deprived of the heat which gave it power and magnitude, there remains nothing except the few spoonfuls of water from which all that volume of steam had arisen, now lying inert at the bottom of the cylinder. This dead water is not yet cold. It is evident that in the primary generation of steam in the boiler, the supply of water must be rapidly diminished by this boiling off, and this water must somehow be supplied. Now, here lies an opportunity for economy; this waste, instead of being supplied by cold water, may be better replenished with the water of the condenser, which is highly heated in condensing the steam from the cylinder.

Mr Watt's engine was first used as a substitute for the engine of Newcomen in pumping up water or draining mines. In 1788 it had attained the form represented in fig. 14, as placed within the walls of a building, the anterior portion of which is omitted, to show the machine. On the left stands the boiler outside the building; and on the right also outside the house, is the large pump, by which the water is raised and the work of the engine performed. Nearly in the middle stands the cylinder, with its appendages, and below these are the well and condensing apparatus.

Beginning with the apparatus for generating steam. It is the boiler of what is called the wagon shape, set in a furnace of brickwork immediately over the fire, which rests on the fire-bars at *p*, over a deep ash-pit; the flame passes under the concave bottom of the boiler to the further end, and there, instead of proceeding at once up the chimney, returns by O on the left side of the boiler, through the brick channel or flue, giving out additional heat to the water, and after passing across the front of the boiler, proceeds along the right hand flue *o* in the chimney. The draught of the chimney is regulated by the damper *r*, which is lowered into the flue or raised out of it in any degree by the attendant, and so permits the gases to rush with

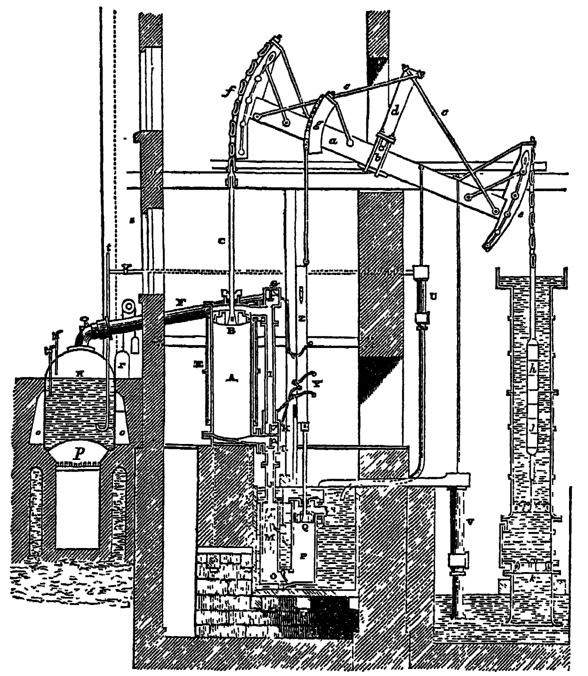

Fig. 14.

greater or less ease up the chimney. A tube *t*, regulated by a stop-cock, comes from a small pump U, on the right hand side of the cylinder, which raises the warm water discharged by the air-pump, and sends it into the boiler, so as to replenish its waste; this pipe and pump being generally named the feed-pipe and tube. The two little tubes proceeding from the water in the boiler are open at both ends, and have external stop-cocks, which are always shut, except when the attendant wishes to ascertain the height of the water in the boiler. He then opens these guage-cocks, and observing whether water or steam issues from them, forms his judgment accordingly. F is the steam-pipe which carries the steam from the boiler to the cylinder.

The second great member of the machine, the working-cylinder A, is placed in the engine-house. It contains the moving piston B, which communicates the force impressed on it by the steam, through the piston-rod *c*, and the chain *f* to the end of the great lever or working-beam *f a e*, which is forced up and down around the fixed centre or iron gudgeon *b*, and so raises or depresses the other end of the lever on the right hand side of the figure, and thus

gives the required motion to *hj* the piston and rods in the barrel of the great pump, in which the work of raising water to a height or from a mine is the useful labour or duty to be performed by the engine. Returning to the cylinder at A, we have now to examine the mechanism by which the steam is admitted alternately above and below the piston, through the openings or ports which may be observed on the right hand side of the cylinder at top and bottom. F is the steam-pipe which brings steam from the boiler to the top of the valve-passages, and the pipe I conducts it down to the bottom valves and port at K, and the pipe J forming the eduction-pipe, conducts the steam into the refrigerating apparatus, where it is finally condensed. In commencing to work the machine, the duty of the attendant is to allow the steam to pass freely into all the pipes, passages, and ports F, G, I, J, &c., filling the cylinder A, the condenser M, and passing out at an aperture O, closed by a valve, called the blow-off valve, by means of which operation the whole of the parts being filled with steam, are rendered vacuous from air, and this preparatory process is called blowing through. At G is a steam nozzle and valve, or regulator, which allows the steam to enter the cylinder at the upper part whenever it is opened, by raising the metallic cover or valve from the opening of the nozzle immediately below, which it exactly fits. At K is a similar contrivance, called the equilibrium valve and nozzle, which admits steam through the pipe I into the bottom part of the cylinder, and the third, or exhaustion valve and nozzle or aperture, allows the final egress of the steam into the condenser. After the engine has been wholly filled with steam, the piston B, being at the top of the cylinder, the injection-cock N is suddenly opened, and the cold jet of water playing amongst the steam condenses it instantaneously, forming a vacuum into which the steam from the cylinder instantly rushes, and is in like manner annihilated, leaving the cylinder below the piston equally vacuous; and, of course, the steam from the boiler, on being admitted by the valve G to the upper side of the piston, instantly presses it down into the vacuum below with a force proportional to the perfection of that vacuum and to the pressure of the steam. Thus, the engine makes its first stroke, and raises the water of the great pump on the right of the figure, and the weight of the chain, rod, and bucket, and also a counterpoise *h*, added for restoring the beam to its former position, which it does in the following manner. The equilibrium valve K is opened, and the steam getting admission below the piston, as well as above it, ceases to urge it in either direction, and being thus in equilibrio, the piston would remain passively in its place at the bottom of the cylinder; but the counterpoise *h*, and the weight of the pump, rods, and bucket in the large pump on the outside, draw down the outer end of the great lever or working-beam *f a e*, and so raise the anterior end *f* and the piston B to the top of the cylinder. The equilibrium valve is then closed at K, and the eduction-valve L is opened, so as to allow the steam below the piston to rush down into the condenser and leave a vacuum under the piston, into which it is immediately forced down by the pressure of the steam above A, as at first, and raising water at the other end of the beam through a second stroke; and thus, by the continual opening and shutting of the valves by the attendant, the engine performs its work. But we have still to consider the mechanism by which the machine shuts and opens its own valves; for this purpose we have given in fig. 15 two separate and enlarged drawings of one of the valves and its working gear; *l i l* is a part of the air-pump rod, formed of wood, called the plug-frame or plug-tree, on which are two projecting plugs of wood to work the upper and lower valves. One of these plugs is seen at *i*. As the plugtree moves up and down, the plugs strike the handles or working gear of the valves, and open or shut them at the proper instant. The valve D E is called a conical valve, because the small cover D which closes the opening of the nozzle is slightly tapered downwards, so as the more readily to fit its seat, from which it is lifted by a small-toothed rack and pinion *c*, moved by a spindle from without, and communicating by rods with the valve gear at *r*, or at *z* and *y* in figure 14. When the plug frame *l i l* descends, the valve D is closed by the plug *i*, and the valve K is shut, and the valve L in fig. 14 opened by the plug *y*.

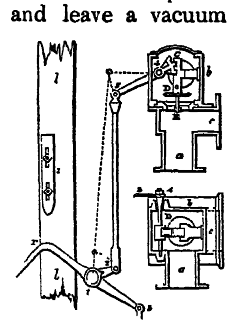

Fig 15.

Returning to figure 14, where the condensing apparatus and its appendages are placed almost immediately under the cylinder, and to the right of it. The eduction-pipe J conducts the steam into the condensing chamber M, which is in the middle of the cold well, wholly surrounded by cold water, and through the regulated aperture N a jet of cold water, pressed in by the atmosphere, is allowed to play in the inside of it amongst the steam. P the air-pump is also placed in the cold well, surrounded by water; Q the piston or bucket of the air-pump, is worked up and down by the piston-rod Q Y Z *g* from the great lever. The valve R closes when the piston descends, and opens on its ascent, allowing water and air to pass into the air-pump, but preventing their return; and the upper valve of the air-pump S allows the escape of water and air outwards, but prevents their return; this valve S leads to the hot well T, from which the feed-pump U supplies water for the boiler.

The great advantage of Mr Watt's form consists in avoiding the excessive waste of steam formerly occasioned by condensing in the cylinder itself. The cylinder now is always hot, and therefore perfectly dry. By the time Mr Watt had completed these improvements, his experiments on steam had given him a pretty accurate knowledge of its density; and he found that the quantity of steam employed did not much exceed what would fill the cylinder, so that very little was unavoidably wasted. But before he could bring the engine to this degree of perfection, he had many difficulties to overcome. He enclosed the cylinder in another containing steam, and that in a wooden case at a small distance from it, which effectually prevented all condensation in the inner cylinder from external influence; and the condensation by the outer cylinder was very small.

In order to regulate the power of the engines when working light loads, Mr Watt introduced the variety which he called the *expansive engine*, the principle of which had first occurred to him in 1769, and was applied by him about 1776. "The steam-valve is always allowed to open fully; the pins of the plug-frame are regulated so that that valve shall shut the moment the piston has descended a certain portion, suppose one-fourth, one-third, or one-half of the length of the cylinder. Thus far the cylinder is occupied by steam as elastic as common air. In pressing the piston farther down, it behoves the steam to expand and its elasticity to diminish. It is plain that this can be done in any degree we please, and that the adjustment can be varied in a minute by shifting the plug-pins.

"In the meantime, the pressure on the piston is continually changing, and consequently the accelerating force. The motion, therefore, will no longer be uniformly accelerated. It will approach much faster to uniformity; nay, it may be retarded, because, although the pressure on the piston at the beginning of the stroke may exceed the resistance of the load, yet, when the piston is near the bottom, the resistance may exceed the pressure."

Hitherto we have considered the condensing steam-engine of Watt as applied to work the large pumps used to

draw water from mines, or to supply reservoirs from a lower level. This, indeed, was the most obvious and immediate application of the steam-engine, which was at first introduced as a substitute for the atmospheric pumping-engine of Newcomen. But it had always been matter of regret that one-half of the motion was unaccompanied by any work. It was a very obvious thing to Mr Watt, that as the steam admitted above the piston pressed it down, so steam admitted below the piston would press it up with the same force, provided a vacuum was made on its upper side. This was easily done, by connecting the lower end of the cylinder with the boiler, and the upper end with the condenser. The steam-engine of revolution of Mr Watt was an invention subsequent to the mining steam-engine, or "water commanding machine." Previously to the time of Watt, indeed, there had been a few attempts to produce a revolving motion by steam, such as the case where the engines of Savery and Newcomen drew up water to turn a wheel. There had also been many attempts to apply the old pumping-engine directly to this purpose. Jonathan Hulls, Keane, Fitzgerald, Mr Oxley, John Stewart, and Matthew Wasbrough, had all contrived some means of producing a revolving motion from the reciprocation of the great beam; but Watt's engine alone was capable of being rendered an efficient and economical motive-power for driving machinery of continual motion. The earliest record of the invention was in 1774. The Albion Mill

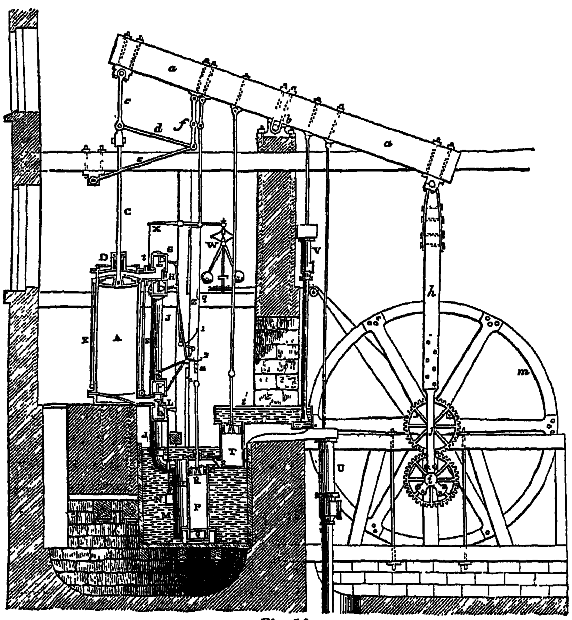

Fig. 16.

engine (figs. 16 and 17) were amongst the earliest rotative engines made for sale.

The steam-pipe F conveys steam from the boiler n to the cross-pipe or upper steam-nozzle G, and by the perpendicular steam-pipe I, to the lower steam-nozzle K. In the nozzle G is a valve, which, when open, admits steam into the cylinder above the piston B (fig. 16), through the horizontal square pipe at its top; and in the lower steam-nozzle K there is another valve, which, when open, admits steam into the cylinder below the piston. In the upper exhaustion-nozzle H is a valve, which, when open, admits steam to pass from the cylinder above the piston into the exhaustion-pipe J, which conveys it to the condensing vessel M, where it meets the jet of the injection from the cock M, and is reduced to water; and in the lower exhaustion-nozzle L there is also a valve, which, when open, admits steam to pass out of the cylinder below the piston, by the eduction-pipe into the condenser M.

"The piston being at the top of its stroke, the valves G and L are to be opened, and the fly-wheel M turned by hand about the eighth of a revolution, or more, in

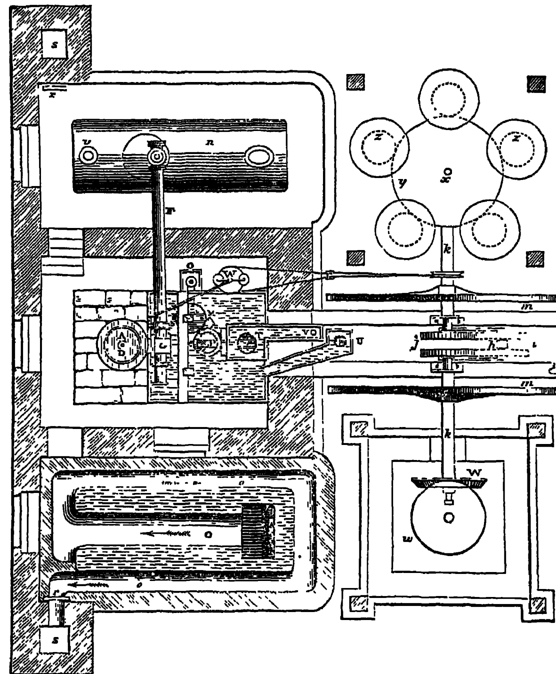

Fig. 17.

the direction in which it is intended to move; the steam which is then in the cylinder will pass by L into the condenser, when, meeting the jet of water from the injection-cock, it will be converted into water, and the cylinder thus becoming exhausted, the steam, entering the cylinder by the valve G, will press upon the piston, and cause it to descend, while, by its action upon the working-beam through the piston-rod, &c., it pulls down the cylinder out of the beam and raises up the outer end and the connecting-rod h, which causes the planet-wheel i to tend to revolve round the sun-wheel j; but the former of these wheels being fixed upon the connecting-rod, so that it cannot turn upon its own axis, and its teeth being engaged in those of the sun-wheel, the latter, and the fly-wheel, upon whose axle or shaft it is fixed, are made to revolve in the desired direction, and give motion to the millwork.

"As the piston descends, the plug-tree Z also descends, and a clamp or slider q, fixed upon the side of the plug-tree, presses upon the handle 1 of the upper Y shaft, or axis, and thereby shuts the valves G and L; and the same operation, by disengaging a detent, permits a weight suspended to the arm of the lower Y shaft to turn the shaft upon its axis, and thereby to open the valves K and H. Just before the opening of these valves, the piston had reached the lowest part of its stroke, and the cylinder above the piston was filled with steam; but as soon as H is opened, that steam rushes, by the eduction-pipe J, into the condenser, and leaves the cylinder empty above the piston. The steam from the boiler entering by I and K, acts upon the lower side of the piston, and forces it to return to the top of the cylinder. When the piston is very near the upper limit of its stroke, another slider A raises the handle Q, and in so doing disengages the catch, which permits the upper Y shaft to revolve upon its own axis and open the valves G and L, and the downward stroke recommences, as has been related.

When the piston descends, the buckets R, T of the air-pump p and hot-water pump T also descend. The water which is contained in these pumps passes through the valves

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of their buckets, and is drawn up and discharged by them through the lander or trough *t* by the next descending stroke of the piston. Part of this water is raised up by the pump N for the supply of the boiler, and the rest runs to waste.

The history of the steam-engine in a great measure ends with the history of Mr Watt's labours. There remain, of course, important improvements in points more nearly of detail; and it would be unfair to ignore the doings of Watt, and others, in the article of boilers. For a consideration of these and other points arising for discussion, the reader is referred to the succeeding portions of this treatise.

The names of many individuals who have in earlier times distinguished themselves by ingenuity directed to the steam-engine have been omitted in this notice, not because we consider their labours either undeserving of notice or uninteresting to the general reader, but because they have not contributed towards the production of the modern steam-engine, and because an account of their works would rather serve to illustrate the possible varieties of the machine and the fertility of the human mind in mechanical devices, than either to conduct the reader along the stream of historical succession, or render him better acquainted with the nature and mechanical peculiarities of the steam-engine itself.

For the important purpose of converting reciprocating rectilineal into rotary motion, Mr Watt had early designed the application of the crank. A crank is an elementary machine, which has been used from the earliest times for converting a revolving into a rectilineal motion, or the reverse. A crank is merely a handle to a wheel, by which it may be turned round. In fig. 18, let *ax* be an axis of a wheel *bcd*, and *a*RP the usual bent (or crooked) handle by which it is turned round by the man, whose arm first pushes it from him, and then draws it towards him, and so continually turns the wheel round, then the part *a*R radiating from the centre, is called the crank, the axis *ax* is called the crank-axle, and the straight part PR is called the crank-pin.

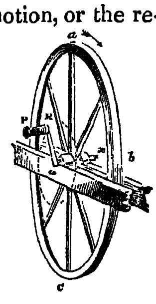


Fig. 18.

The idea of the crank had very early occurred to Mr Watt; "but my attention," says he, "being fully employed in making and erecting engines for raising water, it remained *in petto* until about the year 1778 or 1779, when Mr Wasbrough erected one of his ratchet-wheel engines at Birmingham, the frequent breakages and irregularities of which recalled the subject to my mind, and I proceeded to make a model of my method, which answered my expectations; but having neglected to take out a patent, the invention was communicated by a workman employed to make the model to some of the people about Mr Wasbrough's engine, and a patent was taken out by them for the application of the crank to steam-engines. This fact the said workman confessed, and the engineer who directed the works acknowledged it, but said, nevertheless, the same idea had occurred to him prior to his hearing of mine, and that he had even made a model of it before that time, which might be a fact, as the application of a single crank was sufficiently obvious. In these circumstances I thought it better to endeavour to accomplish the same end by other means, than to enter into litigation, and if successful, by demolishing the patent, to lay the matter open to every body. Accordingly, in 1781, I invented and took out a patent for several methods of producing rotative motions from reciprocating ones, amongst which was the method of the sun and planet wheels, above described."

Oliver Evans, of Philadelphia, United States, devoted himself to the development of the non-condensing, high-pressure steam-engine, in which the condenser was superseded, and the steam was treated as in Leupold's engine, and exhausted into the atmosphere. Before 1785 he had erected and made experiments upon a high-pressure engine, which seems to have been in all essential respects similar to our own. Indeed, it appears that the Americans have taken the form and arrangements of their engines from Evans, as implicitly as in this country we have adopted those of Watt. The history of Evans consists almost entirely of the romance of real life. Sanguine and energetic, he continually encountered difficulties only to overcome them, and to encounter renewed disaster and disappointment, till he at length died of a broken heart. To him may be attributed the rapid advancement of America, at the commencement of the present century, in all that relates to the introduction of the steam-engine in its multifarious applications, and especially in steam navigation. He had awakened in that nation a lively sense of the advantages they were likely to derive from the power of steam, and placed in their hands an instrument well fitted for their use, and which they were not slow to adopt and apply.

Cylinder-Valves and their Mechanism.

SECTION II.—CYLINDER-VALVES AND THEIR MECHANISM—HISTORICAL AND DESCRIPTIVE ACCOUNT.

The modern non-condensing steam-engine is in principle the same as Leupold's engine; and if the latter be supposed to be consolidated into one cylinder, double-acting, analogous to the conversion of the single-acting condensing engine by Mr Watt into double action, its operation would be represented by the figure 19, which comprises an automatic valve, or four-way cock, opened and closed by the reciprocating movements of the beam. A vertical rod, II^2, being suspended from the lever, with two plugs by which the handle H of the valve is raised; in that position the steam enters at S, and passes up the superior passage into the top of the cylinder, forcing the piston down, while the steam, acting below the piston, finds free egress along the inferior passage B, through the valve, and escapes by the eduction-pipe E into the open air. Just before the piston gets to the bottom of the stroke, the plug I strikes the handle H into the position H^2, when the direction of the passages is reversed; the steam enters below the piston, and escapes from above. The four-way cock was superseded by Murray's "slide-valve," now in ordinary use, by means of which the distribution of the steam was more simply effected. In this case all the four passages are united in a square box called a valve-box, or valve-chest, as in fig. 20; S, E, A, B being the steam, eduction, upper and lower passages. Into this box is introduced a small valve or cover D (fig. 21), which is of such a size as at one time to leave open only one of the three openings on the right; so that, by covering two of the openings A and E, as in fig. 22, the steam from S can only find its way through B into the lower part of the engine, while the steam already in the upper part of the cylinder can find its way, below the valve D, into the eduction-pipe E, so as to escape into the air. The valve is next shown in fig. 23, in its middle position, where all the three passages are closed, preparatory to reversing the direction of the steam, as in the third position when it slides from the upper port A, as is shown in fig. 24, so as to allow the steam to

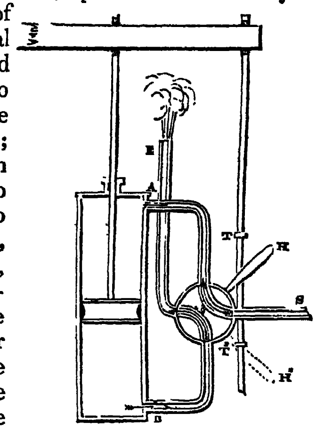


Fig. 19.

enter above the piston and press it down, while the steam formerly below the piston escapes into the air through the

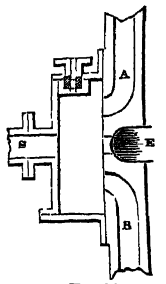


Fig. 20.

Fig. 21.

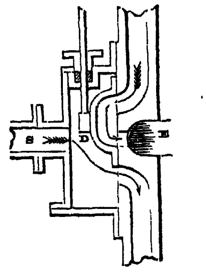


Fig. 22.

passage B, under the valve D, by the eduction-pipe E. This valve, named from its figure the D valve, is also

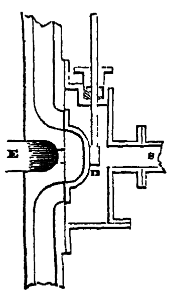


Fig. 23.

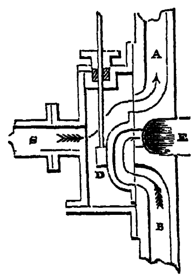


Fig. 24.

worked by the machine itself, either by some of its moving parts striking plugs on a rod which is fixed to the valve, or by some of the other apparatus, which will afterwards be described.

Another form is that called the long slide or long D valve, the invention of Mr Murdoch, which gives the advantage of shutting off the steam close to its ingress into the cylinder, and so saving what in the common short D slide is lost in the passage from A and B to the ends of the cylinder. It is formed thus:—The valve-chest extends along the side of the cylinder. It is shown in fig. 25 without the valve. In fig. 26 the long D slide valve is shown separately. It is a sort of pipe, extending along the whole length of the cylinder. Towards the ends, this pipe is almost semi-circular, with two narrow flat plates capable of covering the openings or ports of the cylinder. This pipe is left open, and perfectly clear from the one end to the other, so that the steam may traverse it freely lengthwise. The steam-pipe is

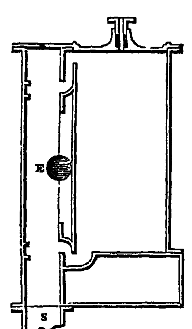


Fig. 25.

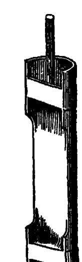


Fig. 26.

represented as entering the valve-chest from below at S, and the eduction-pipe in the middle as at E. In this valve-chest are placed packing-boxes, as they are called, immediately opposite the ports of the cylinder. They contain soft, elastic hemp, soaked in oily matter, the object of which is to press against the truly cylindrical and polished outside of the slide-valve when it its place, and make steam-tight partitions in the valve-chest, to prevent communication between the middle and the two ends.

In the figs. 27 and 28, the valve is shown in the working position. In fig. 28, the steam from S rises up along the centre of the slide, and enters the upper port A, while the

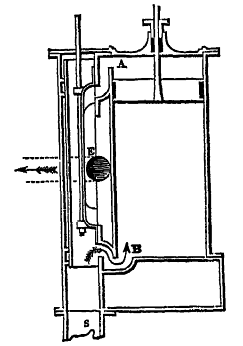


Fig. 27.

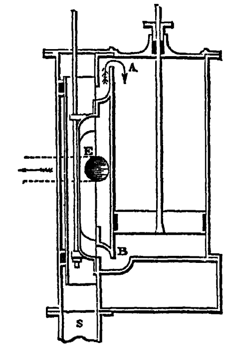


Fig. 28.

steam in the under part of the cylinder has free egress through B to the eduction-pipe E. In fig. 27, the steam has free access to the lower port B, while the steam already above the piston has free egress through the upper port A to the eduction-pipe E. In this species of slide, there is scarcely any loss of steam in the passages, as it is cut off close to the cylinder.

Instead of the long D-slide, which is very heavy, on a large scale, two short slides, similar to its two ends, and connected together by bars, have been used in the following form. Fig. 29 is a section of the slide; fig. 30 a face view; and fig. 31 a section of the cylinder with the valves

Fig. 29.

Fig. 30.

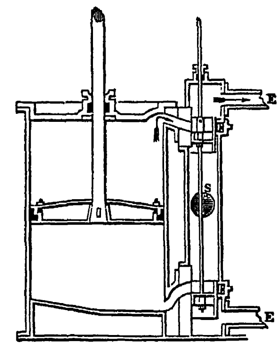


Fig. 31.

in their places. In this case, however, there are two eduction-pipes E, E instead of one, as formerly, and the steam-pipe S enters between the valves.

A cylindrical slide-valve of the following form has been used in a considerable number of engines, and works well. The valve-chest is an upright cylindrical pipe P Q, the inside of which is bored truly cylindrical, and is exactly fitted by two metallic cylindrical plugs, which are ground so smooth in their places as to be steam-tight. It will be apparent from the figure that these two plugs, being raised and depressed by the valve-rod which connects them, will effect the same purpose as the former valve. (Fig. 32.)

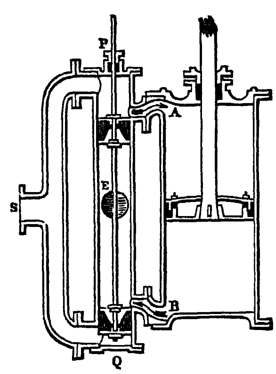


Fig. 32.

The conical-valve, spindle-valve, or button-valve, as it is variously designated, is a species introduced by Mr Watt, and improved by his assistant Mr Murdoch, from whom the steam-engine of Watt has received many valuable ap-

Cylinder-Valves and their Mechanism.

pendages and much of its practical perfection. It has been applied in two forms. Mr Watt's own form, the earlier one, is given in the following figures. For a single engine four valves are required. One of them is represented separately in figures 33, 34, which are vertical sections through the valve, at right angles to each other. The valve is shown open in fig. 33, and shut in 34. S is the entrance of the steam, A the port, V the conical valve, and N the seat or nozzle which it covers. On a cursory glance, it is evident that when the conical cover V of the aperture N is up, as in the first diagram, the steam has free entrance; and when it is closed, the steam will merely press the valve down into its seat, without obtaining an escape from the nozzle.

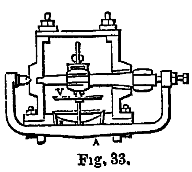


Fig. 33.

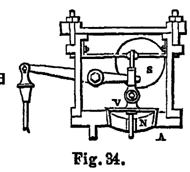


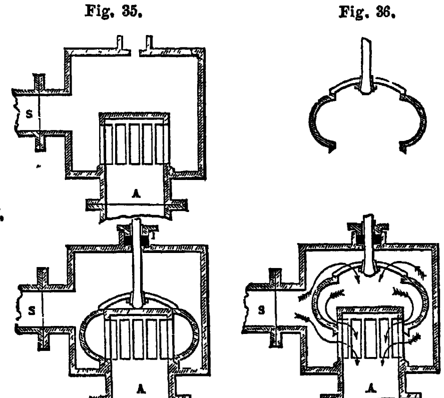
Fig. 34.

The last valve which may here be described is the crown-valve, or equilibrium-valve, which is in use on the Cornish engine, and has also been introduced into rotative engines. Its value consists in effecting a large opening, and requiring little force to work it, while large valves of the common sort are heavy, or are so much pressed in one direction by the steam as to require great force to work them.

The crown-valve is so named from its resemblance to a diadem. Conceive a chamber, fig. 35, out of which an aperture A leads into the cylinder, and into which a pipe S brings steam. The aperture A is surrounded by an upright ring or collar rising a few inches into the chamber, which ring is on all sides perforated by slits of considerable size, but closed at the top. Figure 36 represents the crown or cover of this valve, which is also a ring attached to a steel rod or spindle, by which it is raised or depressed. All round at the top and bottom, the collar in the chamber and the crown-valve are ground so as accurately to fit each other. Fig. 37 shows the valve on its seat and closed on all sides, so that no steam can find admittance; and fig. 38 represents it open or raised up from its seat, with steam

Fig. 35. Fig. 36.

Fig. 37. Fig. 38.



entering freely on every side. There are two ways in which valves are worked by the steam-engine itself. The first of these is by the agency of some part of the engine that happens to move up and down, or performs a reciprocating motion, and the other is by the agency of some part which revolves. The following is a simple method, which has been applied to the short D slide, already described. In fig. 39, ABP is the cylinder, P the piston, acting on the end L of the great lever LL^2, raising and depressing it alternately; while the other end L^2, united by the connecting-rod L^2R to the crank of the fly-wheel, turns it round. The manner in which the steam-valves are moved, is by the long vertical bar or plug-rod TT, suspended from the lever LL^2, so as to move up and down with it. This bar TT carries two projecting plugs of wood ss^2 upon it, which strike alternately up and down upon the handle ll^2 at the bottom and

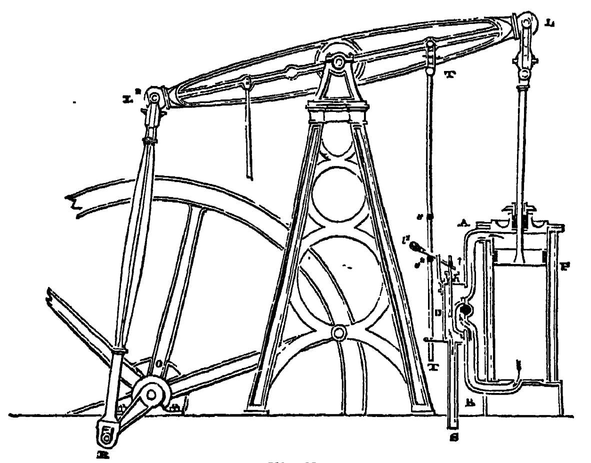


Fig. 39.

top of the stroke, and so produce the reciprocating motion of the slide-valve D; and by admitting the steam on alternate sides of the piston, and discharging it at the opposite ports, produce the continuous motion of the engine. In the figure, the steam is supposed to be forcing down the piston; but when the piston gets near the bottom, the plug s will have come in contact with the valve-rod ll^2, and will have forced it and the slide-valve D into the opposite position, and so permitted the steam formerly above the piston to pass into the open air, while the steam on the other side presses up the piston, so as to bring the plug s^2 in contact with the lever, pressing it up, and the valve D down into its first position, and so on alternately. This method of moving the valves, by a plug-frame, rising and falling with the strokes of the piston, has been principally adopted for pumping engines that have no revolving motion.

In the second system of valve apparatus, by which the steam-engine is rendered automatic, the steam-valves are worked by the revolving of one of the shafts or wheels. Of the various methods in which this has been done, the following are some examples. On the axis *o* of the crank (at the bottom of the right side of fig. 40), which is turned

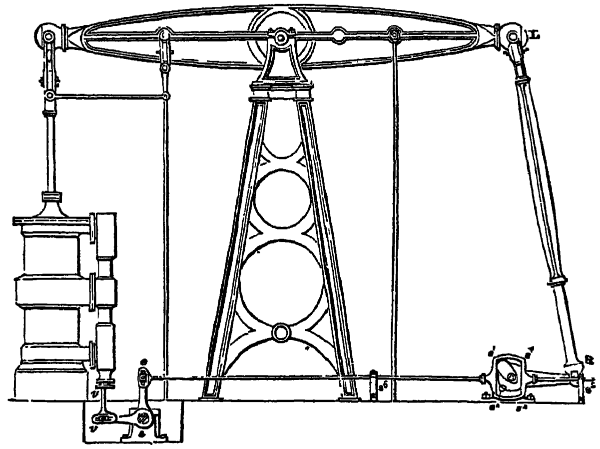


Fig. 40.

round by the rod L R during each alternate ascent and descent of the piston, is placed a cam or projection. A square frame s^1 s^2 s^3 s^4 encloses this cam. As the axis turns round, the cam comes into such positions as to bear upon the sides s^1 s^2 and s^3 s^4 of the frame successively, and so pushes the frame towards the right and left alternately. *s e v* is a bell

Cylinder-Valves and their Mechanism.

crank, which the horizontal rod ss^1 attached to the frame moves on its centre *e*, and so shifts the point *v* and the valve-rod *v v* up and down alternately, together with the valves. The different positions into which the frame is forced by the cam are sketched in figs. 41, 42, and 43.

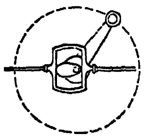


Fig. 41.

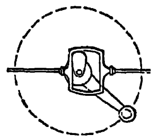


Fig. 42.

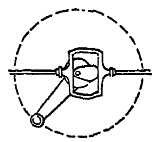


Fig. 43.

But that modification of this principle which is in by far the most general use, is in the form called "the eccentric;" which is a circular disc, or ring of metal, placed upon the shaft or axis, turned by the crank. In fig. 44, *o* is the centre of the shaft or axis, to which revolution is given by the crank R of the steam-engine. On this axis the circular disc E E E is placed, but eccentric to it, so that its centre *d* moves round the axis. The distance of the centre *d* of the disc from the centre *o* of the axis is called the eccentricity, and it is equal to half the throw or range of the motion of the valves to be moved by the eccentric. The rod, fig. 45, is called the eccentric rod, and is attached to a hoop, or circle, that exactly fits the eccentric disc. The various positions which the eccentric will take during the revolution of the engine is shown in figs. 46 to 49.

Fig. 44.

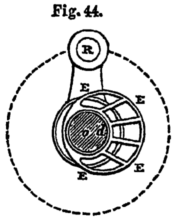


Fig. 45.

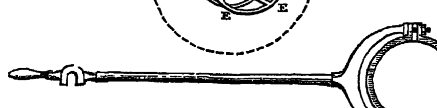


Fig. 46.

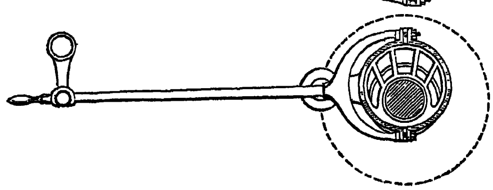


Fig. 47.

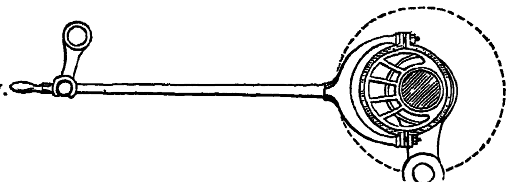


Fig. 48.

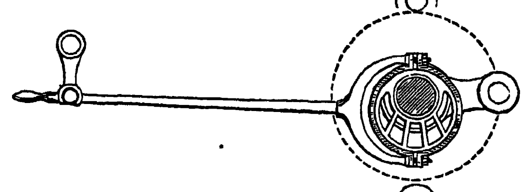
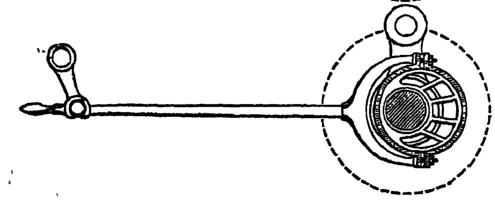


Fig. 49.



In the application of valve-gear to railway locomotives, it appeared that the gearing must be capable of being readily reversed. In the early engines of the Killingworth Railway, before 1820, the valves were moved by means of a "square box or tumbler, which was superseded by a loose eccentric, fitting the driving-axle (fig. 50), a motion which

Cylinder-Valves and their Mechanism.

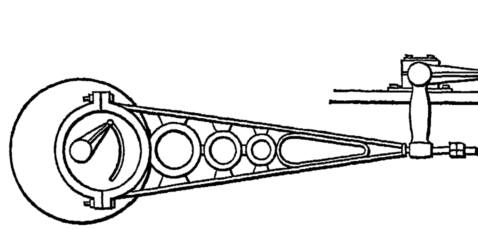


Fig. 50.

exactly answered the purpose, and was employed till the revolutionary year in railway history, 1829. A lever was fixed upon, and revolved with the driving-axle, formed with a stud, which entered and slid freely in a concentric groove cut in the body of the eccentric. The stud found its way to one end of the groove, and determined the position of the eccentric on the axle, for the fore or back gear. The small end of the eccentric rod was permitted some longitudinal play in the eye of the intermediate lever, adjustable by nuts. With an adjustable eccentric, of sufficient throw, and the adjustable limits of the travel of valve, the valve was quickly opened and closed, and its movement was equally good for both directions. The motion so derived was obviously similar to that of the ancient tappet frame, or the more modern cam. Loose eccentric gear was employed by Hackworth, and in the original inside cylinder engines of the Liverpool and Manchester Railway. The two eccentrics were cast in two pieces, and bolted together into one mass, capable of sliding laterally on the axle between the cranks. No play was permitted between the eccentric rods and the valve-levers: a necessary precaution in high-speed engines. The eccentrics were engaged in fore and back gear, by two snugs or catches fixed on the axle, behind each crank; the locking of the eccentrics being accomplished by a forcible lateral movement. Separate mechanism was employed to control the small ends of the eccentric-rods, formed with gabs to disengage them when it was necessary to work the valves by "hand-gear," which was occasionally required at starting, as in Bury's valve-gear, fig. 51. But the system of loose eccentrics was, for

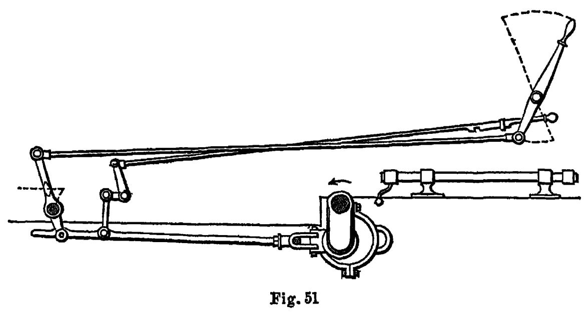


Fig. 51

locomotives, cumbrous, complicated, abrupt, and easily deranged. It was, therefore, readily abandoned for a simpler and firmer plan. Two fast eccentrics were substituted for the loose ones, one to each cylinder. This was partially a reversion to the primitive plan of the fixed cam; and the same difficulty of working equally well in fore and back gear was encountered. Mechanism suitable for working each valve with one fixed eccentric, affording the required lead both ways, was invented by J. and C. Carmichael, of Dundee, in 1818, and has been variously applied by them. For locomotives (fig. 52), the eccentric rod was finished with a double fork, to gear with the pivots of a double spanner on the traverse shaft of the valve, and was

grvooed to receive a roller on the end of the reversing lever, by which it was placed in fore or back gear, with the

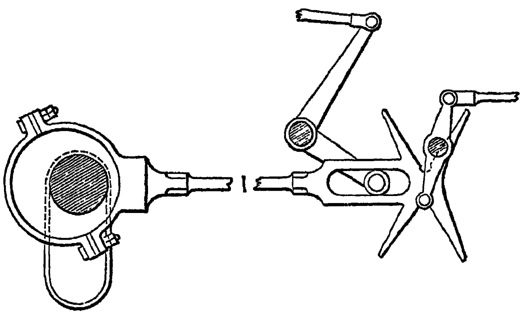


Fig. 52.

lower or upper spanner. The spread of the forks enabled them to engage the pivots of the spanner in all positions of the valve, and to bring them home to the gabs. This motion, duly proportioned, preserved the lead of the valve both ways—a matter of fact which for many years proved a *pons asinorum* for ingenious youths. It was a real advance upon the system of the loose eccentric, as one handle sufficed for working the gear, and all the parts were solidly put together.

The inconvenience of combining in one eccentric the functions of two, was removed by the adoption of four fixed eccentrics, of which the authorship is uncertain. Two were provided for each cylinder, for working respectively in fore and back gear. Each eccentric had its own fork; and though the plan entailed the use of four eccentrics, and additional bearings, the increased workmanship was compensated by precision and certainty of action. The first application of four eccentrics to locomotives was made by the Hawthorns of Newcastle, in 1837. It has been ascertained, however, that some time previously, an ingenious mechanic, in private circumstances, residing at Newcastle, had contrived and constructed an efficient model of valve-gear for locomotives, in which four eccentrics were employed, in the manner afterwards wrought out in practice. In all the forms of double-eccentric gear, it was necessary to effect simultaneously the disengagement of one pair of eccentrics, and the engagement of the other. Various plans of reversing were adopted. Stephenson employed two transverse shafts (fig. 53), the principal of which was worked by

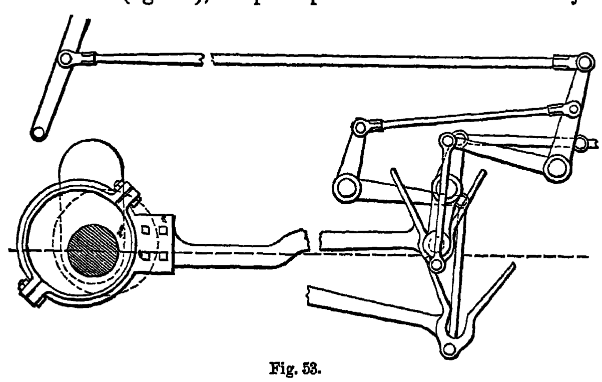


Fig. 53.

the reversing handle, and commanded the four gabs; the secondary shaft was linked to, and worked by, the principal shaft, and it had charge of the back gabs. All the forks geared from below, and one movement of the reversing handle elevated one pair and lowered the other. Thus, the manipulation was simple and easy, as the reciprocal action of the gear balanced the weight of one pair of rods with that of the other. To consolidate the gearing by dispensing with the second shaft, Buddicom employed a system for the outside-cylinder engines of the Paris and Rouen Railway, in which the forks were opposed, and worked by one lever on the reversing shaft, which was placed below, and left clear head-room under the boiler.

In these plans an intermediate traverse shaft was necessary to transmit the motion to the valves, as the valve-spindles could not, according to the prevailing arrangement of the steam-chest over the cylinder, be in the same horizontal plane with the driving-axle. A modification was introduced, however, by which the valve-chests were removed from the top and placed between the cylinders, uniting into one capacious chest, with vertical valve faces, which brought the valve-spindles to the level of the driving-axle, to dismiss the intermediate shaft, and to work the valves directly. The forks were transferred to the valve-rods, and the eccentric rod-ends formed with plain pins, and linked. This motion, as it was the most direct, and involved the fewest parts, was the best of all that had yet appeared.

EXPANSION VALVES.

The conical valves of Watt, operated by tappets, which opened and closed them at any desirable point of the stroke of the piston, afforded ample range for expansive-working; and equal facilities were afforded by the use of cams. But when slide-valves and eccentric motion came in, the benefits of expansive-working and a clear exhaustion of steam were sacrificed to the simplicity and smoothness of action of the new mechanism of distribution. The essential proportions of the primitive slide-valves, and the steam-ports over which they travelled, are shown in section in fig. 54, in which it is apparent that the length of the valve was a very little greater than the extent of the ports *a*, *a*, so as barely to lap one-sixteenth inch over these openings, just as an assurance that the steam

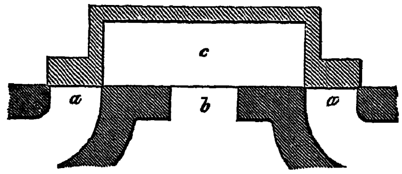


Fig. 54.

should not enter at both ends of the cylinder at the same time; the body of the valve was made just so long that the walls of the cavity *c* just closed the steam-ports *a*, *a*, on the inside, when the valve stood midway. Engineers desired chiefly to insure timely and free admission of steam, overlooking the much greater necessity that existed for an early and liberal exhaustion; this valve, with such properties, was in common use until 1838. The steam-passage was opened to the exhaust immediately after it was closed for admission, and both events took place at the termination of the slider. Thus, no time was allowed for exhaustion previously to the beginning of the succeeding stroke; and so little were the defects of this valve understood in locomotives, where the highest speeds of piston were practised, that when, in 1836, according to Mr Edward Woods, short-stroke passenger-engines were introduced on the Liverpool and Manchester Railway, to run at high speed, their greater consumption of fuel was ascribed to the supposed mechanical disadvantage of the short stroke. Mr John Gray, then locomotive-foreman at Liverpool, appears to have been the first to have suspected the cause of the excessive consumption of fuel; and after having made a few preliminary experiments on the valves of the stationary engine, and satisfied himself that the evils complained of could be traced to defective exhaustion, he lengthened the valves of one of the locomotives, which had originally a "lap" over the steam-port at each end, of only $\frac{1}{8}$ inch to $\frac{3}{8}$ inch. The effect was, that the eccentric being shifted and advanced on the shaft, so as to cause the valve, with the additional lap, to be just open at the beginning of the stroke, the inside was open at least $\frac{3}{8}$ inch to the exhaust, whereas, previously, it was not open at all. The consumption of

Expansion Valves.

fuel was, in consequence of the timely and more efficient exhaust, reduced about one-fourth. Further experience led the way to the adoption by Mr John Dewrance of 1 inch of lap at each end of the valve, with a travel of $4\frac{1}{4}$ inches, as depicted in fig. 55. By the use of the long valve, which just opened for steam at the beginning of the stroke, and stood 1 inch open for the exhaust, the steam was cut off

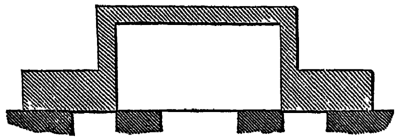


Fig. 55.

at 79 per cent. of the stroke, expanded in the cylinder to 95 per cent., or 5 per cent. from the end of the steam-stroke, and at this point it was exhausted. The waste steam which had previously been choked up in the cylinder, owing to the difficulty of escape, and so causing excessive back-pressure on the piston, was freely released, less steam was thus consumed, and other natural advantages accrued.

The necessity and advantage of lap on the valve was thus established in railway practice, both as to its facilities for affording a free exhaust, and for working steam expansively. Without lap there could be no expansion; and though it was introduced primarily for the purpose of an efficient release, its advantages as a means of working expansively became likewise apparent. It was quickly adopted on other lines of railway, as a specially good thing for high-speed engines, and by slow degrees circulated also in stationary and marine practice, in which, certainly, pistons moved at a more moderate velocity. In order to vary the degree of expansive-working of steam, according to circumstances, two classes of mechanism have been employed for slide-valves—first, those mechanisms which operate upon single valves by varying their travel; second, those in which two valves are employed, one of which is specially designed for varying the expansion. Increase of expansion, it must be observed, is obtained simply by causing the valve to cut off the steam earlier in the course of the stroke. In mechanisms of the first-class, the travel is varied by means of mechanism external to the valve-chest, of which the merit of the first application was made by Mr John Gray, on the Liverpool and Manchester Railway in 1839. In his plan, the pin at the end of the eccentric-rod slides in a segmented lever, curved to the radius of the rod, the upper end of the lever being linked to the valve-rod; thus the travel of the valve could be varied by raising or lowering the eccentric-rod end in the segmented lever. The celebrated "link-motion" was originally introduced in 1843, by Robert Stephenson and Co., on locomotives, and is now universally applied to them; it is also extensively applied in marine and winding engines. It is shown at fig. 56, as applied by that firm to locomotives,

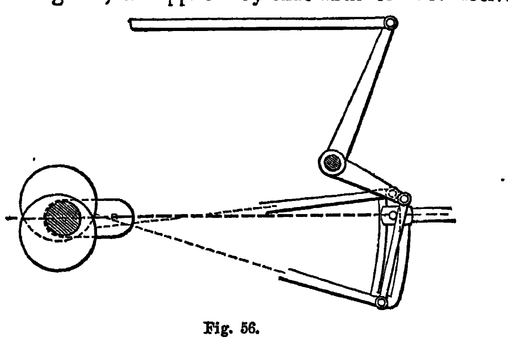


Fig. 56.

and is specially adapted for situations where the engine requires to be quickly and easily reversed, whilst its capacity for advantageously working by variable expansion, in varying the travel of the valve, is unquestionable. The two eccentrics, fore and aft, usually provided, have the ends of their rods connected by a slotted link, the slot of which embraces the end of the valve-spindle from which the valve is worked. The link is commanded by a reversing lever, and may be raised or lowered, so as to bring the valve and spindle into gear with, and receive the motion of, the fore or the back eccentric; and, while the link would partake of the two motions jointly of the two eccentrics, its horizontal motion would be smallest at the centre of its length, and would be extended towards the extremities. By shifting the block or end of the valve-spindle towards the centre, the travel of the valve is reduced, and variable expansion obtained.

Historical notice of Steam-Boilers.

Variable-expansion gear of the second-class, with two or more valves, has been applied in many different forms. The use of a secondary valve, in addition to the principal valve for expansive-working, is now limited to stationary engines. For locomotives, it has often been tried and abandoned, except in the United States, where, however, the link-motion with a single valve is steadily superseding the double-valves.

SECT. III.—HISTORICAL NOTICE OF STEAM-BOILERS.

During the first period of the history of the steam-engine, the danger of bursting the boiler, and the difficulty of making it strong enough to resist the internal force acting towards explosion, and also of making the joints tight against the leakage of highly elastic steam, formed the chief obstacles to the introduction of steam as a mechanical mover. The first important point in preparing a steam-boiler is to secure strength without unnecessary expense. The globular or spherical shape was very early adopted as one of greatest capacity, as a shape in which, the pressure at every point being equal, there remained no force tending to produce flexure, or destroy the equilibrium of strength and strain at any point. A fire was lighted below the boiler, and the steam confined until the heat had raised it to the required pressure. This form was accordingly adopted by Hero, Savery, and others, as already noticed.

It was soon found that a spherical boiler, when set upon an open fire, required an enormous consumption of fuel to raise a small quantity of steam, the heat being copiously communicated not only to the water in the boiler, but also in very great quantity to the surrounding objects, besides being rapidly carried off by the air. To surround the spherical boiler with non-conducting substances, and to keep the flame throughout its whole extent in contact with the boiler, so as to prevent radiation to surrounding objects, and also to diminish the size of the fire by making it wind round the boiler, were the first steps towards improvement; and we accordingly find in the work of Dr Desaguliers the form of boiler (fig. 57), which is built into a brick casing, with the fireplace below, and the flue winding round the boiler on its way to the chimney.

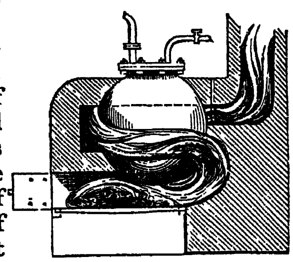


Fig. 57.

The form next in simplicity to the spherical boiler is the cylindrical. From the facility with which a cylinder is made, it was introduced at a very early period. It stood upright like a bottle, as in fig. 58, the fire being placed at the bottom, and the flue winding round that part of the sides covered with water. This form of boiler was found, however, to be weak in the bottom part.

For the prevention of these two evils, the cylindrical form of boiler was very soon modified and improved by two opposite expedients, one applied at the top and the other at the bottom of the cylinder. The top being made hemispherical, possessed all the advantages of a spherical

Historical notice of Steam-Boilers.

boiler; and the bottom being arched upwards, so as to present a large concave dome to the impact of the flame.

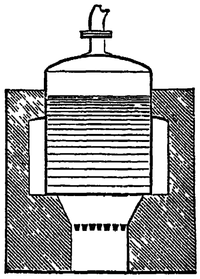


Fig. 58.

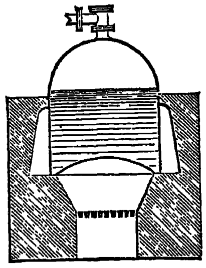


Fig. 59.

This dome being sustained by the cylindrical belt round its spring, a very strong and extensive surface was obtained, as in fig. 59.

In this cylindro-spherical boiler it was found that the action of the flame on the upright round sides produced but a very slight effect in raising heat. It was therefore desirable that the flame should be brought somewhat under the sides by inclining them a little outwards. From the form the boiler then assumed, and which has since become very common, it has not inaptly been named the hay-stack boiler, fig. 60. The same effect was next obtained in many of the boilers of Newcomen in the way represented in fig. 61, so that the flame in the flues impinged upon a surface

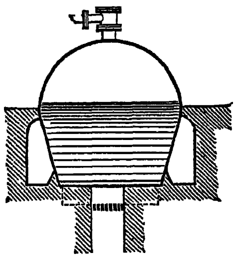


Fig. 60.

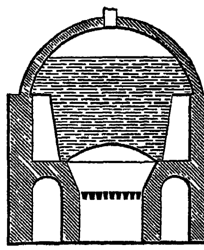


Fig. 61.

directly over them, the flues in this case forming a recess in the sides of the boiler, instead of being built around it by the brick-work alone.

In process of time, boilers of much larger size came to be required, and the spherical shape was found cumbrous and too capacious; that is to say, contained an enormous mass of water, which it required much time and fuel to heat to the boiling point before any steam could be raised. The diameter, also, of the boiler was so great when much steam was required, that the enormous dome became weakened. To make a stronger boiler, and one which should at the same time cover a large fire, the waggon-boiler (fig. 62), so named from its form, was introduced by Mr Watt. It was made of considerable length, and its transverse section resembles that of the old cylindrical boiler. In this form the boiler was long made by Messrs Boulton and Watt. It was afterwards improved by hollowing the sides (see figs. 63 and

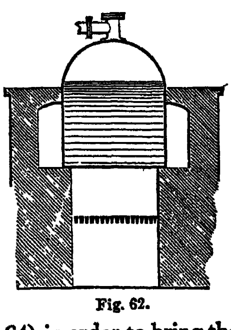


Fig. 62.

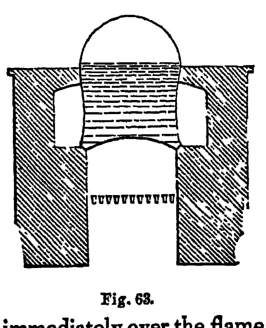


Fig. 63.

64) in order to bring them more immediately over the flame. These forms of boiler, although very convenient, are weak; they are very different from the spherical or cylindro-spherical boilers in strength and safety, and it is necessary to place in them strong iron stays, which are essential to

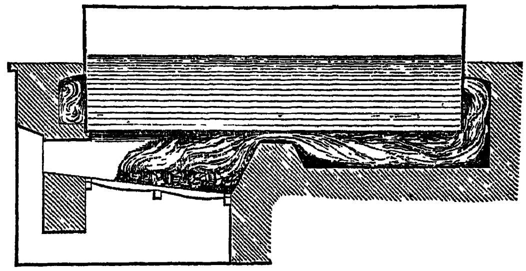


Fig. 64.

strength and security in boilers having large surfaces, concave outwardly, or perfectly flat. To avoid the use of stays, and to secure great strength without any other metal than the shell of the boiler itself, is the object of the cylindrical boiler with two hemispherical ends (fig. 65), laid

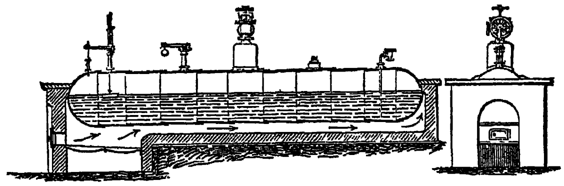


Fig. 65.

with its axis nearly horizontal, and below it, at one end, is placed the fire, enclosed by brick, as usual. The flame traverses the bottom of the boiler, beating directly upon its under horizontal surface, till it reaches the end furthest from the fire. The flame and hot air then, in some examples, return along the one side of the cylinder, being confined in a brick flue, and passing along in front of the end which is over the fire, traverses the other side towards the chimney, which it enters after having thus traversed the length of the boiler three times, and applied its heat successively to every point of the cylinder, which is covered with water. This is a boiler that requires no stays, and is valuable where room is not important. It contains much water, requires much heat to raise its temperature after being cooled at night, and is very bulky.

The spherical, cylindrical, and waggon shaped may properly be denominated the simple boilers. But some hundred kinds of boilers have been invented for different purposes; almost all of them designed to save either bulk, weight, or fuel. For these purposes one great object of improvements in boilers has been to increase as much as possible the extent of heating surface without increasing the general dimensions. Thus Boulton and Watt have inserted a flue in the middle of the large waggon-boiler in the manner shown in figs. 66 and 67, so that, after the flame has passed along the bottom of the boiler to the further end, it returns along the flue in the middle of the water to the front, and then makes an entire circuit of the outside of the boiler before entering the chimney. The same plan has been employed in cylindrical-boilers, the flame and hot air being made to traverse a hollow tube or cylinder in the interior of the boiler; sometimes several such flues have been used.

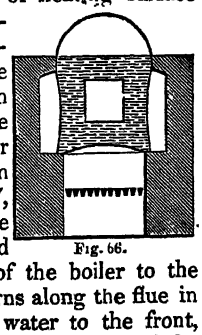


Fig. 66.

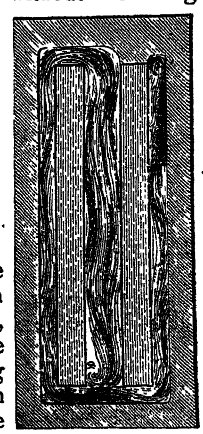


Fig. 67.

Historical notice of Steam-Boilers.

In these boilers, a large surface is still exposed to the cold air; and the brick-work, in which the fire is placed, radiates off a considerable portion of heat, which is lost. To remedy this evil, the furnace has been so contrived that the fire is in the inside of the boiler. This was probably done for the first time by Smeaton, who succeeded in producing almost as high a proportion of steam from fuel as engineers of a more modern date. His portable engine-boiler is represented in figs. 68, 69. The interior of this

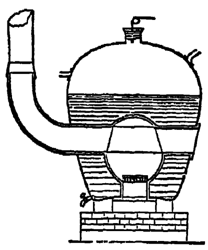


Fig. 68.

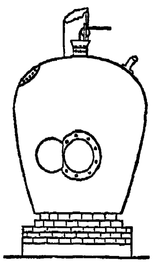


Fig. 69.

hay-cock boiler contains a hollow ball of cast-iron, in which the fuel is burned. Air enters by an aperture at the bottom; a large cast-iron pipe leads through the water to the door, and another pipe, in the opposite direction, passes through the water, conducting the products of combustion to the chimney, immediately round which are introduced the fresh supplies of cold water for replenishing the boiler. But a much better boiler than this, and one which indeed might bear comparison with many boilers of the present day, is given by Mr Farey as the invention of an unknown author. In the centre of a large old-fashioned hay-stack boiler, figs. 70, 71, is placed a large round furnace, from

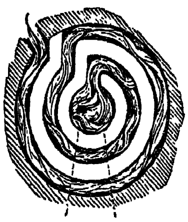


Fig. 70.

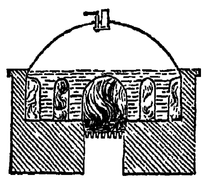


Fig. 71.

which there passes a simple rectangular flue, winding round and round the boiler in spiral circuits till it reaches the outside, and thence passes to the chimney. In the same way, it has often been provided, that the furnace should be in the interior of a cylindrical boiler, by placing another cylindrical tube, of large dimensions, in the interior of the outer-case, as in fig. 72, to serve at once as furnace and flue.

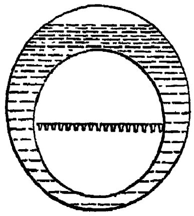


Fig. 72.

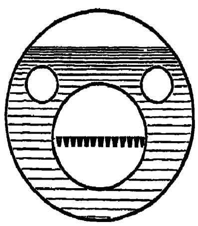


Fig. 73.

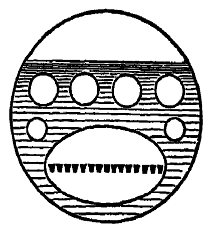


Fig. 74.

This was probably first done by Trevithick, the advocate of high-pressure engines in this country.

To the great central flue there have been sometimes added lateral flues on each side, for the return of the products of combustion, fig. 73. Thus, again, this internal flue has been made elliptical, fig. 74, a weak, and therefore dangerous, form. It is one of the faults of the boilers that have their fires in the internal tubes, that the ash-pit and interior of the furnace over the fuel are so confined as to prevent that perfect combustion of fuel which may be obtained by a deep ash-pit, a large expanse of fire-grate, and a deep and wide furnace. These evils may, in some measure, be obviated by an internal flue of large dimensions, or by the following species of boiler, figs. 75, 76, where

Historical notice of Steam-Boilers.

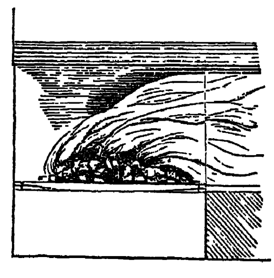


Fig. 75.

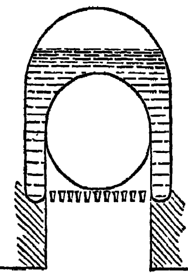


Fig. 76.

the fire is still surrounded by water, and gives ample room for the most perfect combustion. In this species of boiler, the tube opens out at the front, so as to leave a semi-cylinder above the fire, and two vertical spaces, or "water-legs," as they are called, which cover the fire on both sides; thus obstructing the heat that would otherwise pass away into the brick-building, and, at the same time, covering a large and wide space of furnace-bars, a deep ash-pit, and so insuring adequate combustion. The internal surface of this boiler has been still further increased, by substituting for this single tube a number of smaller ones, which in some cases are not more than two inches in diameter, as in figs. 77, 78. After passing through all these tubes,

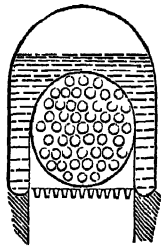


Fig. 77.

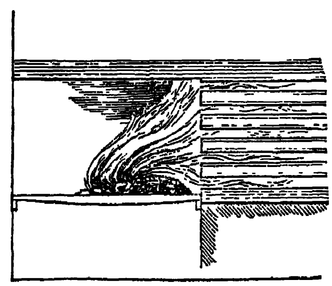


Fig. 78.

the flame and hot gases again return along the bottom and sides on the right of the boiler, and pass back on the other side to the chimney. The Butterly boiler (figs. 79, 80),

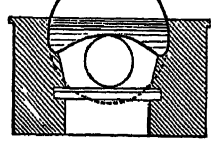


Fig. 79.

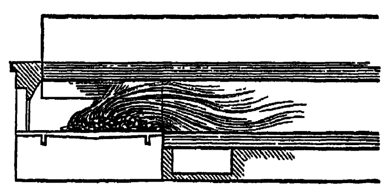


Fig. 80.

and similar to this, has been much used in Lancashire. It has the large internal flue, but wants the fire-legs, and, in this respect, is inferior to the former.

Definition of the Organs of the Engine proper.

Definition of the Parts of Boilers.

PART II.—THE MODERN STEAM-ENGINE.

SECTION I.—THE MECHANICAL ORGANS OF THE MODERN STEAM-ENGINE—THEIR DYNAMICAL ACTION.

CHAP. I.—ENUMERATION AND DEFINITION OF THE ORGANS OF THE ENGINE PROPER.

The steam is conducted to the engine through the *steam-pipe*, in which the *stop-valve* is placed; also the *throttle-valve*, or *regulator*, for adjusting the supply of steam to the cylinder; the supply may be regulated by hand or by a *governor*. The steam-pipe sometimes contains also the *cut-off* or *expansion-valve*, for cutting off the steam at any part of the stroke, and may be controlled by the governor.

The *cylinder* may be single or double-acting. When single-acting, or operating in one direction only under the steam pressure, the *piston* is made to return in the opposite direction by the action of a weight or *counterpoise*. In a double-acting cylinder, the steam is admitted on the piston at both ends alternately. The steam passes into the cylinder through *steam-passages*, or *steam-ways*, or *ports*, the entrances to which are sometimes called specifically the *ports*, sometimes *nozzles*, opened and closed by the *induction* and *eduction-valves*. When these are in one, it is called a *slide-valve*, which is placed in the *valve-chest*.

In *non-condensing engines*, conventionally called *high-pressure engines*, the *waste steam* discharged from the cylinder escapes into the atmosphere through an *exhaust-pipe*, or *blast-pipe* as in locomotives. The *cylinder-cover* has a *stuffing-box* to pass the *piston-rod*, which, if tubular, is called a *trunk*. A *grease-cock* is fixed to the cylinder, or the cover, for the lubrication of the piston. An *escape-valve*, held by a spring, may be placed at each end of the cylinder, or *blow-through*, or *cylinder-cocks*, for the escape of water collected in the cylinder, either by condensation or by the *priming* of liquid water from the boiler. To prevent condensation in the cylinder, it is cased in a *jacket*, filled with steam from the boiler, or hot air; and the jacket is covered with *clothing*, or *cleading*, of felt and wood.

Double-cylinder engines have two cylinders, the steam being admitted from the boiler to the first cylinder, and filling the second by expansion from the first. The *condenser* is a steam and air-tight vessel, into which the steam from the cylinder is discharged and condensed by a shower of cold water from the overheated *injection-valve*. In land engines the *injection-water* is supplied from the *cold well* surrounding the condenser, which is filled by the *cold water pump*. In marine engines the water enters direct from the sea. In the *surface condenser* the steam is condensed within tubes, or other passages, surrounded by cold water or air. The *blow-through* valves connect the cylinder with the condenser, and there is a *snifting-valve* opening to the atmosphere; through these valves steam may be blown to expel air from the cylinder and condenser before the engine is set to work. The *vacuum-guage* on the condenser shows how much the pressure in the condenser falls below the atmospheric pressure. Residual steam, air, and water are extracted from the condenser by the *air-pump*, and discharged into the *hot well*, from which the boiler is supplied with water. The surplus is discharged into a pond to cool, in land engines; in marine engines it is delivered into the sea.

The *cross-head* of the piston-rod is guided by a *parallel motion*, to move in a straight line; except in *trunk-engines*, guided by the stuffing-box; *oscillating-engines*, in which the cylinders oscillate on *trunnions*, and the piston-rod is connected direct to the crank; Mr Hunt's *Z-crank-engines*, *disc-engines*, and *rotatory-engines*. The reciprocations of the piston are either transmitted through a *beam*, and a *connecting-rod*, to the *crank*, and the *crank-shaft*, for double-acting *rotative-engines*; or the beam may be dispensed with, and the piston-rod coupled to the connecting-rod, forming a *direct-action* engine. The *fly-wheel* on the crank or main shaft equalizes the motion. The mechanism to work the valves is called the *valve-gearing*, or *valve-motion*.

A *pair* of engines work together on the same shaft; they have a *pair* of cylinders, a *pair* of pistons, a *pair* of cranks. Engines are properly in *pairs*, when they are designed simply to equalize the action of the power.

CHAP. II.—ENUMERATION AND DEFINITION OF THE PARTS AND APPENDAGES OF BOILERS.

The *shell* of the boiler, or outer part, commonly of iron, is spherical, cylindrical, or flat in figure, or a combination of these forms. The *steam-chest*, or *dome*, on the upper side of the boiler, is a reservoir, whence the steam is supplied to the engine by the *steam-pipe*, which is fitted with a *stop-valve*. The *furnace* is the chamber for the combustion of the fuel; when within the shell, it is called a *fire-box*. The *flues*, or conduits for the products, are either *external* or *internal* to the boiler; cylindrical metal flues are *flue-tubes*, and they are fixed at the ends into *tube-plates*. The *man-hole* is the entrance to the boiler for inspection, &c. *Mud-holes* are placed at or near the bottom for the discharge of sediment, &c. The water is supplied by the *feed-apparatus;* its level is indicated by a *float*. The boiler is emptied by the *blowoff-cock;* the surface of the water is cleared by the *scum-cock*. *Brine-pumps* may be used instead of *blowoff-cocks* to draw off the brine from marine boilers. *Sediment-collectors* receive the solid impurities floating in the water. Surplus steam escapes by the *safety-valves*. *Vacuum-valves* admit air into the boiler, when the pressure is less than that of the atmosphere, to prevent collapse. *Fusible plugs* are inserted in the boiler, over the fire, which melt and give vent to the steam when the pressure and temperature in the boiler become excessive and dangerous. The pressure is indicated by the *pressure-gauge*. The *water-gauge* shows the level of the water: it may be a *glass-tube*, or it may be *guage-cocks*. The boiler is strengthened by *stays*, which may consist of *rods*, *bolts*, or *gussets*. The boiler is covered with *clothing* or *cleading*.

The *fire-grate* carries the fuel, and consists of *fire-bars* or *grate-bars*, supported by *cross-bearers* or *bar-frames*. The *mouth-piece* is the entrance to the furnace, and rests on the *dead-plate;* the *fire-door* is fitted to and hung by it.

The *heating-surface* is the surface of the boiler exposed to the flame and hot gases from the furnace. The *boiler-room*, or internal capacity of the boiler, is divided into the *water-room*, occupied by water; and the *steam-room*, occupied by steam.

CHAP. III.—THE CRANK AND FLY-WHEEL.

The introductory historical account of the steam-engine —in particular the engine of Watt—prepares the way for a more systematic investigation of the modern steam-engine, with its manifold adaptations to the demands of engineering practice. The cylinder and piston, the crank and the main shaft, are the primary elements of steam-engines; the cylinder to contain the steam, the others to receive and transmit its energy. The following chapter is to be devoted to a consideration of the movements and action of the mechanical organs of the steam-engine, geometrically con-

The Crank and Fly-Wheel.

sidered, prior to the study of the behaviour and performance of the steam within the cylinder.

The Crank and Fly-wheel.—One of the most important appendages of the steam-engine is the crank, by means of which the force of steam, although at first producing motion only upwards and downwards in the straight line of the axis of the cylinder, is nevertheless rendered capable of exerting that force equally well in a circular direction. When the steam-engine is only employed for some such purpose as pumping up water no crank is necessary; but as some of the most usual and valuable applications of the steam-engine are those where it turns wheels of mills, of cotton machinery, of steam-vessels, or locomotive engines, the crank, by which this is accomplished in an admirable and simple manner, which has superseded every other plan of transmission, is entitled to very minute consideration. On examining in detail the action of the crank, it is to be observed that the force exerted by the steam is neither constant in direction nor in action. If the steam be admitted first below the piston, it forces it to the top of the cylinder; it is then cut off, preparatory to its being admitted above the piston; and in the interval it has no motive action. When admitted above the piston, it forces it to the bottom of the cylinder; and again there is a cessation in its action during the change in the position of the valve. Now it is evident that this recurring cessation of action between the alternating impulses would interrupt the continuous revolution in the wheel, but for the power of the wheel itself to continue the motion, by what is termed the momentum of its mass. When the steam, during a stroke of the machine, is acting most powerfully on the piston, part of its power is spent in accelerating the wheel; and when, at the end of the stroke, it ceases for a time to act, the wheel gives out the power which it had gained, and continues its motion until the next stroke gives it a fresh accession of power. A wheel of this kind, when attached to an axle for equalizing motion, is termed a fly-wheel; and to obtain the full benefit of its equalizing power it is made of large diameter, that its rim may move rapidly, and it is made of great weight, being formed of iron, that it may acquire momentum to render the motion as uniform as possible.

From the circumstance that at one period the steam possesses no power of turning the crank, it has been imagined that some considerable loss of the power of the steam takes place during its transmission through the crank. This is a grave error. Figs. 81 to 84 represent the crank in different positions. In figs. 81, 84, the connecting rod and crank are in the same straight line, technically called the position "on the centre," or passing the line of centres, in which the action of the the steam neither tends to turn the crank in the one direction nor the other. Again at M and N (figs. 82, 83), where the crank is acted upon at right angles by the connecting-rod, it is plain that the whole force transferred through the rod is acting to turn the crank; while in the intermediate positions there are two efforts, one acting on the centre of the crank, and another to turn it round. For examining the proportion of these forces to each other, we may use the two following diagrams. Fig. 85 represents the circle of the crank, the arrows showing the direction in which the crank-rod would require to act, in order that all its force should be undivided, and produce alone the single effect of causing revolution.

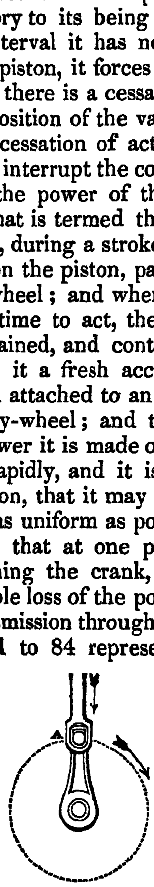


Fig. 81.

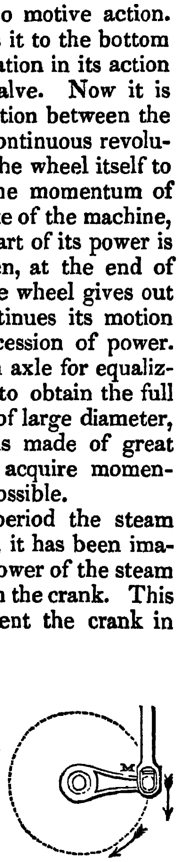


Fig. 82.

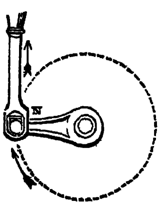


Fig. 83.

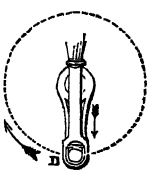


Fig. 84.

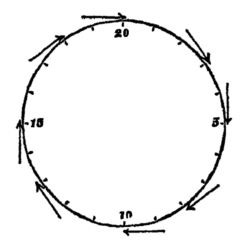


Fig. 85.

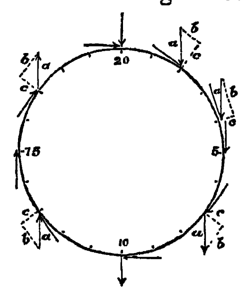


Fig. 86.

Fig. 86 indicates the deviation which the actual motion of the crank exhibits from this hypothetical condition. The arrow *a* indicates the direction of the action of the connecting-rod, which at divisions 10 and 20 is acting only towards the centre of the circle, with no effect in producing revolution. At divisions 5 and 15 the whole effect takes place in producing revolution only. Through the first half of the circle the pressure of the rod acts wholly downwards, and through the latter half of the circle wholly upwards. The circumference of the circle being divided into twenty equal parts, the analysis of the force is given in the figure at several of these points. At the second division, *a* represents the direction of action of the crank-rod; *b* is parallel to the direction of the circumference (or tangent) of the circle at that point, while the line *c* is directed to the centre; *a* indicating the direction of the whole force of the connecting-rod, *b* representing the effect produced in the direction of the tangent to turn it round, and *c* the effect of the force of the connecting-rod acting to produce pressure on the centre of the crank; but as the centre of the crank is fixed and prevented from moving, none of the moving power of the crank is given out in producing motion towards the centre, but only in producing motion in the circumference. At the fourth division of the circumference, it may be observed that the effect of the connecting-rod is differently distributed. The whole force *a* is now more nearly in the direction of *b*, and *c* is comparatively small; showing that, as we approach the end of the first quarter's revolution, the force of the connecting-rod is producing much less pressure in the centre of the crank, and pressing in a higher proportion in the direction of the revolving effect, until at last the connecting-rod being at right angles to the crank, its whole pressure acting to turn round the crank, none of it is directed towards the centre. After passing the quadrantal point 5, the crank-rod still presses downwards, as shown by the arrow *a* at point 7; but, of its two effective pressures, one represented by *b* still acts in turning round the crank, while another, represented by *c*, instead of acting towards the centre, as in the upper quadrant, now produces a pressure which would draw the crank away from the centre; but as the crank is fixed, none of the motive-power is employed in producing any motion of the crank away from its centre. Similar alternating effects are produced through the other quadrants; so that while the pressure of the steam, acting through the connecting-rod upon the extremity of the crank, is divided into two effects, one of these is prevented from expending the moving force of the engine by the fixedness of the crank-centre, and the whole motive-power is given out only at the circumference of the crank-circle in turning it round, but in a proportion of pressure that is continually varying from 0 to a maximum, and from a maximum to 0, through every successive quadrant of the circle. In order to simplify the inquiry, it proceeds, meantime, on the assumption that the pressure transmitted through the connecting-rod is constant. In general practice, with expansive-working and other circumstances, it varies, and the influence of this

The Crank and Fly-Wheel.

variation will be another subject for consideration. The variation of pressure circumferentially on the crank of a steam-engine may be conveniently represented by curves. Let the circumference of the circle described by the crank be represented by the straight line A X (fig. 87), and

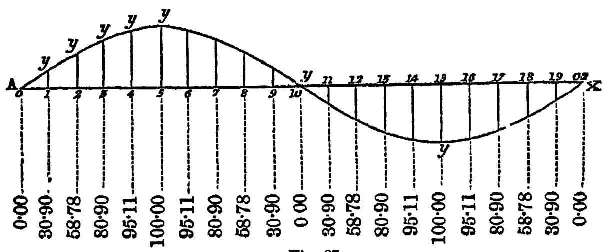


Fig. 87.

divided into any number of equal parts; let straight lines $y^1 y^2 y^3$, &c., be drawn to represent the amount of pressure converted into the direction of the motion of the crank, according to the line *b* in fig. 118, being the amounts represented in the line of figures, then the curved line A, *y y y x*, passing through the summit of all these lines, will represent the variation in the power of the crank at each instant of time, each ordinate $y^1 y^2 y^3$ being the pressure, and the area of the whole figure will represent the whole motive-power, having a maximum at y^5 and y^{15}, and a point of change of direction from pressure one way to pressure the opposite way at y^{10}.

Now, one method of equalizing the rotative pressure on the crank has been proposed, and is very generally adopted,—viz., to make two steam-engines act on the same axis by means of two cranks at right angles to each other, so that when the one ceases to exert force the other may be at its point of greatest force.

Thus, in figs. 88 to 91, two cranks are represented as coming from two cylinders, and attached to the same axis, so that when the one of them is at 0 the other is at 5, when the first is at 5 the second is at 10, and so on; so that while either is on the line of cessation of force, the other is at the point of maximum.

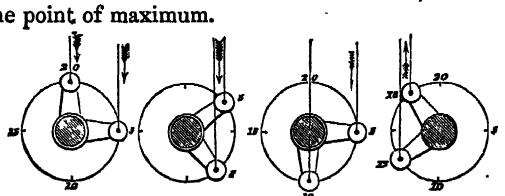


Fig. 88. Fig. 89. Fig. 90. Fig. 91.

The joint effect of two such cranks may be represented by curves in the following way:—Let the circumference of each crank-circle be represented by the lines A X, and $A^2 X^2$ (figs. 92, 93), as formerly, each semi-circumference being divided into eight parts, and let the pressure be calculated from a table of sines, where each will be found as the sine of the arch of the circumference to which it corresponds; the numbers thus obtained being set off on the base lines, the varying quantity of force, but without regarding the reversion of direction. If, now, we place these curves together, as in fig. 94, their whole ordinates taken across from the one curve to the other, will represent the amount of the sum of the forces and its variation; and if we place all these ordinates from a fourth axis, we shall have represented by the new curve (fig. 95) the variations of the sum of the forces of the two cranks.

When a lever intervenes between the crank-rod and the piston-rod, new irregularities are introduced. The variation in the direction of the connecting-link, and in the position of the lever-ends from a straight line, introduces modifications of these effects of a serious nature, but not of a large amount. It is worthy the attention of practical men to consider these variations, and the manner in which they affect the uniformity of the pressure. They affect it by way of increase at the beginning and end of the stroke. By proper arrangements these very obliquities may be ren-

The Connecting-Rod and Parallel Motion.

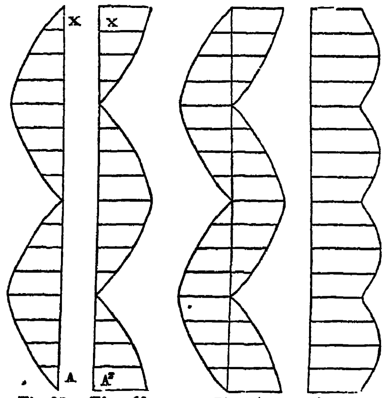


Fig. 92. Fig. 93. Fig. 94. Fig. 95.

First.	Second.	Sum.
00·000	100 000	100·000
38·268	92·388	130·656
70·710	70·710	141·420
92·388	38·268	130·656
100·000	00·000	100·000
92·388	38·268	130·656
70·710	70·710	141·420
38·268	92·388	130·656
00·000	100·000	100·000
38·268	92·388	130·656
70·710	70·710	141·420
92·388	38·268	130·656
100·000	00·000	100·000
92·388	38 268	130·656
70·710	70·710	141·420
38·268	92·388	130·656
00·000	100·000	100·000

dered very considerable improvements in the working of the engine. It should also be observed that the stroke of the piston and crank will not remain of the same length. The agency of the crank in transmitting a force parallel to the piston-rod has been represented by the curve of sines, as in fig. 96. But if we represent in a similar way the pressures produced by the obliquity of the connecting-rod, we shall find the form become that given in the following figures. Fig. 97 represents the variation of pressure with a connecting-rod of four times the length of the crank; fig. 98 with a connecting-rod of double the length of the crank; and fig. 99 with a connecting-rod equal to the length of the crank. It is obvious that with the shortening of the connecting-rod, the irregularity of the motion becomes very great. Two maxima rapidly succeed each other, and these are wide apart from the next pair. Thus two violent pressures succeed at a short interval, and a long pause intervenes when the force is very small.

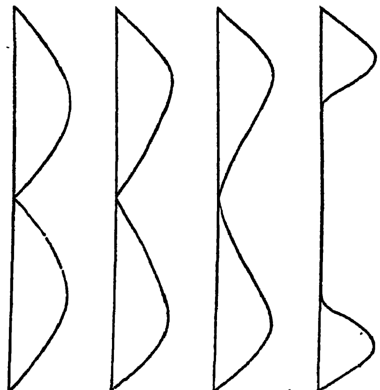


Fig. 96. Fig. 97. Fig. 98. Fig. 99.

Instead of using two cranks for applying the force of two steam-engines to the same axis of revolution, two engines have been used with their cylinders laid at right angles to each other, and having their connecting-rods applied to the same cranks.

CHAP. IV.—THE CONNECTING-ROD AND PARALLEL MOTION—THE GOVERNOR.

In considering the agency of the crank in modifying the force and velocity of steam, so as to connect its direction, and distribute its force in the manner required to produce a rotative motion in the machinery from the original reciprocating motion of the piston in the cylinder, we have hitherto avoided the introduction of another important element, by which a further variation of force and of motion is produced. The connecting-rod is a rigid bar of metal, which conveys the motion of the piston from the piston-rod to the crank, either immediately or through the interposition of the lever or beam; and as the connecting-rod, in doing so, takes various directions, different from those either of the piston-rod or of the crank, there is an obliquity of pressure

The Connecting-Rod and Parallel Motion.

produced at both extremities of the connecting-rod, which gives rise to a variation of force and of direction which must be practically provided for, and carefully appreciated in quantity, in so far as it may affect the ultimate operation of the machine.

There are two ways in which the motion of the piston-rod is most commonly transferred to the crank,—either immediately through the connecting-rod, as in fig. 100, or

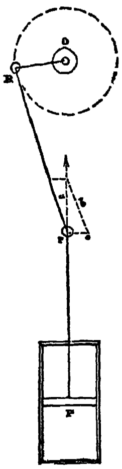


Fig. 100.

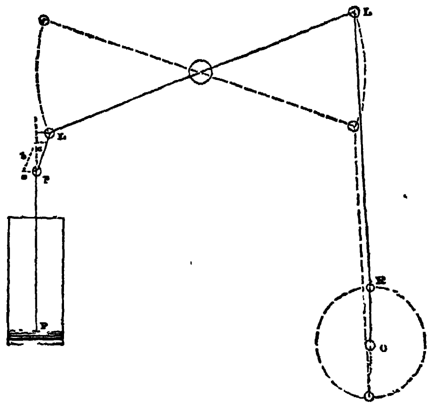


Fig. 101.

through the medium of the great lever, as in fig. 101, both ends of that lever describing circles around its middle fulcrum as a centre, and the head of the piston-rod being connected with the one end of the lever by means of an iron strap or connecting-link. From inspection of the figure it becomes plain that the connecting-rod or link is never, except at two points, in the same straight line with the piston-rod, so as to propagate its remodified force to the crank, but that in these oblique positions it would produce a lateral motion in the end of the piston-rod, which would not only be a waste of power in producing motion in a place where it is useless, but would have the effect of continually bending the piston-rod in opposite sides, so as either to break it or materially to impair its working. In the first of these figures, P p being the direction of the piston-rod, p R that of the crank, the force in the piston-rod in the direction $p\,a$ becomes resolved into two parts p R and $p\,c$, p R being effective in the direction of the crank-rod, and $p\,c$ tending only to give lateral motion to the piston-rod, or else to bend it or break it across. And so also in the second figure there is a similar separation of pressure. To prevent these oblique pressures from wasting the power of the steam, by producing lateral, useless, or injurious motions, is the object of a series of contrivances called parallel motions or parallel guides. The most notable of these we owe to Mr Watt.

Let it be supposed that we desire to prevent the top of the piston-rod p (fig. 102) from being moved by the obliquity of the connecting-rod pR, either towards the right or the left, then it is accomplished in the following way:—A fixed support s is found on one side of the piston-rod, and another on the other s^1, at equal distances from it, and two parallel bars $g\,s$ and $g^1\,s^1$ are placed between the piston-rod and these points, so that it may be steadied between them. These parallel bars are made so as to revolve freely round the points s, s^1, as centres, each of the ends g g^1 describing the circles g, g^3, g^1, g^2; from which it is evident that, if these rods were directly

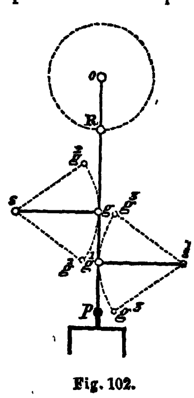


Fig. 102.

attached to the piston-rod at g and g^1, they should have the effect of keeping the point p in the straight line $o\,g\,g^1\,p$. As these bars $s\,g$ and $s\,g^1$ must describe circles round s and s^1, they would, in the positions $s\,g^2$, $s^1\,g^3$, deviate altogether from the straight line of the piston-rod; but as the one will act nearly as much in the one direction as the other in the opposite, it occurred to Mr Watt that, by connecting their extremities with a link $g\,g^1$, and attaching the piston-rod, not to the ends of the guide-bars, but to the middle of this link, the point p might be prevented from deviating to any appreciable extent from the straight line. This is accordingly produced in a very simple way. The following figures, 103, 104, 105, show the effect of these links in various positions.

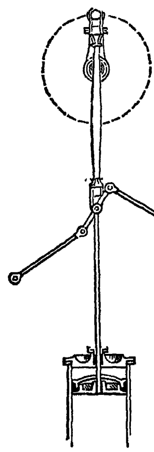


Fig. 103.

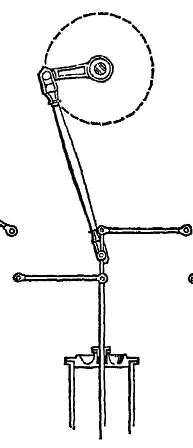


Fig. 104.

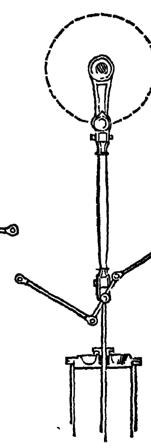


Fig. 105.

This elegant and simple contrivance is not, however, absolutely perfect. At the best, only a part of the line which it describes makes an approximation to a straight line, of scarcely sufficient length, and beyond which the stroke of the piston cannot be increased without being seriously deranged. Nor can this be remedied but by constructing the apparatus on a scale so large as to be highly objectionable. Thus, in the above arrangement, the point p is not kept perfectly in a straight line, but is, on the contrary, compelled to deviate from it so as to describe a looped curve. The nature of this deviation will become very evident if we suppose the parallel motion to be altogether detached from the piston-rod, and the motion of the parallel bar and link carried to its extreme, as in the following figures, 106, 107. A pencil being used to trace the motion

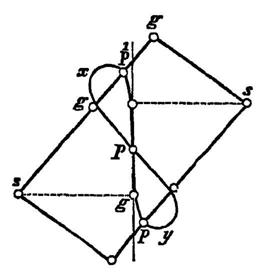


Fig. 106.

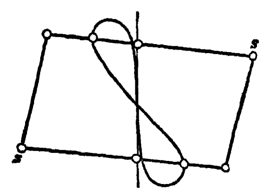


Fig. 107.

of the middle point, p will describe, not a straight line, but a curve $p\,x\,y$. When we carry the rods up to the position represented in fig. 106, where the bar $g\,s$ comes into the straight line with the link $g\,g$, the point p deviates from the straight line by turning to p^1; and this is reversed in the opposite extreme. In figure 107 the deviation is much greater when the link $g\,g$ comes into the same line with the other bar $g\,s$, and is also reversed in the position at the bottom of the figure. By the time the links have been re-

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turned to their primitive position, they have described the curve $x\,p\,y$.

It is important to diminish this deviation, which increases more rapidly than the square of the length of the stroke. Having ascertained the greatest deviation at the end of the stroke, and also at $\frac{1}{8}$th part of the stroke from the middle, bring the centres s and s nearer each other by a quantity equal to the deviation at the said eighth part, and the greatest deviation will now be reduced to less than one quarter of its former amount; the curve will now become a line of the sixth (eighth ?) order.

The parallel motion of one point having thus been secured, it is easy to transfer it to any other point. This is most commonly done by a pointed parallelogram. Thus, to transfer it to a point in connection with $s\,g$ prolonged to t (figs. 108 to 110), take a second link $t\,q$, equal to $g\,g$,

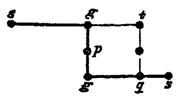

Fig. 108.

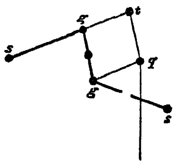

Fig. 109.

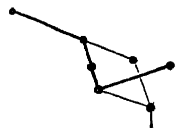

Fig. 110.

and a second bar, called the parallel bar $g\,q$, equal to $g\,t$, the corner q of the parallelogram will give a motion $t\,q$ similar to p. Figs. 111, 112, show the parallel motion

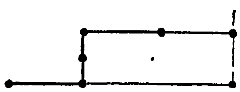

Fig. 111.

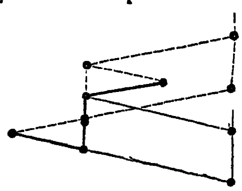

Fig. 112.

transferred to a point still farther from the original point.

Another form of Mr Watt's invention consists in placing two bars in the same direction, with such a difference in their length as may afford the means of compensation. Suppose that the point p (fig. 113) is to be guided to move

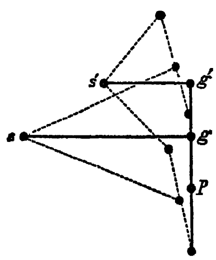

Fig. 113.

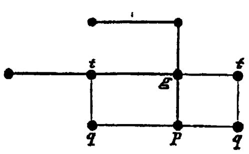

Fig. 114.

in the straight line $p\,g\,g'$; $s\,s'$ are points on the same side of the required direction of motion, and $s\,g$, $s'\,g'$, are the differential bars connected by a link $g'g$, which is prolonged to p. The dotted lines of the figures show the bars in different positions. The point p does not describe a straight line, but a curve, like figs. 106, 107. The motion of the point p may be transferred to a distance, as in the former instance, by a jointed parallelogram $g\,p\,t\,q$ (fig. 114). All these parallel motions may be inverted, and, indeed, generally are inverted, in steamboat engines. For practical examples of them the reader may consult the plates.

All these motions, as well as the first, being imperfect, various plans have from time to time been adopted for remedying the evil. In American steam-engines, Watt's parallel motion has been to a great extent abandoned, because in them long strokes and long cranks are preferred; and because, in such cases, the deviations of the point p—that is to say, of the piston-rod from a straight line—would, with Watt's method, become excessive. Watt and his assistants and followers were perfectly aware of this, and hence were led to construct beams, and connecting-rods, and parallel motions, of very great length, so as to diminish the evil as far as possible. This has, of course, the effect of rendering the whole engine both bulky and expensive, and is, therefore, in many cases inexpedient. The American engineers, therefore, use the sliding parallel motion; that is, they have substituted for the radius bars of the parallel motion of Mr Watt a sliding-bar or groove, in which the top of the piston-rod is guided. The head of the piston-rod p (figs. 115, 116) is enclosed between two flat surfaces, or between two parallel iron bars, which are kept in the vertical position by means of stiff framing; on these it slides, or, to diminish the friction, wheels may be added; but there are reasons why such wheels do not, in practice, work very well, and the plain slide is therefore preferred. In fig. 115 we have represented this motion as applied to

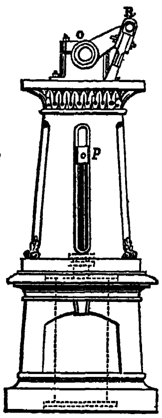

Fig. 115.

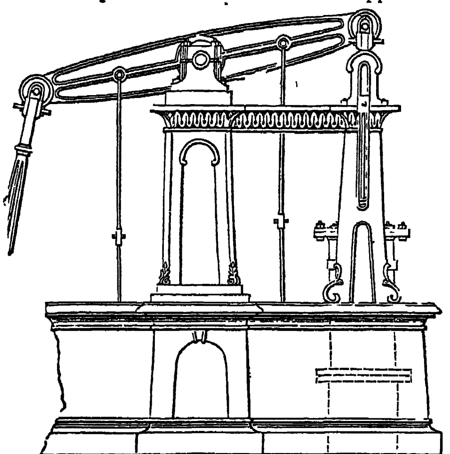

Fig. 116.

an engine of the simplest form; and in fig. 116, to a beam engine. In locomotives and some classes of marine engines, the guide-bars are universally employed.

Another species of parallel motion was, we think, first adopted in America; but it has also been used in this country. It is the engine with vibrating pillar. The pillar, which supports the beam or lever, instead of being fixed in an upright position, has a joint at the bottom, as will be seen in fig. 117, on which it, and the beam, and the

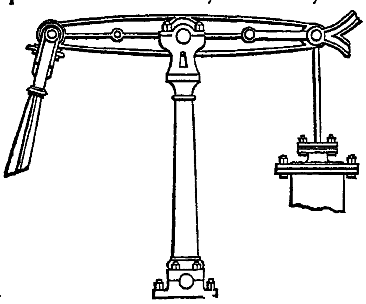

Fig. 117.

crank-rod perform a joggling motion backwards and forwards during each stroke. The motion is of the following nature:—The point s (fig. 118) is fixed; so is s'; $s\,g$ and $s'\,g'$ are moveable bars; $p\,g$ is $\frac{1}{2}$ of $p\,g'$. The point g describes a circle round s, and g' round s'; hence p describes the curve $p\,s\,p'$ of the sixth order. The oscillation of the moving mass of the engine in alternate directions, with a sudden jolt at the end of the stroke, renders this a bad engine when made

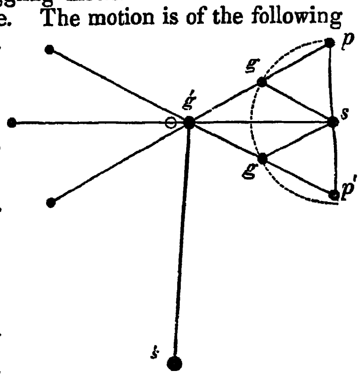

Fig. 118.

The Connecting-Rod and Parallel Motion.

on a large scale; and it is obvious that the deviation of the piston-rod from the straight line is very great.

But the principle which furnishes the most perfect parallel motion is one which, although not new, we have never seen applied to practice. It is well known that the locus of the extremity of a straight line, the middle of which moves in a circle, the other end being confined to one straight line, is also another straight line at right angles to the former. Let a straight bar $x\,y$ (fig. 119) be placed with one end y confined in an horizontal groove $a\,s$, and let a pin in the middle g be allowed to slide in circular groove $y\,g\,x$, then the end x will always describe a straight

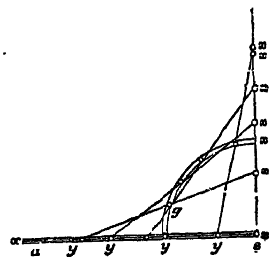

Fig. 119.

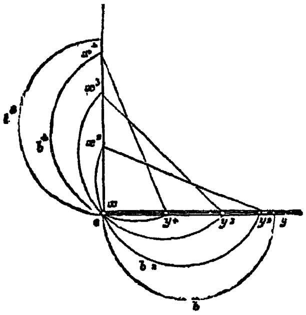

Fig. 120.

line $s\,x$ perpendicular to the first. Or it may be thus modified:—If the arc of a semi-circle have one of its extremities placed in a given straight line, while it moves along a given fixed point, the other extremity of the arc will describe another straight line at right angles to the former. Let a semi-circular round bar $y\,b\,x$ (fig. 120) be allowed to slide through a fixed centre at s, the one end y sliding in a groove, or along a bar $s\,y$, then the point x will describe the perpendicular $s\,x^4$, a perfect straight line.

To put this in practice in a form which shall not deviate widely from received forms of construction, is not difficult. The semi-circular groove and the semi-circular bar are not good constructive expedients. But if we take a radius bar $s\,g$ (figs. 121, 122, 123), fixed at a centre s, so that its end

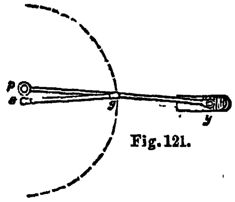

Fig. 121.

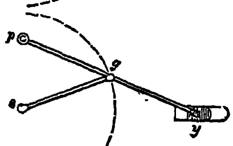

Fig. 122.

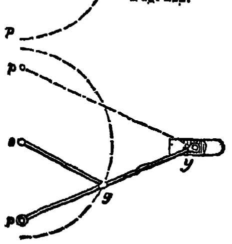

Fig. 123.

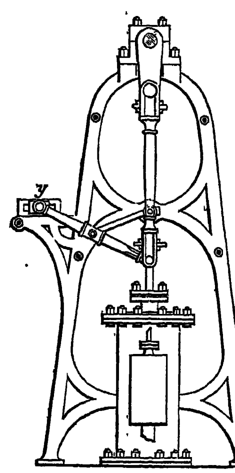

Fig. 124.

g describes a circle freely round it; and if we take a rigid bar $p\,y$ of double the length of $s\,g$, and united to it at g, then the middle of $p\,y$ being thus constrained to move in the circle round s, we have only to permit y to slide freely in an horizontal groove, and the point p being carried up and down, will describe the straight line $p\,s\,p$. Fig. 124 shows the application of this motion to the simple engine, and fig. 125 to the beam engine.

The Connecting-Rod and Parallel Motion.

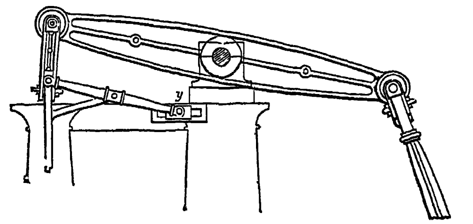

Fig. 125.

Such is the mechanism which the obliquity of the direction between the connecting-rod, or link, renders necessary to prevent any of the motion, propagated through them, from being expended in producing oblique transverse motion in the top of the piston-rod. Still, however, the motion of the piston-rod is modified by transference in an oblique direction, and we have now to consider the nature of that modification. With an indefinitely long connecting-rod, of which the angularity is inconsiderable, the relation of the motion of the crank and the piston is represented by the annexed diagram (fig. 126), in which $a\,c$ is the stroke of the piston, and $a\,b\,c$ the half revolution of the crank-pin simultaneously described. Let the path of the crank-pin be divided into equal parts at the points 1, 2, 3, 4, and draw verticals from the points of division to the line $a\,c$; then, as the angular speed of the crank is uniform, and the divisions of the circular path $a\,b\,c$ are equal, the line $a\,c$ will be divided by the perpendiculars already drawn into segments representing spaces described by the piston in equal times; and therefore, also, the varying average velocity of the piston in the same spaces. Whence it is obvious, that the speed of the piston, during one stroke, begins and ends at nothing at the extreme or dead points a, c; that it accelerates towards b, the position, at half stroke, when it reaches a maximum, and that beyond this point it is retarded till it gains the end of its stroke. The two halves of the stroke are described in equal times; and in these halves the variation of the velocity of the piston are exact counterparts.

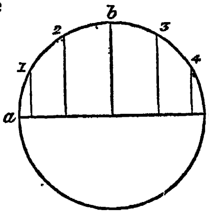

Fig. 126.

The obliquity of the connecting-rod destroys the symmetry here observed. In a stroke of the piston there are three cardinal points—the commencement, the middle, and the termination of the stroke. According to the preceding diagram, these three points are arrived at by the piston simultaneously with the horizontal and vertical positions of the crank. But the angularity of the connecting-rod at half-stroke of the piston virtually shortens its length, and the crank-pin is by as much short of its midway position. As the crank is presumed to move with a uniform angular velocity, it follows that the piston describes the two halves of its stroke with different average velocities, and in unequal times. In an engine, for example, with a stroke of 22 inches, and a connecting-rod $5\frac{1}{2}$ feet long, or six times the length of the crank, we find from the annexed diagram (fig. 127) of the relative positions of the piston and the crank, that, at half-stroke of the piston, the connecting-rod $a\,b$ falls short of the vertical centre line of the crank by the amount $o\,r$, fully 1 inch. Dividing the stroke of the piston into three equal parts, the connecting-rod being in the relative positions, $c\,d$, $e\,f$, the distances of the points d, f, from the centre line, are $o\,s$, $o\,t$, respectively $4\frac{1}{2}$ and $2\frac{3}{4}$ inches. The corresponding angular positions of the crank are, for the half-stroke of the piston, 6° with the vertical, and for the one-third of the stroke respectively 26°

The Governor.

and 15°. The sum of 26° and 15°, or 41°, is the angular motion of the crank during the middle third of the stroke,

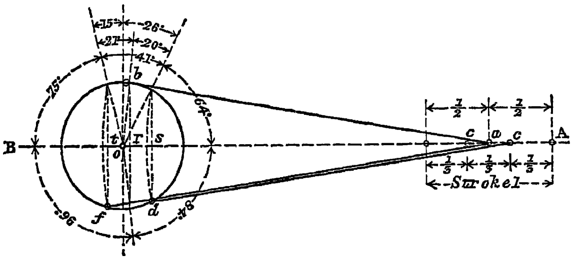

Fig. 127.

and the complements of these 75° and 64° are the angular motions for the extreme thirds. The average speeds of the piston, therefore, in describing the successive thirds of its stroke in the direction AB, are inversely as 64, 41, 75, or directly, as 6, 9, 5, nearly; and the two halves of the whole stroke are described with average speeds inversely as 84 to 96, or directly, as 8 to 7. The shorter the connecting-rod, the greater is the irregularity so introduced into the motion of the piston. The general effect, therefore, of the connecting-rod on the motion of the piston is, that the piston anticipates the position which it would occupy if the connecting-rod were "indefinitely" long at any point throughout the whole of the front stroke, which is described towards the crank; and that throughout the back stroke the piston is in the same degree behind the position due to the crank alone.

The Governor.—The governor is an appendage to a steam-engine of much value in regulating all its applications to the production of uniform revolving motion. It is merely a modification of an apparatus similar to the pendulum, and by which Huyghens once attempted to regulate a time-keeper instead of the common pendulum. If we suppose the axis Ax (fig. 128) to revolve along with the ball B, hung by a thread from x, and also with two pieces of iron xC, xC, bent so as to form cheeks, of a form called the cycloidal curve; then, when the string Bx comes in contact with those cheeks, the ball will perform each revolution in the same time as it would make two oscillations if merely swinging as a common pendulum; that is, if there be 39·1 inches from the centre of B to x, the pendulum will revolve once in two seconds. If, however, the ball B be suspended from x by a straight bar, such as Bx in fig. 129, the line Bx, in deviating from Ax, will describe the circular arch AB instead of a cycloid as formerly, and the time of oscillation will vary as the ball recedes from A, the revolutions being more rapid at b than at B. If, in the position B, the perpendicular height xC be 39·14 inches, then will the revolution be performed in two seconds, or at the rate of 30 per minute; while at b they will be performed in less time, and between B and A more slowly. The height Cx for any required number of revolutions is equal to the length of a simple pendulum, which will give double the number of vibrations in the same time.

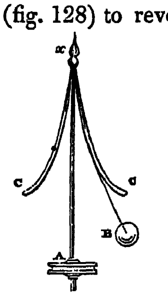

Fig. 128.

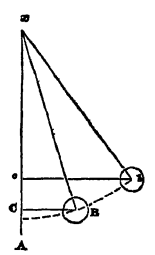

Fig. 129.

The regulation of the engine by the rate of the admission of steam to the cylinder is effected in the following manner:—The balls BB (fig. 130), showing Watt's original governor, are suspended by rigid bars from the fixed point or centre x. These bars, being prolonged to kk, are joined by links ky and ky to a moveable socket y, which can slide up and down the axis. The straight lever yp is acted on at one end by y, and at the other it draws up or pushes down the handle of a circular disc v, so as either to close or open it to different degrees; this disc, called the throttle-valve, is placed within or in connection with the steam-pipe that supplies the cylinder, so that if the engine should at any time move too slowly from having too much work to do, the balls will collapse, raise up y, and open v to the fullest extent, as at 4 in the small sectional figure to the right, 3 being the mean position; while, on the other hand, should the engine, from its work being taken off, go too quickly, the balls would fly off from the axis, bring down y, and close the valve to 2; or if it had happened, as by an accident, that the load was suddenly withdrawn, close the valve altogether, as at 1 in the side figure. Instead, however, of the bars being always, as here, prolonged above x, they have frequently the points $k\,k$ placed below x, and the socket y below these again, as in several of the plates and woodcut illustrations.

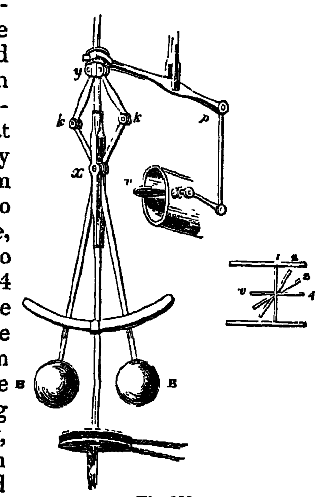

Fig. 130.

Distribution and Behaviour of Steam in the Steam-Engine.

SECTION II.—THE DISTRIBUTION AND BEHAVIOUR OF STEAM IN THE STEAM-ENGINE.

CHAP. I.—INTRODUCTORY.

It is within the cylinder that the power of steam is exerted and its work consummated, and our next business is to study the behaviour of steam in the cylinder, and to discover the conditions upon which its good working properties may most efficiently be turned to advantage.

Steam, as it is commonly employed, is drawn directly from the boiler, and is in the condition of maximum density for the pressure and temperature, under which it is generated and delivered over to the cylinder. The slightest reduction of temperature, or abstraction of heat, does, therefore, unavoidably incur the condensation of a portion of the steam. It is this peculiarity of ordinary or saturated steam—its sensitiveness to cold and susceptibility of condensation—which defeats the ordinary expedients for increasing its efficiency; and it is essential that the nature and extent of this distinction should be understood and appreciated, in order to show how it may be prevented.

From the detailed description already accorded to Watt's engines, it may be gathered that steam operates in the cylinder in a twofold manner—first, it is admitted freely from the boiler into the cylinder, following the piston, and exerting pressure upon it throughout a greater or less portion of the whole stroke; second, the communication from the boiler to the cylinder being cut off, the volume of steam thus enclosed within the cylinder continues, though isolated, to press upon the piston and to follow it to the end of the stroke, or at least for so far as the steam is therein confined—that is to say, the steam is "worked expansively." The energy resident in the steam, and of which only a part is utilised in following the piston direct from the boiler, is further utilised in virtue of the inherent elasticity of the body of steam cut off into the cylinder. Strictly speaking, the whole process is one of expansive action, as the steam admitted direct from the boiler flows into the cylinder by its elastic or expansive force, the boiler constituting the fulcrum, or "point d'appui," of

Distribution and Behaviour of Steam in the Steam-Engine.

action. The process is continued on a more limited scale within the cylinder, after the steam is shut off, the steam continuing, in virtue of the same elastic force, its expansive action against the piston, the end of the cylinders constituting the fulcrum. The boiler, of course, exercises independently its function of generating fresh steam to replace that which is expelled.

Although, however, there is no generic distinction between the admission of steam direct from the boiler to the cylinder, and the subsequent continuation of duty under the name of expansive working—seeing that it is but elastic action in both cases—yet it is convenient in practice to draw a line of demarcation between the period of the stroke during which steam is admitted into the cylinder and the period during which it is simply expanded therein. The different conditions of the pressure or elastic force during these two periods is usually quite apparent in the indications of the internal pressure which, by means of suitable instruments, may readily be observed and registered, where proper proportions subsist in the mechanism employed for the distribution of the steam; but in certain conditions the distinction is obliterated, and the steady uniform pressure with which the entering steam ought to take its place in the cylinder merges frequently in the descending pressure characteristic of simply expanding steam. This descending pressure, indicated while yet the communication between the boiler and the cylinder is not finally cut off, is the result of what is expressively called "wire-drawing" the steam, the current of steam into the cylinder being partially intercepted at the "port" or entrance, by the nearly-closed valve or slide, and thus wire-drawn, "throttled," or spun into steam of reduced density and pressure. Thus, then, in consequence of what is technically considered an imperfection of mechanism, interrupting the flow of steam before it is fairly shut off, the process of "expansive working,"—an economising process and nominally initiated when the cylinder is fully closed,—may be anticipated at an earlier part of the stroke.

In describing the cycle of events known as the "distribution," or the ordering of the steam admitted to and subsequently discharged from the cylinder, it should be noted, by way of recapitulation—speaking of engines as ordinarily formed—that with the cylinder is associated the valve-chest or steam-chest, into which the steam from the boiler enters previously to its passing into the cylinder,—an ante-room where the steam waits in readiness to enter the cylinder when admitted. The form and position of the chest or chamber varies indefinitely with the design of the engine. From this chest three passages are formed, one leading to each end of the cylinder, and the third passage leading to the condenser or to the atmosphere, or otherwise for the exit of the steam from the cylinder. The orifices of these three passages or thoroughfares are known as ports, and are usually brought together and placed parallel, terminating in a flat surface on the side of the cylinder, on which the valve reciprocates. The function of the valve is to distribute the steam, for which purpose it is impressed with a simple reciprocating motion, by which it alternately covers and uncovers each port leading to the cylinder, admitting the steam from the chest, suppressing or cutting it off, and ultimately releasing it from the cylinder by opening a means of exit by the third port already mentioned. The reciprocating motion of the valve is derived from an eccentric, in the simpler forms of mechanism, fixed on the driving-axle, and revolving with it. The linear motion derived to the valve from the eccentric is, on a smaller scale, exactly similar to that of the piston in connection with the crank.

That the steam may gain admission to the interior of the cylinder at the commencement of each stroke, the eccentric is so set on the axle, in advance of the crank, as to have the valve moved sufficiently aside at that juncture, that the steam-port may be uncovered by a small amount known as "lead," at the beginning of the stroke. When the piston has described a portion of the stroke, the valve returns in obedience to the return of the eccentric, and closes the port, thereby shutting off the further supply of steam to the cylinder behind the advancing piston; and confining what has been admitted, during an additional portion of the stroke. As the valve continues in its retrograde motion, it uncovers the steam-port on the inside, while the piston is still some distance from the end of the stroke, and opens the way out of the cylinder for the steam within, from which accordingly it emerges, and rushes into the condenser or the atmosphere. This external communication continues open, not only to the end of the "steam-stroke" through which the course of the piston has been traced, but also during the greater part of the "return-stroke," while the steam from the valve-chest is busy on the other face of the piston. Shortly before the completion of the return-stroke, the valve, in the regular course of the motion prescribed for it by the eccentric, closes the port to the atmosphere, and, finally, at a very small distance from the end of the return-stroke, the port is again opened, and the valve obtains the necessary lead in timely preparation for the entrance of steam from the valve-chest, before the commencement of the next steam-stroke, and the development of the full steam-pressure on the piston for another cycle of duty.

The periodical and cotemporaneous operations of the piston, the valve, and the steam, just described for one end of the cylinder and one face of the piston, take place independently for the other face of the piston; so that, two performances are proceeding together in one cylinder, and the engine is thence denominated double-acting. Four distinct events take place in consecutive order with respect to each end of the cylinder—first, the admission of the steam at or just before the beginning of the stroke; second, the suppression of the steam; third, the release or exhaust of the steam; and finally, the lock-up, or compression of the exhaust steam, prior to the opening of the port for admission. These four events together constitute the "distribution" for the cylinder, and their durations, measured in parts of the stroke, are the "periods of the distribution." By the aid of the indicator, which, as its name implies, is a sort of stethoscope for the observation of what transpires within the cylinder—a simple instrument for receiving and registering the tension of the steam—a minute and accurate picture of the operations within is transferred by pencil to paper, affording valuable and indeed indispensable data for the measurement of the power and efficiency of the steam in the cylinder. But before proceeding with this part of the inquiry, the movement and action of the slide-valve, in its relation to that of the piston, had better be explained by the process of geometrical illustration.

CHAP. II.—GEOMETRICAL ILLUSTRATION OF THE ACTION OF THE SLIDE-VALVE.

Geometrical Illustration of the Action of the Slide-Valve.

As the path of the crank-pin is represented by a circle, and the stroke of the piston by a straight line, equal to the diameter of that circle, so also the path of the eccentric is represented by a circle, and the travel of the slide-valve by a straight line, equal to the diameter of the eccentric circle—assuming, for the sake of illustration, that the valve is actuated in direct connection with the eccentric. If, then, two circles be described on a common centre O (fig. 131), for the crank-path and the eccentric-path respectively, their diameters AB, *ab*, are the stroke of the piston, and the travel of the valve. When the piston is at one end of the stroke at A′, the valve is opening the port at *a*″, and is just as much in advance of its middle position over the ports as is needed to

Geometrical Illustration of the Action of the Slide-Valve.

draw the lap clear off the edge of the port at a', in addition to the lead or opening of the port at the beginning of the

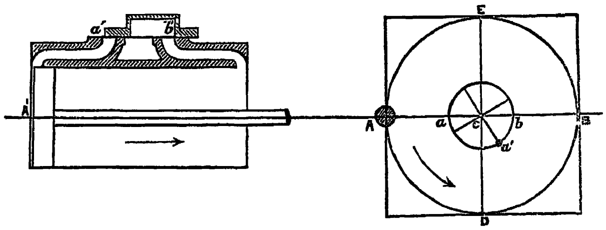

Fig. 131.

stroke. The position of the eccentric, then, (represented by its own revolving-centre), must be at the point a'', which is in advance of its position at half-throw, in the line DE, by as much as the lap *plus* the lead. As the axle revolves, the valve is further opened by the retiring eccentric, till it falls into the line AB, when the crank is getting on to half-throw. When the crank has attained to half-throw, in the position CD, the eccentric is on its way returning, and the motion of the valve is reversed on the way to close the port. The port is actually closed sometime before the valve and the eccentric return to their midway position—the former over the ports, and the latter in the line CE,—in virtue of the lap on the valve. Further, when the valve and the eccentric do arrive at their middle positions, half-travel and half-throw, the edge of the cavity of the valve coincides with the inner edge of the steam-port, and the opening of the port to the exhaust-passage, through the medium of the cavity, is forthwith established by the progressive motion of the valve. All that has just been described of the operation of the eccentric on the valve is effected before the crank completes a half-revolution, that is, before the crank-pin arrives at the point B, and, consequently, before the piston completes its stroke. The valve, indeed, makes another change before this; it opens the other port at b', for the other end of the cylinder, the lap having been completely withdrawn, and an additional movement for the lead effected, just as the stroke is completed.

The successive positions occupied by the valve during a revolution of the crank may be graphically represented, as in fig. 132, where AB and ab, being the circles of the crank

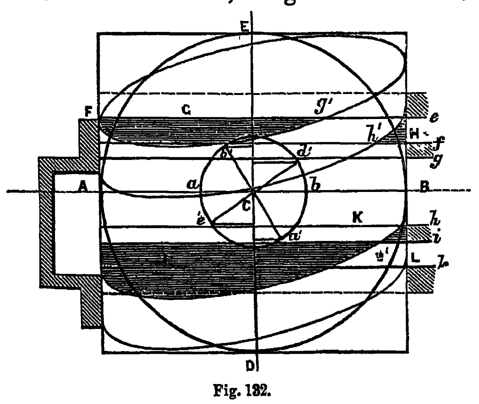

Fig. 132.

and the eccentric respectively, are divided into any equal number of parts, of which the points A, a', are respectively the positions of the crank and the eccentric at the beginning of the stroke; the other points, B, b', D, d', E, e', show the simultaneous positions of the crank and eccentric at intervals of one-fourth of a revolution. Draw the lines e, f, g, h, i, k, parallel to the centre line AB, spaced apart at intervals, equal to the exhaust and steam-ports and the intervening bridges; ef and ik being the steam-ports, and gh the exhaust-port. Place the valve on the perpendicular at A, in the right position with respect to the parallels e, f, k, for the commencement of the stroke, showing the requisite lead at F, and set off its positions on the face of the diagram, according with the positions of the crank. The elliptic lines, traced so as to connect these positions, represent the linear motion of the valve relative to the ports and to the crank, and, with the aid of a little shading, they clearly show the successive periods and changes of the distribution, subject, of course, to correction for the angularity of the connecting-rod. The shaded space G shows the period of admission, terminating at g'; and the shaded space H, the period of exhaustion, commencing at h'. The shaded space I shows the exhaustion for the alternate end of the cylinder, K the compression, and L the short period of pre-admission of steam for the following stroke.

The Indicator-Diagram.

On the same system, diagrams of motions may be constructed for any other proportions, or other species of valve, whether double or superposed valves, conical valves, moved by cams, or with conditions otherwise varied. The link-motion, as a variable expansion gear, operates by varying the travel of the valve; the extra expansion, and diminished period of admission, being affected by the shortening of the travel:—the result being precisely the same as if an eccentric of correspondingly smaller throw were substituted for an eccentric of greater throw.

CHAP. III.—THE INDICATOR-DIAGRAM—THE GENERAL BEHAVIOUR OF STEAM IN THE CYLINDER.

Proceeding to the investigation of the behaviour of steam in the cylinder, it may be noted that the action is fundamentally the same with condensing as with non-condensing engines; the difference being chiefly in degree. The receptacle into which the steam from the cylinder is discharged, is, in one case, the artificial atmosphere of the condenser, which causes an absolute pressure of 1 lb. per square inch, less or more; in the other case, the natural atmosphere, having a higher absolute pressure of 14·7 lb., or, in round numbers, 15 lb. per square inch. The action of steam is developed, in its most simple form, in the non-condensing engine, in which the question of the vacuum has no part; and the writer will, therefore, open the inquiry with a summary of his experimental analysis of the behaviour of steam in non-condensing engines, chiefly of the locomotive class, first published in 1851, in *Railway Machinery*.

In illustration of the function and utility of the indicator, by means of which most of the writer's observations were conducted, examples of indicator-diagrams, obtained by the writer from one of the cylinders of a locomotive, are illustrated in fig. 133. The base line A B is the line of

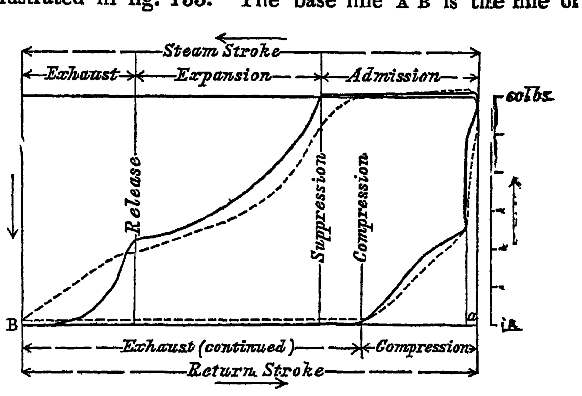

Fig. 133.

atmospheric pressure, and represents the stroke of the piston; and the rectangular space above it may be supposed to be the interior of the cylinder. The heavily lined figure is a diagram of the indicated action of the steam, when the piston moved in the cylinder at an average slow speed of

Behaviour of Steam in the Cylinder.

40 feet per minute, and shows, by its angularity, how the steam is controlled by the valve, and the precise points of the stroke at which the changes of the distribution take place. The piston is represented as having started from the right hand end of the cylinder, under a uniform pressure of 61 lb. steam above the atmosphere, traced from the upper right hand corner, till it reaches the point of suppression. The admission being terminated, the period of expansion is commenced, the pressure declines as the piston advances before the expanding steam, and continues to do so till the piston reaches the point of release. At this point the piston enters on its third and last stage of progress toward the end of the steam-stroke; the steam, primarily admitted at 61 lb. above the atmosphere, and attenuated to 23 lb. pressure previously to being released, quickly discharges itself into the atmosphere, in virtue of its remaining elasticity, and is entirely evacuated before the end of the stroke, as indicated by the quick and total decline of the steam-line during the period of exhaust towards the point B. The evacuation is, however, only relative, not absolute, as steam of atmospheric pressure remains in the cylinder, though not obviously sensible in the indicator-diagram; during the return stroke, therefore, the valve ought to maintain the exhausted end of the cylinder continuously open, to allow the steam of one atmosphere to escape before the returning piston, and the benefit of this provision is proved by the diagram, in which it appears that during the continuation of the exhaust the steam of latent pressure remains at the zero point of the scale. At the instant of closing or compression, however, when there is no longer an exit for the latent steam before the piston, the diagram-line slopes upwards towards the right hand side, and the steam is compressed against the end of the cylinder. While the volume of the compressed steam is being thus forcibly reduced, the density is increased, the pressure is raised, until the accumulation of back-pressure so induced is merged into the superior pressure of the steam admitted by anticipation for the business of the next steam-stroke. The point at which this irruption of pressure occurs is indicated by the small compartment *a* in the figure, representing the "period of pre-admission;" instantly the pressure mounts to the maximum initial pressure of 61 lb., in readiness for the succeeding steam-stroke.

The behaviour of the steam in the cylinder may thus, with the aid of the indicator-diagram, be clearly traced through the cycle of changes. The period of admission, in the example just described is, it appears, about one-third of the whole stroke; that of expansion is something more, and a simple inspection of the diagram shows that, in this instance, one-half of the work of the steam is performed by simple expansion while shut up in the cylinder. Even the period of exhaust supplies its quota of effect, inasmuch as the evacuation is a work of time, and the extra positive pressure so yielded is represented by the small triangular space between the point of release and the end of the stroke. The force developed by compression is properly designated resistance, as it is opposed to the motion of the piston, and must be classed with the slight opposition also made by the entering steam during its pre-admission for the steam-stroke.

But the important inquiry remains to be urged, How is the behaviour of the steam affected by the speed of the piston? If the piston move slowly, there is plenty of time for the steam to go about its mechanical duties. While the steam is admitted, it follows up the piston at full pressure; while the exhaust is open, it thoroughly evacuates itself. But at higher speed, the time for each evolution is proportionally shortened; and it remains to be considered, in what way this acceleration of duty is discharged. The dotted-line diagram, fig. 133, illustrates the behaviour of the steam in the same cylinder, under the altered circumstance of a higher speed of piston, averaging 310 feet per minute, other circumstances being the same. The steam enters at an initial pressure of 62 lb. per square inch, but suffers a slight reduction of pressure as the piston recedes before it —a circumstance which may at once be attributed to the accelerating speed of the piston in the cylinder, specifically due to the nature of the crank-motion, and the consequently greater difficulty of following it. The difficulty, however, is not considerable, and it is only when the piston nears the point of suppression, and the port is nearly closed by the valve, that the pressure rapidly falls in the diagram towards the suppression-line. This is a case of simple wire-drawing, as the opening of the port, previously wide enough to admit all the steam that could find its way into the cylinder, against the frictional resistance and bends of the passage, is now reduced to the minimum width consistent with this condition, and a further contraction and final closing necessarily occasions an accelerated fall of the pressure. The pressure at the instant of suppression, or cut off, under these circumstances, is 54 lb. above the atmosphere. The curve descends during the period of expansion, and cuts the line of release at a pressure of 19 lb., and on reaching the end of the stroke it attains a minimum of 2 lb. pressure. The curve of expansion, it appears, runs into those of the admission and the exhaust without any of the abruptness which distinguishes the slow diagram; the fact being that, before the steam was nominally cut off, expansion, technically so called, had begun—a result implied in wire-drawing—and there was therefore not the same liability to sudden change of pressure on entering the period of simple expansion. At the termination of the period of expansion, the curve crosses the exhaust line nearly at right angles, and barely reaches the minimum pressure at the termination of the stroke. The comparative delay so evinced in the accomplishment of the exhaust, is plainly a consequence of the shorter time allowed for this purpose by the greater speed of the piston; and, accordingly, we perceive a material accession to the area of the diagram, or the useful effect of the steam, in the very circumstance that it exhausts less freely. On the other hand, a drawback on this additional effect exists in the sustained back-pressure of 2 lb. per square inch, as indicated during the return stroke, referable to the same cause, imperfect exhaustion. The exhaust-line runs into the compression-line with a slight bend; and it is observable, that before the pre-admission takes place, the compressed steam attains to a higher pressure than that found by the slow diagram, a circumstance referable to condensation of steam in the cylinder at the low speed, which will be fully considered. But, though the curve of high speed is in advance of that of the low speed at the instant of admission of fresh steam, it falls behind at the commencement of the stroke; at this point the pressure does not get beyond 51 lb. above the atmosphere, and only attains the maximum, 62 lb., when the piston has described half an inch of the steam-stroke. This deficiency is attributable chiefly to the shortness of time allowed for the re-establishment of the working pressure, and indicates the need for more lead of the valve.

Behaviour of Steam in the Cylinder during admission.

CHAP. IV.—THE BEHAVIOUR OF STEAM IN THE CYLINDER DURING ADMISSION.

In the flow of steam from the boiler to the cylinder it meets with hindrances to its passage which usually operate to cause a considerable reduction of pressure when it reaches the cylinder, even if all the passages be thrown wide open. The actual charge of steam transmitted through an irregular passage of considerable length, and of a given sectional area, is, in all cases, less than what can be passed through an aperture, of a very short length, as in a thin plate of the

Behaviour of Steam in the Cylinder during admission.

same sectional area, owing to the bends and lateral friction of the long passage. It, therefore, frequently happens, that the opening of the port allowed by the valve, though it may be much less than the total area of the port, is sufficiently large to pass all the steam that can force its way along the passage. This fact is constantly exemplified in practice; it is known that opening the port beyond a certain amount, in all cases less than the area of the port itself, ceases to be advantageous in facilitating the passage of the steam into the cylinder. Similarly, the opening of the regulator, or "throttle-valve," beyond a small fraction of the sectional area of the steam-pipe, does not add to the available pressure at the valve-chest. When the steam is not dry, or contains water in suspension, the labour of moving in passages is greatly increased, owing to the quantity of dead inelastic weight to be dragged along, and the reduction of pressure is consequently much more than with dry steam.

Directing attention, for the present, to the behaviour of steam within the cylinder, it is to be premised that, notwithstanding the objections that have been urged against the ordinary slide-valve, worked by eccentric-motion, for want of sufficient celerity of action, there is no material wire-drawing of steam by the closing valve, when the period of admission exceeds two-thirds of the stroke, unless at very high speeds of piston, exceeding 500 to 600 feet per minute. When the steam is cut off at shorter periods, however, the travel of the valve being less, and therefore also its velocity of motion, the wire-drawing increases at high speeds, though at low speeds it does not. For example, the indicator-diagrams, fig. 134, were taken from a locomo-

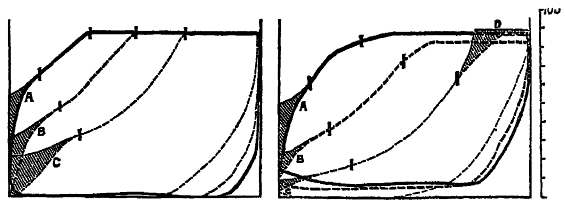

Fig. 134.

tive-cylinder, 18 inches diameter, 24 inches stroke; steam-ports, 13 inches by 2 inches; exhaust-port, 13 by $3\frac{1}{2}$ inches; lap of valve outside, $1\frac{1}{4}$ inch; inside, $\frac{1}{16}$ inch. Each figure shows three diagrams for periods of admission, respectively 16, $11\frac{3}{4}$, and 7 inches of the stroke, the terminations of which, and of the expansions, are pointed off on the figures; for the first figure the speed of piston was 240 feet per minute; for the second, 770 feet per minute. The wire-drawing at the lower speed was obviously nothing; at the higher speed, the pressure fell 3 lb., 12 lb., and 25 lb., below the initial pressure before the steam was cut off. This shows that the wire-drawing increased very much in proportion as the steam was cut off earlier—doubtless explained by the fact, that, in the three cases, the travel of the valves was, respectively, $4\frac{3}{4}$, $3\frac{15}{16}$, $3\frac{7}{16}$, inches; and the maximum opening of the port was $1\frac{3}{32}$, $\frac{11}{16}$ nearly, and $\frac{1}{2}$ inch. It was found, however, that, in the third case, with the shortest admission, the steam line was practically straight and parallel to the atmospheric line, at speeds of piston up to 450 feet per minute. In inferiorly arranged engines, with short lap and short travel of valve, wire-drawing is considerably greater than in the example just illustrated. With the same sizes of cylinders, a $\frac{5}{8}$ inch lap wire-draws considerably more than 1 inch lap of valve.

Long lap, in conjunction with wide ports, reduces the wire-drawing to a minimum. The more dry the steam is, the more susceptible it is of apparent wire-drawing, as indicated in the cylinder, because dry steam enters the cylinder more freely than wet steam, and attains a higher initial pressure.

As to the quantity of lead of the valve needful to insure ample and timely admission of steam into the cylinder at the commencement of the stroke, one-fifth of the length of the steam-port is sufficient. When the lead is excessive, the steam is admitted so readily as to be momentarily compressed, and to cause, in some cases, an unfavourable pulsatory action of the steam. The total absence of lead likewise occasions an unsteady pulsatory pressure in the cylinder. If lead is deficient, or wanting, the maximum pressure of steam in the cylinder is not attained until after a portion of the stroke is travelled by the piston.

Behaviour of Steam in the Cylinder during expansion.

CHAP. V.—THE BEHAVIOUR OF STEAM IN THE CYLINDER DURING EXPANSION.

When steam is admitted into the cylinder, while the latter is comparatively cold, or colder than the steam, a very sensible condensation of the steam takes place during admission, in the process of heating the cylinder to the temperature of the steam, which continues to a certain extent during the period of expansion. A portion of this heat, though but a small part, passes off and is lost; the remainder is retained by the cylinder until it is re-absorbed by the precipitated steam during the expansion of the remaining steam, if it be long enough continued—that is, until the temperature of the latter falls below that of the cylinder. This is a destructive process, occasioning an absolute loss of steam, and the amount of steam thus injuriously precipitated, and but partially revived, increases rapidly in proportion as the steam is earlier cut off and expansion extended. In the cylinders of ordinary steam-engines, the extra consumption and waste of steam devoted to the heating of the cylinder in the first part of the stroke is above 12 per cent. of the whole steam consumed for a period of admission of one-third of the stroke. In exposed locomotive cylinders, the loss has been proved to amount to nearly 40 per cent. of the whole steam consumed, when cut off at an eighth of the stroke.

This important species of loss is inseparable from the attempt to work steam expansively where there is no provision for the heating of the cylinder, and maintaining it at a suitably high temperature, equal, at least, to the initial temperature of the steam. The magnitude of the loss is so great as to defeat all such attempts at economy of fuel and steam by expansive-working, and it affords a sufficient explanation of the fact, in engineering practice, that expansive-working has been found to be expensive working, and that, in many cases, an absolutely greater quantity of fuel has been consumed in extended expansive-working, while less power is actually developed.

With respect to the ratio of pressure to expansion of steam in cylinders, observed in ordinary practice, it may be sufficient to remark in this place, that the quantity or weight of steam in the cylinder is the same throughout the process of expansion, estimated in terms of the pressure and the volume of the steam, as saturated at different points of the stroke, when the steam is dry, and the temperature of the cylinder is properly maintained; and that, consequently, the pressure of expanding steam in a cylinder, under such circumstances, may be determined with sufficient accuracy, for any degree of expansion, in terms of the ascertained density of saturated steam. On the contrary, in cylinders imperfectly heated, when the steam is partially precipitated during admission, and during the first part of the expansion, the expanding pressure at first declines more rapidly than would be due to the maintenance of a constant quantity of steam, and, afterwards less rapidly, rising above the expanding line of pressure, proper for a constant weight of steam, equal to that contained in the cylinder at the commencement of expansion. This want of conformity is exemplified in a diagram taken from an outside-cylinder locomotive, with a stroke of 24 inches, at a low speed (fig. 135), in which the dotted lines show the expansion-curve which

Behaviour of Steam in the Cylinder during exhaustion.

would have been described with a constant weight of steam. This process of successive condensation and re-evaporation is distinctly indicated: for, no sooner is the steam cut off at A, than condensation is made visible by the vertical sinking of the expansion-curve below the standard or normal curve, until the temperatures of the steam and the material of the cylinder become equal, when, as the pressure continues to fall, and the temperature of the steam with it, the curve rises and crosses the normal curve at C, in virtue of a partial re-evaporation of the steam previously precipitated, caused by the cylinder itself, which, at first colder than the steam, and heated by it in the first stage of the expansion, is then relatively hotter, and partially restores the heat of which it had previously robbed the steam. The process of restoration of heat goes on to the end of the expansion, as farther proved by the increasing excess of the indicated above the normal pressure at the point D, amounting to above 10 lb. per square inch at the point of exhaustion.

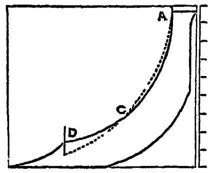

Fig. 135.

That the condensing power of an unprotected cylinder is something very considerable, is rendered very obvious by an indicator-diagram (fig. 136), taken from the same cylinder, in full gear, at a low speed, shortly after starting with a train. It shows that the pressure could not be maintained in the cylinder, as condensation in heating the cylinder proceeded faster than steam could be supplied through the opening of the port. Had the cylinder been hot, the pressure would have been fully maintained, according to the dotted line.

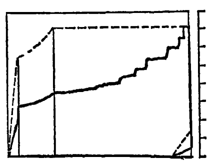
Fig. 136.

CHAP. VI.—THE BEHAVIOUR OF STEAM IN THE CYLINDER DURING EXHAUSTION.

In no part of the distribution is the advantage of time more apparent than during the period of exhaust. It is plain, by reference to figs. 133 and 134, that the steam does not discharge itself instantaneously from the cylinder at the point of release, as the piston, in all the diagrams, has visibly to go some distance before the pressure falls to a minimum. In fig. 133, at the lower speed, the piston moves $3\frac{1}{2}$ inches from the point at which the steam is released to the point at which the pressure falls to the atmospheric line. At the higher speed, the steam only reaches the minimum pressure of 2 lb., when the piston has attained to the end of the stroke, through 5 inches of the cylinder. These are elementary proofs of the benefit of time for insuring a good exhaust.

As the velocity of steam, escaping uninterruptedly, would practically suffice to evacuate the cylinder in good time, to prevent the evil of back-pressure, there is no doubt that the back-pressure which does actually arise is owing to the circumstantial hindrance of mixed water, strictures, bends, and friction. The retarded motion of the piston towards the end of the stroke, in virtue of the action of the crank, is peculiarly favourable for the exhaustion of the steam, as it allows time for its escape before the piston returns upon it. At the higher speeds, however, the escaping steam may be overtaken, and driven before the piston into the atmosphere, should its remaining elasticity prove insufficient, and then an opposing back-pressure is established. The wider the lead for the exhaust, the less is the back-pressure, on account of the increased facility for escape. For the usual speeds of pistons of stationary engines, about 300 feet per minute, the back-pressure is practically unimportant, if the cylinder be properly heated and the steam dry. On the contrary, the back-pressure is very great when the steam is condensed within the cylinder, or if it be loaded with water by priming. Fig. 137 shows, in contrast, the evil of condensation in a cylinder, in causing back-pressure. In the one case, the steam admitted at 80 lb. pressure above the atmosphere is cut off at one-sixth of the stroke, and exhausted at half-stroke, yet it is so loaded with water, when discharged, that it incurs a back-pressure of 12 lb. per inch in being expelled by the piston, moving at an average speed of 430 feet per minute. In the other case, illustrated in the same figure, the steam was admitted in a much greater volume, though half the stroke, at a speed of piston of 580 feet per minute, whilst the exhaust-pressure fell to about $2\frac{1}{2}$ lb. per square inch. The cylinder had been previously heated by hard work, the steam was comparatively dry, and the opposing pressure was, consequently, almost entirely removed.

Behaviour of Steam in the Cylinder during exhaustion.

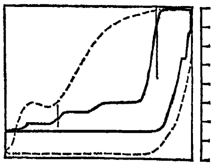
Fig. 137.

The ordinary effect of the priming of muddy water from a locomotive boiler is illustrated by fig. 138, in which are shown indicator-diagrams, taken from the cylinder immediately previous and subsequent to blowing off the boiler when the water had been unusually impure, at the same speed of piston, about 600 feet per minute. The full line was described before, and the dot-line after the boiler was supplied with clean water; and other circumstances being the same, the back-pressure fell from 9 lb. to about $1\frac{1}{2}$ lb. per square inch above the atmosphere. In some cases, the priming of water into the cylinder has been found to reduce the effective pressure more than a half.

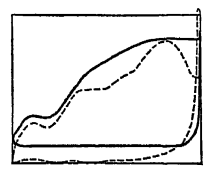
Fig. 138.

The blast-pipe of locomotives should be larger in sectional area than the steam-passages in the cylinder, in order to discharge the steam with facility. The orifice of the blast-pipe should not be less, and it need not be greater than the smallest part of the passage from the cylinder; if smaller, it increases back-pressure.

Summary of data as to Back-pressure.—If the steam working in steam-engines could escape freely, without resistance, the back-pressure would be simply the pressure of the atmosphere, in non-condensing engines; and, in condensing engines, it would be the pressure corresponding to the temperature in the condenser—what Professor Rankine calls the "pressure of condensation." The mean back-pressure, however, always—sometimes considerably—exceeds the pressure of condensation. One cause of this, in condensing engines, is the presence of air mixed with the steam, which causes the pressure in the condenser, and also the back-pressure, to be greater than the pressure of condensation of the steam. The ordinary temperature in the condenser, in proper working order, is about 104° Fahr., for which the pressure is 1·06 lb. per square inch; whilst the actual pressure in the best condensers of ordinary engines may be scarcely ever less than 2 lb. on the square inch.

The principal cause, however, of increased back-pressure is resistance to the escape of the steam from the cylinder, amounting to from 1 to 3 lb. per inch greater than the pressure in the condenser. Professor Rankine thus summarises the ordinary results of observation on the back-pressure in condensing engines:—

	Mean Back-pressure.
Ratio of expansion from $1\frac{1}{2}$ to 3.........	5 lb. per square inch.
Ditto.....................4 to 7.........	$4\frac{1}{2}$ to $3\frac{1}{2}$ lb. „
Ditto...................8 to 15.........	$3\frac{1}{2}$ to 3 lb. „

There is no doubt that, practically, in condensing engines, the back-pressure increases with the speed of the engine, and also with the density of the exhausted steam, and with

Relative Pressure of Steam in the Boiler, &c.

the size of the exhaust-ports. In non-condensing locomotive-engines, Mr D. K. Clark, in *Railway Machinery*, has found that the excess of back-pressure above the atmospheric pressure varies nearly as the square of the speed;—as the pressure of the exhaust-steam at the commencement of the exhaust;—and inversely as the square of the area of the orifice of the blast-pipe; that it is less, the greater the ratio of expansion; that it is less, the longer the time during which the exhaustion of the steam lasts; and that it is increased by the presence of liquid water amongst the steam.

CHAP. VII.—RELATIVE PRESSURES OF STEAM IN THE BOILER, THE VALVE-CHEST, AND THE CYLINDER.

As in the cylinder, so in the intermediate thoroughfares between that and the boiler, the movements of steam are affected by the conditions of dryness, as well as by the size and form of the passages. In well-protected cylinders, with dry steam, and ports $\frac{1}{15}$th of the area of the piston, the fall of pressure, or wire-drawing, in the cylinder-passages is about 16 per cent. of the pressure in the valve-chest, at a speed of piston of 600 feet per minute; and with a port $\frac{1}{10}$th the area of the piston, the fall of pressure does not exceed 10 per cent. at any speed. An example of the relative indicated pressures in the valve-chest and the cylinder of a locomotive is shown in fig. 139, when the former is represented to have oscillated above 5 lb. per square inch.

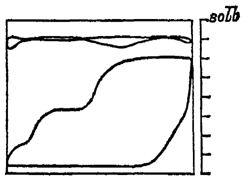

Fig. 139.

In imperfectly protected cylinders, when the steam is not dry, the fall of pressure varies from 20 to 40 per cent. The fall of pressure in passing through pipes less than $\frac{1}{16}$th of the piston in area, may be from one-third to one-fourth; in a pipe of $\frac{1}{10}$th the piston, the fall is inconsiderable. If the steam be highly dried, a pipe of ordinary length, $\frac{1}{13}$th the area of piston, is sufficient to transmit the steam undiminished in pressure.

The greatest useful opening of the regulator does not exceed $\frac{1}{20}$th the area of the piston. A greater opening is not found to add to the facility of transmission.

SECTION III.—MEASUREMENT OF POWER—HORSE-POWER.

CHAP. I.—MEASUREMENT OF WORK DONE IN THE CYLINDER FROM THE INDICATOR-DIAGRAM—FRICTION-BRAKES.

Definition of Work.—Work is an exertion of pressure through space. The unit by which quantities of work are measurable is the labour necessary to raise one pound weight through the height of one foot—that is, a foot-pound. The rate at which work is done is expressed in horse-power, and one horse-power is equivalent to work done at the rate of 33,000 lb. raised through one foot in one minute of time, or 33,000 foot-pounds—that is, one horse-power is expressed by the performance of 33,000 units of work per minute. The rather odd number 33,000 was adopted by the fathers of steam-engines, for the measure of power, because it was actually the measure of the performance of an average working-horse, under favourable circumstances; and though it was a useful and convenient measure at the time of its adoption, when horses rivalled steam-engines, the number 33,000 is only now retained because it is inconvenient to alter what has continued for so long a period to be the standard measure of power.

The indicator-diagram represents the active pressure and the back-pressure per square inch exerted by the steam on one face of the piston. During one stroke of the piston, therefore, if the steam-pressure be supposed to be exerted uniformly throughout the stroke, and if there be no back-pressure, the work done would be simply expressed by the product of the whole pressure on the piston in lbs. into the stroke in feet. The diagram expressing such an uniform exertion of force would necessarily be rectangular, and the product of its length in feet by its weight in lbs., measured by scale, would be an expression of its area, and would express the work done for one stroke per square inch of piston. If an uniform back-pressure were indicated, it would form a deduction from the useful pressure; and the difference of height representing power and resistance on the diagram, would be the effective pressure, which, multiplied by the length, would express, as before, the useful area of the diagram, or the useful work done per square inch of piston.

Measurement of Work done in the Cylinder.

But, in practice, the lines of positive-pressure and back-pressure on the diagram are not straight but curved. These conditions involve a preliminary process of reduction before the area of the diagram can be estimated, and the work for one stroke determined. Let the diagram be divided vertically into a sufficient number of parts by a series of parallels, drawn at equal distances across the figure transversely to the atmospheric line, representing the stroke of the piston; measure the mean effective pressure in each section by the scale, take the sum of the pressures thus found, and divide by the number of divisions of the diagram. The quotient is the effective mean pressure per unit of surface for the whole diagram. Multiply the effective mean pressure per unit of surface thus found by the area of the piston in the same units of surface, say square inches, and by the length of stroke in feet, and the resulting product expresses the whole effective work done upon the whole surface of the piston for one stroke. Reduce, in a similar manner, a second indicator-diagram for the other face of the piston, and take the mean of the two expressions of work done; or assume for a double-acting engine that the same quantity of work is done in the alternate stroke, multiply by the number of single strokes of the piston per minute, and divide by 33,000; the resulting quotient expresses the indicator horse-power of the engine.

If there be two or more cylinders to the engine, the power must be found in the same way for each cylinder, and the whole added into one sum, to express the entire indicator-power. But the simplest way in dealing with two or more cylinders, of equal diameters and strokes, working on a common main-shaft, is, first, to find from indicator-diagrams the average effective mean pressure on the whole surface of the piston, for all the cylinders; second, to multiply that by the length of the stroke, and by 2, and by the number of revolutions of the shaft per minute, and by the number of cylinders; third, to divide this product by 33,000. The quotient is the indicator horse-power.

On the contrary, should the cylinders be various in their functions, as in compound engines, in which a non-condensing and a condensing cylinder are combined, or should they be differently connected to the main-shaft, or have different diameters or lengths of stroke, it is better to find the power for each cylinder singly, and subsequently to sum the powers together, to find the whole. There is an advantage in this method of procedure, that the contribution of each cylinder, or class of cylinder, to the aggregate of power may be distinguished.

The friction-dynamometer measures the useful work done by a prime mover, by causing the whole of that work to be expended in overcoming the friction of a brake. The magnitude of the work done may be measured by a weight or a spring, as in Prony's dynamometer, in which the moving shaft or pulley is embraced by friction-blocks commanded by a lever weighted at the end.

Horse-Power of Engines.

CHAP. II.—HORSE-POWER OF ENGINES.

Horse-power is the term employed to express the capacity, magnitude, or power of an engine. It sprung from the actual measure of horse-power originally adopted by Mr Watt—namely, the performance of work at the rate of 33,000 foot-pounds or units of work per hour; or the raising of 33,000 pounds, 1 foot high, per hour. From the desire to give over-measure, just as the hundredweight rose from the original 100 lb. weight to 112 lb., as well as from the scanty means of exactly gauging the real power of engines, the horse-power rose to two, three, four, or five times that of actual horse-power; and thus, commercially, real or actual horse-power was altogether disregarded, and was replaced by what is called "nominal horse-power," the estimation of which is based simply upon the dimensions of the cylinder. "Nominal horse-power" is not, then, in any sense, horse-power, but is a commercial unit of capacity or power of performance, to fix the magnitude of the engine, and the price which is to be paid for it. But, even nominal power is not estimated by any uniform standard; individual manufacturers and others adopt different measures, and a uniform and universally recognised measure of power is a desideratum.

Different rules are applied to condensing and to non-condensing engines, the effect of which is to give a larger allowance of capacity to the former than to the latter. For condensing engines, the following are a few of the rules in use:—

Boulton and Watt's Rule.—Assume the speed of the piston to be 128 feet per minute, multiplied by the cube root of the length of stroke in feet; and the mean effective pressure to be 7 lb. per square inch. Then, nominal horse-power $= \frac{\sqrt[3]{\text{stroke in feet}} \times \text{diameter}^2 \text{ in inches}}{60}$. This rule is much in use in the south of England, and to some extent in Manchester.

Manchester Rule.—The common rule is to allow 23 square inches of piston per nominal horse-power; or, nominal horse-power $= \frac{\text{area of piston in inches}}{23}$. Occasionally, 30 is used for the divisor.

Leeds Rule.—This rule is taken in terms of circular inches of piston, or the simple square of the diameter, allowing 30 per nominal horse-power; thus, nominal horse-power $= \frac{\text{diameter}^2 \text{ in inches}}{30}$. This is, practically, almost identical with the Manchester rule, as 30 circular inches are equal to 24 square inches.

For non-condensing engines, the usual rules are as follow:—

Manchester Rule.—Ten square inches of piston are allowed per nominal horse-power; or, nominal horse-power $= \frac{\text{area of piston in inches}}{10}$.

Leeds Rule.—Sixteen circular inches are allowed; thus, nominal horse-power $= \frac{\text{diameter}^2 \text{ in inches}}{16}$.

Glasgow Rule.—Square the diameter of piston in inches, and point off the unit figure. The result is the nominal horse-power. This is the same in form as the Manchester rule, as it is essentially a process of division by 10. The Leeds rule is more liberal than the other, as 16 circular inches are equal to about 13 square inches.

For compound engines, having both non-condensing and condensing cylinders, it is the custom in Leeds to throw in the small or non-condensing cylinder, taking no account of it, and to rule from the condensing cylinder only.

The elements of a sound and comprehensive rule for the power of steam-engines must comprise the mean speed of the piston, its area, and the mean effective pressure. The mean speed is based on the stroke and the number of revolutions in a given time; and as a given number of revolutions is usually required, the formula should contain these two data individually. The effective pressure, also, is the result of the positive and negative pressures, in the boiler on the one part, and the exhaust-pressure on the other part, with the additional element of expansive-working.

Actual horse-power, reckoned according to the principle with which Mr Watt originally started, of dealing with actual quantities, should constitute the basis of a revised code of rules for nominal power. There are two forms in which it may be reckoned: as the indicator horse-power, or the power communicated to the piston, undiminished by friction, measured by the indicator; or as the power delivered at the main or crank-shaft, measured by the brake, which is less than the indicator-power by as much as the friction of the mechanism of the engine employed in transmitting the power from the piston. For commercial purposes, the friction of the engine should be a consideration.

The indicator horse-power of a cylinder, reckoned in terms of the effective mean pressure in lbs. per square inch on the piston, the diameter in inches, the stroke in feet, and the revolutions per minute, is computed thus:—

$$\text{Ind.-h.-p.} = \frac{\text{pressure} \times \text{diam.}^2 \times \cdot 7854 \times \text{stroke} \times 2 \times \text{No. of turns}}{33{,}000}.$$

$$\text{,,} \quad = \frac{\text{pressure} \times \text{diam.}^2 \times \text{stroke} \times \text{No. of turns}}{21{,}000}.$$

$$\text{,,} \quad = \frac{\text{pressure} \times \text{area} \times \text{stroke} \times 2 \times \text{No. of turns}}{33{,}000}.$$

Horse-Power of Boilers.

CHAP. III.—HORSE-POWER OF BOILERS.

The nominal horse-power of boilers is reckoned variously —from the lineal, and from the superficial, dimensions. The old waggon boiler was reckoned at the rate of 1 foot in length per nominal horse-power. For ordinary cylindrical boilers without internal flues, $5\frac{1}{2}$ to 6—usually 6—square feet of horizontal area is allowed per nominal horse-power, the area being taken as the product of the diameter by the length in feet. For boilers having one or two internal fire-tubes, or "Cornish boilers," the diameter of the flue-tube is added to that of the shell to find the proper multiplier. Galloway allows only $5\frac{1}{2}$ to 4 square feet of horizontal area in his boilers, as they have upright water-tubes in the flues, available as heating surface.

Again, reckoning by superficies, 15 square feet of heating surface, and 1 square foot of fire-grate, are commonly allowed per nominal horse-power; the heating surface comprising the actual area of the shell exposed to heat, but only the upper half of the internal flues. For multitubular boilers, of the locomotive type, 16 to 20 square feet of the total heating or exposed surface, and $\frac{1}{2}$, $\frac{2}{3}$, or $\frac{3}{4}$ square foot of fire-grate, are allowed per nominal horse-power; that is, more heating surface, because it is not considered so effective, and less grate used, because the draft is stronger than in Cornish boilers.

SECTION IV.—CLASSIFICATION OF STEAM-ENGINES, WITH EXAMPLES.

The modern steam-engine, comprising under this general designation, the engine proper, and the boiler and furnace, has been moulded into many varieties of form, according to the systems on which it has been constructed, and the various uses to which it has been applied. Irrespective of the uses to which engines are applied, they are distinguished into the two great classes of *condensing engines*,

and *non-condensing engines;* the former exhausting the used steam into an artificial atmosphere of low pressure; the latter exhausting into the natural atmosphere of 14·7 lb. pressure per square inch. The former class is usually more efficient in the production of power from fuel than the latter; but the latter has fewer parts and is simpler in design.

The second classification is based on the uses to which steam-engines are applied, thus:—*First*, stationary-engines, placed in permanent situations, for driving factory-machinery, pumping water, &c. *Second*, portable-engines, placed on wheels, or transportable, to be shifted to the scene of operations, to do the work of stationary-engines. *Third*, locomotive-engines, for propelling vehicles on land, chiefly on railways. *Fourth*, marine-engines, for propelling vessels on water. With the first, second, and third, it is the province of this article to deal; the fourth is reserved for a separate article.

CHAP. I.—STATIONARY BEAM-ENGINES.

Stationary beam-engines are usually made with condensers, and may be typified by the large engines erected by Messrs William Fairbairn and Sons, Manchester, to drive the machinery for preparing, spinning, and weaving alpaca fabrics, at the Saltaire Mills, near Bradford, the property of Mr Titus Salt. The engines are arranged in two pairs, to obtain the requisite uniformity of action, and are placed in large engine-houses on either side of the front entrance to the buildings; and they are supplied with steam from boilers placed in a boiler-house beneath the surface of the ground, and a short distance in front of the mills, according to the general plan and sectional elevations of the engine and boiler houses, Plate XVIII. The following is Mr Fairbairn's account of the Saltaire engines and boilers:—

The Engines.—"Plate XIX. contains a side elevation of one of these engines, giving a general view of the arrangement of the parts. The power generated in the cylinders C, and transmitted through the working beam B B, to the large spur-flywheel W, 24 feet in diameter, is taken direct from its circumference by the pinions P, P, which give it off at the required velocity to the shafting of the mill.

"The working beam is supported on two massive columns *c*, 16 feet high, 14½ inches in least diameter, and 1¼ inch thick of metal; these columns are bolted down beneath the whole mass of masonry supporting the engine. The heavy entablature *e* bolted to each column, and to the columns of the adjoining engine, is firmly fixed in the walls of the engine-house on each side, and the spring-beams A, A, over this and at right angles with it, are similarly attached to the cross-beams, *b*, *b*. In this way an exceedingly strong and rigid support is secured for the main centre of the engine, which, resting in its pedestal *a*, has to sustain the principal strain of working. The spaces between the spring-beams and walls, excepting where the main beam vibrates, are filled with ornamental perforated iron-plates forming the beam-room, approached by the staircase *f*, for the purpose of oiling the centres, repairs, &c. The working-beam receives its motion from the piston-rod *g*, through the parallel motion *h h*, and transmits it by the connecting-rod F and crank G to the fly-wheel W.

"The steam is brought from the boilers through a prolongation of the tunnel in which the smoke passes to the chimney, and enters the engine-house by the pipe D. Having thence been admitted to the cylinder through the valve-chests K K, it repasses, after it has completed its work, to the condenser H, through the eduction-pipe E, in the usual way. The condenser is supplied with cold water from the river Aire, by the pipe *k k*, which communicates with the cold water cistern J; the injector through which the water enters is in these engines 6 inches in diameter, but the supply of water may be diminished if necessary by the injection gear hereafter described. Beside the condenser is the air-pump, for pumping out the water and the air which enters with the water into the condenser, and is worked by the rod *l l* from a part of the parallel motion. A pump to supply the cold-water cistern is worked by the rod *n*, and another pump is worked by the rod *p p*, by which part of the hot water from the condenser is pumped back again for the supply of the boilers, in proportion as the water in them is decreased by the evaporation into steam. The supply of steam to the engine is regulated by the governor N acting on the throttle-valve *q*, and thus the speed of the engine is kept uniform. A shaft *s s*, receiving motion from a bevel-wheel on the crank-shaft, works the equilibrium valves in the valve-chests K K, as will be described. T T is a flooring or stage by which access is gained to the cylinder covers for oiling and cleaning. The cylinder is 50 inches in internal diameter, and has 7 feet stroke; it stands on the circular cylinder bottom C′, which is firmly bolted to the masonry by the long holding-down bolts *r r*.

"Plate XIX. contains also a plan of one engine-house, showing the relative arrangement of one pair of engines. The length of this house is 50 feet, and its breadth 24 feet. It will be seen that the two engines are combined so as to act in concert upon the same crank-shaft and fly-wheel, the cranks being placed at right angles to each other, that, when one engine is passing its top and bottom centres, and exerting least power, the other is in mid-stroke, and exerting its whole power upon the full leverage of the crank. In this way the action of the engines is equalised, and the motion rendered smoother than is possible with an independent engine, whilst, in case of accident to either of the pair, its fellow may be employed alone until the damage is made good.

"Plate XX. exhibits a half elevation and half section of the valve-chests, condensers, air-pumps, &c., showing the valves and the manner of working them. As before, C C are the cylinders, C′ C′ the cylinder-bottoms, K K the upper, and K′ K′ the lower valve-chests, fixed right over the cylinder ports, and communicating by the side-pipes *t t′*. D D steam-pipe, H H condensers, L L air-pumps; M hot-well, into which the air-pump lifts the water accumulating in the condenser; this water passes away by the overflow-pipe *m*; *p*, *p*, *p*, feed-pipes for supplying the boilers, with an air-vessel *p′* for equalising the pressure and preventing injury to the pipes from sudden shocks; *u* injection-cock and injecter, the quantity of water admitted being regulated by the injection-cock, worked by the hand-wheel *f*, through the medium of the small shafts and bell-cranks *n*, *n*.

"The valves in these engines are of a peculiar construction, being modifications of the double beat or equilibrium valve, invented by Mr Hornblower, and generally employed in the mining engines in Cornwall, where the high price of coal has led to that rigid economy for which its engineers have long been justly famous. We believe Mr Fairbairn was the first to introduce and advocate the present system of high steam worked expansively for factory engines, which he accomplished (not without considerable opposition on the part of those for whose benefit it was designed) by perseverance, and with the assistance of an active trade competition, driving the manufacturers to greater economy. It has now become general, much to the advantage of manufacturers, where the same amount of work is accomplished with half the quantity of fuel. Most of the appliances for using steam expansively in rotative engines are open to the objections—first, of wire-drawing the steam; second, of cutting it off too slowly; and third, of leaving too much space between the cut-off valve and the cylinder, whereby much steam is wasted without producing any

Stationary Beam-Engines.

effect. To remedy these defects, Mr Fairbairn employs the shafts and expansion apparatus shown in the plates, which are applicable to all rotative engines working expansively, whether with high or low pressure-steam.

"The steam entering the upper steam-chest K, through the stop-valve *a*, has free access also to the lower steam-chest K′ through the side-pipe *t*, whilst the exhaust steam has also clear access to the condenser through the other side-pipe *t′*. The steam is admitted to the cylinder from the valve-boxes by means of the valves *x* and *x′*, and after having completed its work, it passes through the exhaust-valves *y* and *y′* to the condenser, these valves being opened and shut alternately at the right instant by an apparatus yet to be described. Each of the valves consists of two single conical valves, carefully secured together and accurately fitting their seats, the lower valve being slightly smaller than the upper. The steam is admitted on the upper and lower side of each of these pairs of valves, and presses in opposite directions, so that the downward pressure on the upper valve is neutralized by the upward pressure on the lower, excepting that a slight preponderance is given to the former in consequence of the difference of area in the valves, in order to aid in keeping the valves firmly pressed upon their seats when released by the cams. Hence they lift with the greatest ease, and expose any required opening for the admission of the steam.

"The mode of working these valves is very simple; a shaft (*s s*, Plate XIX.) receives motion from the crank-shaft, and imparts it by the bevel-wheels *b b* to the horizontal-shaft *c c*; this in turn gives motion to the valve-spindles *d d*, which pass continuously through bearings in the valve-chests, and are supported on footsteps on the brackets *e e*. Upon each of these spindles are fixed two discs *g g*, carrying cams upon their upper surfaces so arranged as to lift and release each valve at the proper instant of time. This is effected by a direct and simple action; the height of the cam corresponds with the lift of the valve, its length with the duration of the lift, and its position on the cam ring, which revolves at the same rate as the crank-shaft regulates the instant of time in the course of each stroke at which the valve is opened. The action of the cams is transferred to the valves through the medium of friction pulleys *k k k k*, fixed upon small cross-heads, which are guided in their upward and downward motion by the brass standards on which they work. In the case of the steam-valve, these pulleys are capable of adjustment by sliding along the cross-head, so as to bring them over any section of cam that may be required, and thus the steam may be cut off at a $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, or any required portion of the stroke, the remainder being effected by expansion.

"The exhaust steam being a constant quantity requiring a full opening into the condenser, it is desirable to retain the exhaust-valve open during the whole length of the stroke. By the present arrangement, this is effected with a greater degree of certainty than by any other means hitherto proposed. The exhaust-valves rise suddenly upon the short incline planes of the cams, and having allowed time for the escape of the steam through a wide passage to the condenser, they fall with equal celerity by their own weight, and thus a more complete vacuum is formed under the piston than is perhaps possible to obtain by any other process.

"The stop-valve *a* is a simple conical valve, worked by a lever and hand-wheel *z*, fixed by a bracket to the side of the steam-chest, and is chiefly used for shutting off the steam from the engine.

"The indicator-diagrams (figs. 140 and 141) were taken from these engines on May 4, 1859. The engines were then working at 25 revolutions per minute, and one pair with part of the load off. The maximum vacuum varies from 13·0 to 13·2 lbs. per square inch below the atmosphere; the average vacuum is $12\frac{3}{4}$ lbs. per square inch. Diameter of cylinder, 50 inches; area, 1963·50 square inches; speed of piston, 350 feet per minute.

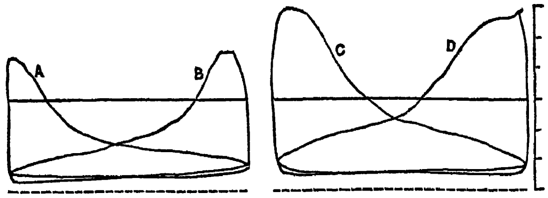

Fig. 140. Fig. 141.

"From these diagrams we get—

Per Square Inch.

"*Engine A.*—Mean pressure of steam..............=7·1684 lb.
Deduct for friction, air-pump, &c...=2·0000 „

Effective pressure.................... 5·1684 „
Actual horses power ... 107·63

"*Engine B.*—Mean pressure of steam..............=7·3646 lb.
Deduct for friction..................... 2·0000 „

5·3646 „
Horses power...........=111·46

"*Engine C.*—Mean pressure of steam..............=13.301 lb.
Deduct for friction ....= 2·000 „

11·301 „
Horses power...........=235·34

"*Engine D.*—Mean pressure of steam .... 12·946 lb.
Deduct for friction .... 2·000 „

10·946 „
Horses power .... 227·95

"With a higher pressure of steam, however, or a shorter expansion, these engines will work to a considerably higher power."

"*The Saltaire Boilers.*—Plate XVIII. contains a general plan of the boiler-house and boilers at Saltaire; and Plate XX. contains enlarged sectional views of one of the boilers. C′, C′, are the boilers, ten in number. They are 24 feet long and 7 feet in diameter, and are of the description known as multitubular. At B′ the upper half of one boiler has been removed so as to expose the flues in the interior, in which the heat is generated; and at A′ the whole boiler has been removed to expose the arrangement of the flues beneath, and the direction of the currents of heated gases as they pass from the furnace to the chimney. The fire generated in the fire-tubes *a′*, *a′*, passes into the mixing-chamber B′, where the air is thoroughly mixed with the flame and smoke, to ensure as perfect a combustion as possible, and thence the gaseous products pass through 109 small tubes, 3 inches in diameter, and descend at *b′*, *b′*, into the brick-work flues beneath the boilers; thence following the direction of the arrows, they return at *c′*, and enter at *d′* the great tunnel T′ T′, through which they are conveyed to a chimney 240 feet high, at some distance on one side of the mill.

"In the tunnel is placed the large steam-pipe *s′ s′ s′*, which communicates with all the boilers by means of the pipes *e′*, *e′*, *e′*; by this arrangement the hot gases round the pipe not only prevent the radiation of heat and condensation of the steam, but in fact in a slight degree superheat it, and render it more effective in working. The steam then passes to the engines by the pipes *t′*, *t′*, *t′*. To supply the waste of water in the boilers caused by evaporation, they are supplied from the engines by means of the feed-pumps, from which the water is conveyed by the feed-pipe *q′ q′* to the tunnel T′ T′, in which it is heated by the waste gases in an apparatus known as Green's fuel economiser. This apparatus consists of a series of upright tubes intro-

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duced in the tunnel between the boilers and the chimney, through which the water is made to pass on its way to the boilers, and is there heated to above the boiling point. The practical difficulty in the employment of this apparatus was the formation of a coating of soot upon the pipes, which effectually prevented the absorption of heat by the pipes and the water. To obviate this, Mr Green employs a number of rings or scrapers encircling the pipes, and kept in motion by means of chains and pulleys, driven by a shaft from the engine; these scrapers traverse the whole length of the pipes, and thus prevent any accumulation of soot upon their surfaces. It has been found that, when the waste gases from a boiler escape at a temperature of only 400° to 500°, the feed water can be heated to an average of 225°, and the temperature of the gases on leaving the pipes is reduced to about 250°. To produce this effect, 10 square feet of heating surface in the pipes are required for each horse-power. In this way a considerable economy of fuel is said to be effected, amounting to 17 to 25 per cent. After passing through this apparatus, the heated feed-water re-enters the boiler-house by the pipe $r' r' r'$, and is thence distributed to the boilers. The safety-valves shown at f', f', f', consist, for each of these boilers, of two valves, each of 12 inches area, loaded with fixed weights to the maximum working pressure of the boiler, and of a third valve of five inches area, attached to a spring-balance, so that any required pressure may be secured by its adjustment. These valves are fixed upon a common valve-seating; m', m', m', are the man-holes by which access is gained when requisite to the interior of the boiler, for the purpose of examination, cleaning, &c. At D′ there is a self-acting elevator for raising the ashes and depositing them at once in railway waggons above. The coal is brought by railway and dropped at once from the waggons into the boiler-house at E′, E′.

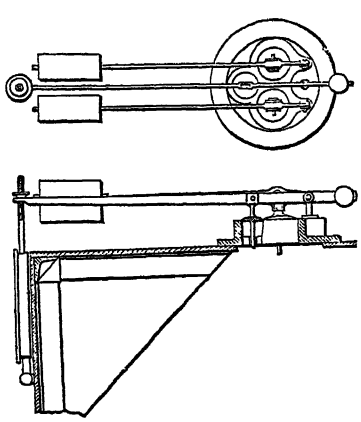

Fig. 142.
Safety-Valves.

"Referring to the sectional views of the boiler and boiler-house, a', a', are the fire-tubes and fire-grates, and n', n', the bridges; B′ the mixing-chamber, in which three vertical tubes p', p', p', will be noticed, which strengthen the flue in its weakest part, viz., where it is elliptical in form, and aid in absorbing the heat by increasing the heating surface; $b' b'$ the descending flue; $d' d$ the entrance to the common flue or tunnel T′; $e' e'$ the steam-pipe, with shut-off valve at y', entering the common steam-pipe s' in the tunnel; r' the feed-pipe, with valve for regulating the supply to each boiler, communicating with the interior by the pipe x'; v', v', v', stays or gussets for strengthening the ends of the boiler; f' safety-valves, with levers, weights, and spring-balance g'; h' the glass water-gauge; i' cock for drawing off the water when requisite; and k' additional man-hole for cleaning the boiler beneath the flues.

"The principal dimensions of the boiler are as follows:—Shell, 7 feet diameter, 24 feet long. The length is divided thus—Fire-tubes, 9 feet long; mixing-chamber, 8 feet; flue-tubes, 7 feet; total, 24 feet. The fire-tubes are 2½ feet in diameter; grates, 2½ feet by 6½ feet long; mixing-chamber, 3 feet 10 inches diameter; 109 flue-tubes, 3 inches diameter.

"The heating surface in each of these boilers may be stated as follows:—

Area of fire-tubes	135	square feet.
Area of mixing-chamber	102	„
Area of vertical tubes	28	„
Area of 3-inch tubes	550	„
Total	815	„
Area of fire-grate (16¼ × 2)	32½	„

"The chimney is 250 feet high above the level of the ground. It is built in the style of an Italian campanile, and consists of an outer ornamental stone casing, and an inner and perfectly distinct parallel brick flue, the space between the flue and the casing being free for the expansion and contraction of the flue. The flue is 6½ feet square, having 42¼ square feet of sectional area, to the summit. The external casing is 20 feet square outside at the base, and tapers to 10 feet square at the summit."

The following are additional particulars and illustrations of the Saltaire engines and boilers, with reference also to the foregoing detail illustrations:—The cylinders (fig. 143) are 50 inches diameter, with 7 feet stroke, of metal, 1½ inches thick, on a pedestal of the same thickness, bolted down to the foundation. The ports are 20 inches wide by 6 inches deep, with a sectional area $\frac{1}{16}$th the area of the piston. The equilibrium valves have the upper disc 12 inches diameter, area 113 square inches; the lower disc is 10½ inches diameter, with 86½ square inches area; difference of areas, 26½ square inches. Lift of steam-valves, 1⅝ inches; of exhaust-valves, 1⅞ inches; steam-branches, 12½ inches diameter; exhaust-pipe, 13 inches; stop-valve, 12½ inches diameter. Condenser, 40 inches diameter; air-pump, 33½ inches, by 3½ feet stroke; foot-valve, 30 inches by 6½ inches, 195 square inches, or $\frac{1}{4.5}$th of the sectional area of the air-pump; discharge-valve, 31 inches by 7 inches; injector, 7 inches diameter. The pistons and air-pump buckets (figs. 145 and 146) are packed with Goodfellow's notched V rings, in one piece. The beam is 21 feet 6 inches long between end centres, or over three times the length of the stroke; it is 3½ feet deep at the middle, or ⅙th of the length, and the web and the rim are 2½ inches thick; the main-centre (fig. 147) is 12 inches diameter in the beam, and 9 inches at the bearings; the connecting-rod (fig. 148) is about 20 feet long, of cast-iron, of a cruciform section in the body, measuring 22 inches across, and 1¾ inches thick at the edges. The spur-flywheel is 24 feet 5 inches in diameter, with 230 cogs in the rim, 14 inches broad, 4 inches pitch;

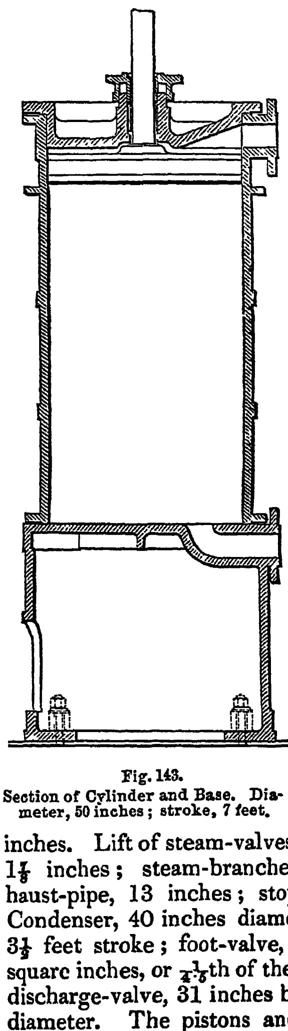

Fig. 143.
Section of Cylinder and Base. Diameter, 50 inches; stroke, 7 feet.

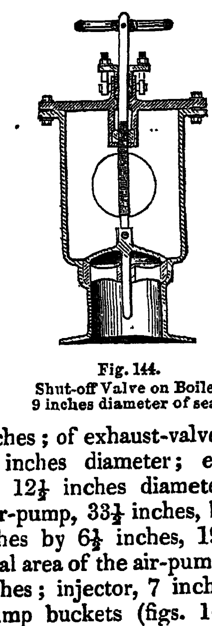

Fig. 144.
Shut-off Valve on Boiler, 9 inches diameter of seat.

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the rim is in 10 segments, and has a sectional area of 200 square inches. In fig. 149, the cover of the centre is re-

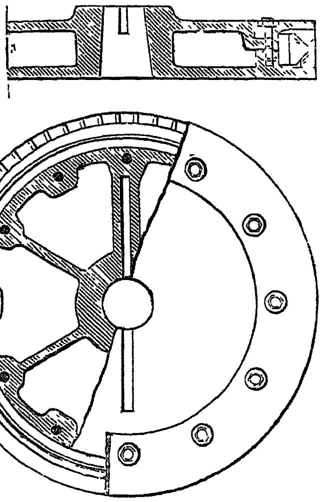
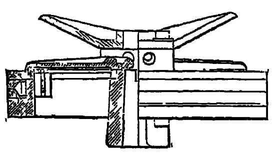


Fig. 145.
Section and plan of Piston on Goodfellow's system; 50 inches diameter.

moved in order to show how the arm of the wheel is inserted and bolted into the recess prepared for it. Fig. 150



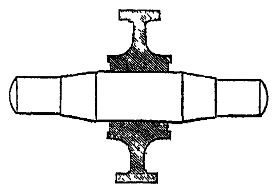


Fig. 147.
Main centre and section of Beam; 3½ feet deep.

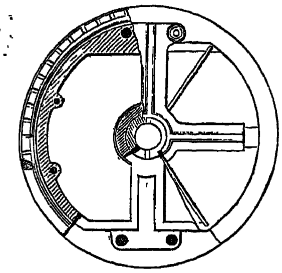


Fig. 146.
Sections of Air-pump Bucket; 33½ inches diameter, 3½ feet stroke.

Fig. 148.
Section of connecting-rod at the middle; 22 inches square.

shows the most recent form of section of spur-flywheel rim, adopted by Messrs Fairbairn. The feed-pump has a plunger 6 inches diameter (fig. 151).

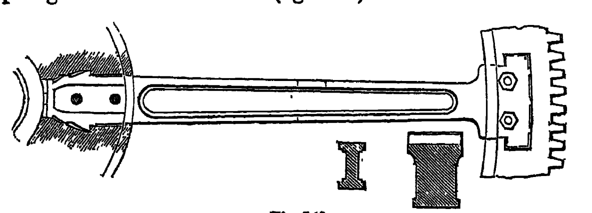


Fig. 149.
Portion of Spur-Flywheel, with sections of the rim and a spoke; 24 feet 5 inches diameter.

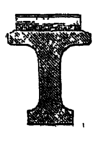


Fig. 150.
Spur-Flywheel Rim, as recently made by Messrs Fairbairn.

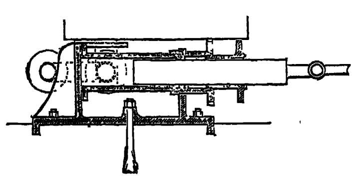


Fig. 151.
Feed-pump: 6 inches diameter, 21 inches stroke; water-way, 4 inches diameter.

Mr Fairbairn estimates each pair of engines at 200 nominal horse-power, or the gross nominal power of the two pairs at 400 horse-power. His rule for nominal power is to multiply the area of the piston, 1963·5 square inches, by 7 lb. pressure per square inch, and by a speed of piston of 240 feet per minute, and to divide by 33,000, which gives 100 nominal horse-power for one cylinder, or

$$\frac{1963{\cdot}5 \times 7 \times 240}{33,000} = 100 \text{ nom. horse-power,}$$

giving 400 horse-power for the four cylinders, or two pairs. According to the ordinary Manchester rule, the united nominal powers would be 341 horse-power.

The boilers are made of best Staffordshire iron-plates, $\frac{5}{16}$ inch thick for the shell, and $\frac{7}{16}$ inch for the ends; $\frac{3}{8}$ inch Lowmoor plates for the flues, except for the furnaces, or upper part of the fire-tubes. The pressure varies from 25 lb. to 30 lb. per square inch, according to the load; it is calculated that the pressure may safely amount to 40 lb. Eight boilers are in steam at one time to supply the mill and the engines when working with their full load; but nine boilers, and sometimes all the ten, are at work when inferior coal is used. In addition to the large engines of 400 nominal horse-power, there are two 25 horse-power blowing-engines, also worked by the boilers, to heat the mills. Each boiler is estimated at 50 nominal horse-power, allowing about $\frac{3}{8}$ square foot of fire-grate surface per horse-power, and is stated to be sufficient to supply steam for 150 indicator horse-power.

The consumption of fuel averages from 3 lb. to $3\frac{1}{4}$ lb of good coal per indicator horse-power per hour, and $4\frac{1}{2}$ to $4\frac{3}{4}$ lb. of slack per indicator horse-power.

The total weight of cast-iron in each pair of engines, exclusive of steam-pipes, is 157 tons, 7 cwt., 1 qr.; of wrought-iron, 11 tons, 8 cwt., 3 qrs.; of brass, 2 tons. 7 cwt., 1 qr.; total weight of metal in one pair of engines, exclusive of connections, 171 tons, 3 cwt., 1 qr.; in two pairs, 342 tons, 6 cwt., 2 qrs. The weight of one boiler complete is $10\frac{1}{2}$ tons; of ten boilers, 105 tons. The gross weight of metal in all the four engines and ten boilers, exclusive of connections, is 447 tons, 6 cwt., 2 qrs.

The peculiar design of non-condensing beam-engines (fig. 152) is the production of the Corliss Steam-Engine Company,

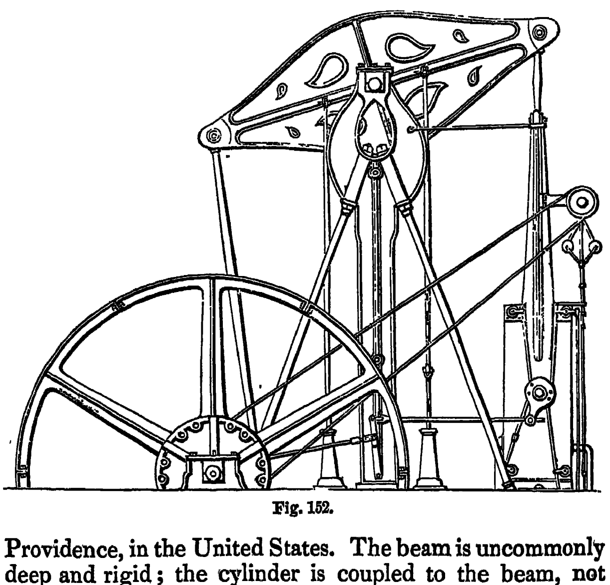


Fig. 152.

Providence, in the United States. The beam is uncommonly deep and rigid; the cylinder is coupled to the beam, not by the usual parallel motion, but by a connecting-rod, from the cross-head of the piston-rod, which is guided by an upright slide. The beam is supported by a cast-iron standard, stayed diagonally by wrought-iron rods. The engine is worked by Corliss's valve-gear. On this system, the steam-passages are reduced to the shortest length prac-

ticable, and a valve is applied to each passage, two for the admission of steam, and two separate passages for exhaust; four in all. The gearing is designed to work the steam with various degrees of expansion, and is operated on by the governor, so that the speed is regulated, not by wire-drawing, as is usual, but by varying the degree of expansion, admitting steam of full pressure into the cylinder before cutting off. The valves are segmental, and rotative-reciprocating in their action; they are worked from a "wrist-plate," shown in the figure, deriving its motion from the eccentric. They are easy to work, and are operated on by the governor, without any resistance to the latter, and thus a steady equable motion of the engine is insured. The governor operates through an ingenious contrivance for disengaging and re-engaging the valve-gear, by means of an inclined-plane motion. The indicator-diagrams produced by this motion are good, and the practical results of its working are excellent.

CHAP. II.—MODIFIED ARRANGEMENTS OF BEAM-ENGINES.

The non-condensing engines made by Messrs Mather, Dixon, and Co., erected to work the inclined plane on the Liverpool and Manchester Railway, at Liverpool Station, Plate XXI., shows how, by simple inversion of the engine, the power is transmitted from the cylinder through the beam, at once to the main-shaft under ground, which carries the large grooved pulley to work the rope. There is a pair of engines to work the main-shaft, connected at right angles. The centres of the beams L L rest at a level of 3 feet above the floor of the engine. A is the cylinder, in section in fig. 2; L *p* is a side-rod from the cylinder cross-head to the lever, and the connecting-rod L K descends to the crank-shaft X. S S the steam-pipes, D D the valves, and *x x* the valve-gear. The foundations are solid red-sandstone rock, in which excavations are made for the shafts and ropes.

Another arrangement of beam-engine, with low-hung beams, Plate XXII., was erected by Messrs Wm. Fairbairn, in a mill at Staley Bridge. The whole of the pair of engines stands on an independent metal sole-plate, and is similar in form to the well-known type of marine engines. The beam L L is, as it were, split in two, one of the halves being placed on each side of the engine, but united at the middle by a large gudgeon, or main-centre, and at the ends by cross-heads, side-rods, and connecting-rod, to the piston and the crank. A the cylinders; B the cross-heads; K the crank; L L the beams; W the spur-flywheel, driving the mill-shaft Y through the smaller spur-wheel *g*; *m* the parallel-motion; *x x* the motion for actuating the valve-gear; *d* a counterpoise to the valves; *w* the governor; H the cross-head to work the air-pump.

CHAP. III.—COMPOUND BEAM-ENGINES.

Mr Wm. M'Naught, of Manchester, introduced an important addition to the ordinary beam-condensing engine, in the application of an additional cylinder, non-condensing, to co-operate with the condensing cylinder, under the same beam, but on the other side of the main-centre. This system is illustrated by the diagram (fig. 153) of a pair of engines, erected at the Gutta Percha Company's Works, City Road, London. A, A, are the ordinary condensing cylinders at one end of the beam, 34 inches diameter, 6-feet stroke; B, B, are the additional, and smaller, non-condensing cylinders, 31 inches diameter, 3-feet stroke, placed under and connected with the other half of the beam, near the crank-end. "High-pressure" steam is admitted from the boiler to the small cylinders B, thence to the large cylinders A, thence to the condenser C, by means of suitably-arranged pipes and gearing; the steam is admitted to the former at a pressure of from 40 lb. to 50 lb. above the atmosphere, and is cut off by means of an ordinary lap-valve, at from ⅓d to ⅔ds, but usually at half-stroke; it is expanded

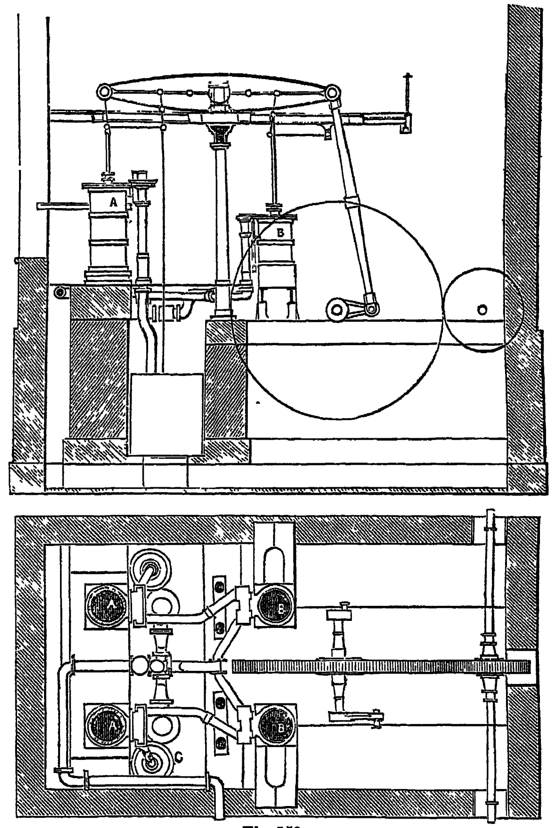


Fig. 153.

to the end of the stroke, and then is exhausted into the large cylinder, which commences its stroke at the termination of the stroke of the first cylinder, and the two cylinders perform respectively their steam-stroke and return-stroke at the same time, the steam continuously expanding from the smaller into the larger, and evacuating the former precisely as if it was exhausted into the atmosphere. At the end of the steam-stroke of the larger cylinder, the steam is exhausted in the usual way into the condenser; and at the end of the return-stroke of the smaller cylinder, the steam from the boiler is admitted into it for the next steam-stroke. The indicator-diagrams (fig. 154) show the conjoint working of the coupled cylinders of one of Mr M'Naught's engines, erected at a grain-mill at Drogheda, in which the high-pressure cylinder is 31½ inches diameter, with 37-inch stroke; and the low-pressure cylinder is 34 inches diameter, with 74-inch stroke, making 20 revolutions per minute. The nearness of the exhaust-line of the former to the expansion-line of the latter, proves the proper

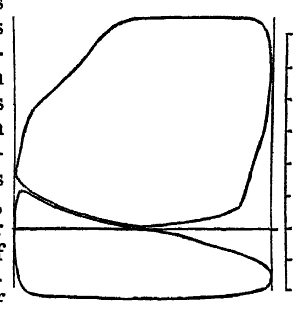


Fig. 154.

action of the system, and that there is no material loss of pressure by the passage of the steam from the one cylinder to the other. The steam is admitted at 33 lb. sensible pressure, and there is a vacuum of 11¼ lb. The indicator horse-power obtained in the small cylinder is 79¾ horse-power; and in the larger, 77 horse-power, nearly equal, making together 156¾ horse-power. The engine works day and night, and consumes 2·84 lb. of Welsh slack per indicator horse-power per hour. In other cases of M'Naught's engines, a fall

Compound Beam-Engines.

of 2 lb. to 3 lb. pressure may be observed in the passage of the steam from the small to the large cylinder, arising from the probable condensation and friction in the passages. The usual consumption of fuel by this class of engine in mills is about 3 lb. per indicator horse-power per hour, which includes the necessary steaming of the mill; in one case it was only 2$\frac{3}{4}$ lb., and if $\frac{3}{4}$ lb. be deducted for other purposes, the usual consumption of M'Naught's engines would be at the rate of 2$\frac{1}{4}$ to 2 lb. per indicator horse-power per hour. With very inferior fuel, the gross consumption has amounted to 5·28 lb. per horse-power. The system has been applied to upwards of 400 engines, and, besides the economy of fuel, it effects a perfectly steady motion, by the equal distribution of the moving force at the two ends of the beam, and reduces the violent strain, or "lift," usual in single-cylinder engines, working expansively at the main-centre and the crank-shaft bearings.

Beam-engines are occasionally compounded by placing two cylinders side by side, under the same end of the beam, exhausting from the top of the small cylinder to the bottom of the large one, and *vice versâ*. On this system the passages between the two cylinders are shorter than on M'Naught's; but there is an obvious disadvantage in the united action of the two cylinders on the beam and the bearings in the same direction.

Mr Charles Swift, Blackburn, constructs a single slide-valve, for exhausting from the high to the low-pressure cylinder, shown in detail in figs. 155, 156. The exhaust takes

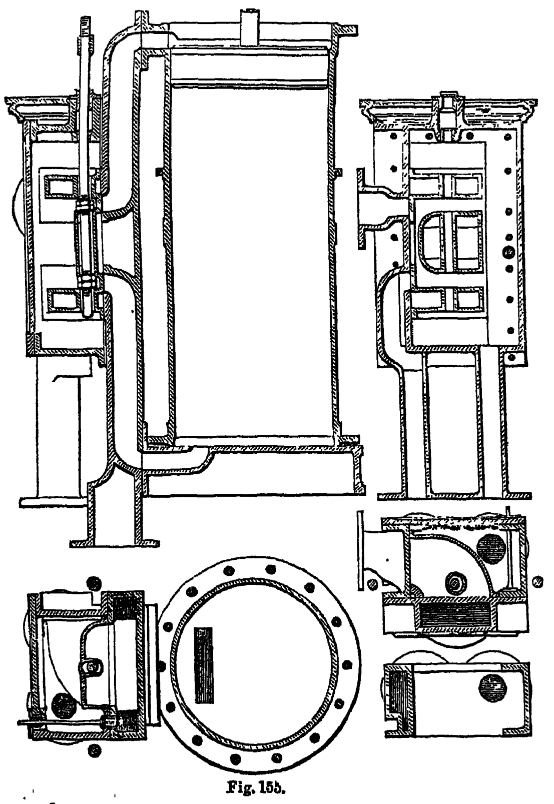


Fig. 155.

place close to the low-pressure cylinder, as shown in the fig. 156, which represents in plan a pair of cylinders, high-pressure and low-pressure, with separate beams and cranks on one shaft. Thus the full pressure of the steam exhausted from the high-pressure cylinder is obtained on the low-pressure piston.

Direct Action Horizontal Engines.

CHAP. IV.—DIRECT ACTION HORIZONTAL ENGINES.

Non-condensing engines are now almost invariably con-

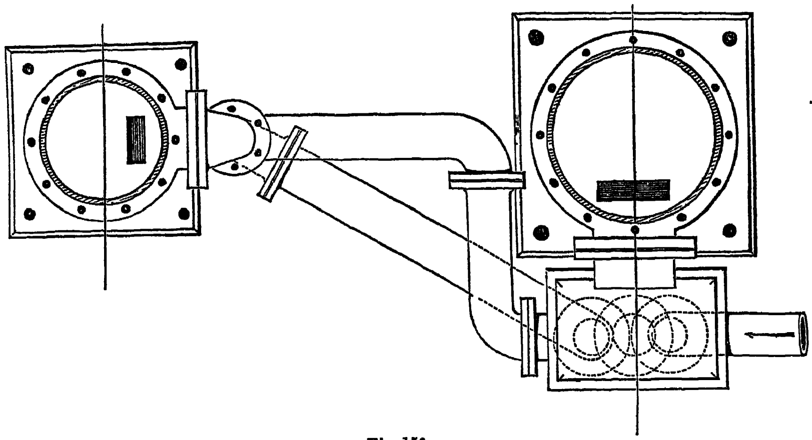


Fig. 156.

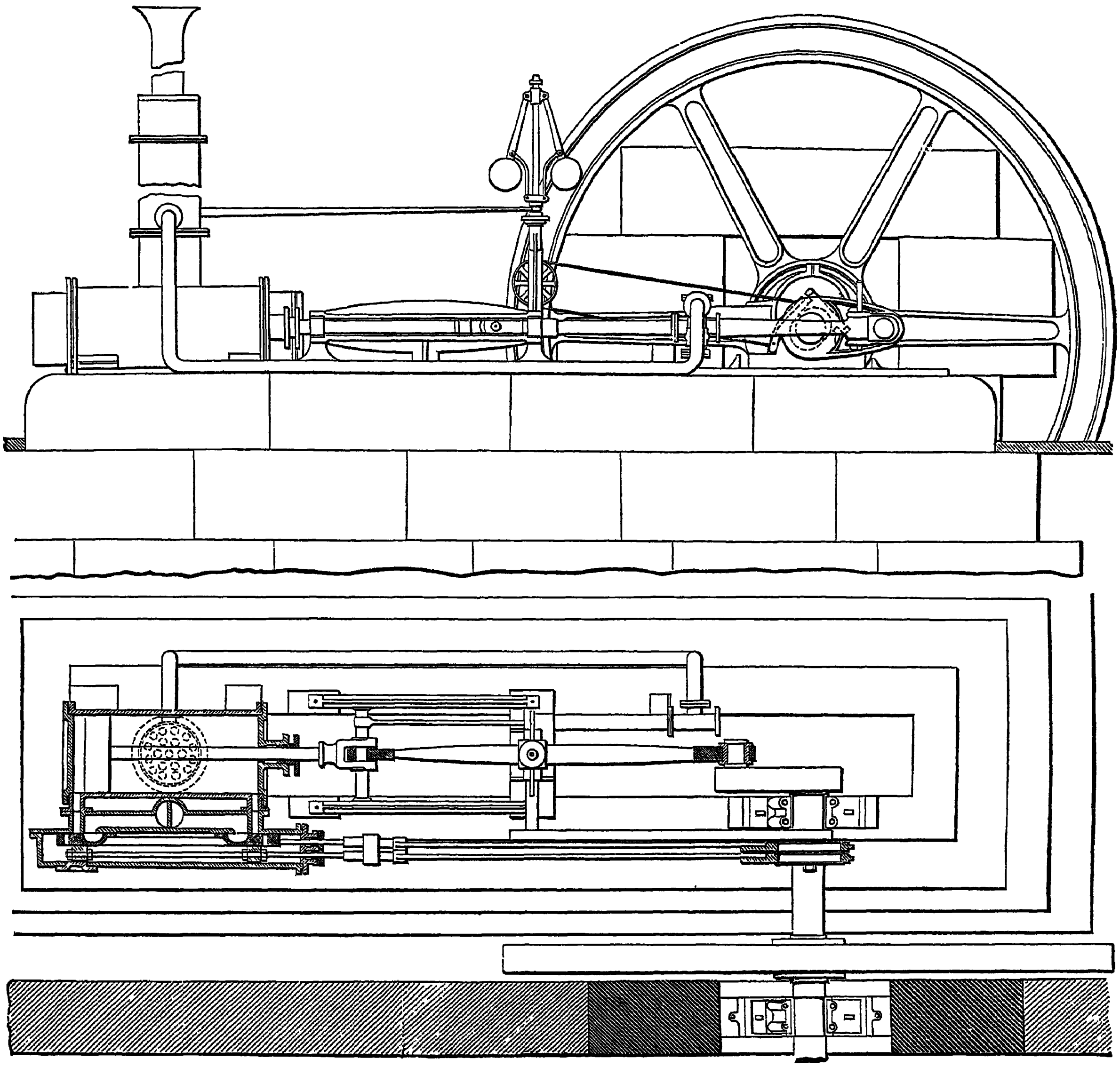
structed "direct-action," or without the intervention of a beam—the connecting-rod uniting the cross-head of the piston-rod to the crank-pin. They are made horizontal and vertical; but the former disposition is most common, and is adopted where space is not limited, and other arrangements permit, as the whole of the engine lies low, under easy inspection, and may be firmly placed on a solid cast-iron base, rested on a plain foundation. The non-condensing horizontal engine, made by Messrs Carrett, Marshall, and Co., Leeds, of 30 nominal horse-power, is shown in figs. 157 and 158. The cylinder is 21 inches in diameter, with 42-inch stroke, with short ports, and is fitted with double valves, to effect variable expansion, the expansion-valve being placed upon the back of the ordinary valve, and worked by a separate eccentric on the main-shaft, adjusted to cut off at various points of the stroke. There is also a feed-water heating apparatus placed over the cylinder, consisting of a fagot of small tubes placed in an upright cylindrical vessel; the steam is exhausted through the tubes, and the feed-water is forced into the vessel around the tubes, by which it is heated from the steam, on its way to the boiler. The advantage of so heating the water on its way from the pump is, that it may be lifted cold by the pump from considerable depths, with more certainty than when hot. The sole-plate of the engine is 20 feet long, in one piece.

Another variety of direct-action horizontal engine, non-condensing, of 10 nominal horse-power, by Messrs Clayton, Shuttleworth, and Co., Lincoln, is represented by figs. 160 and 161. The cylinder is 10 inches diameter, 14-inches stroke, and the engine makes 110 revolutions per minute. The distinguishing feature of this engine is the apparatus for heating the feed-water, which consists of a large pipe underground, 9 feet long, 5 inches diameter, into which the steam is exhausted from the cylinder at one end, and from which it escapes at the other end. The cold water is pumped by the engine into a 2-inch tube, which traverses the heating-pipe from end to end, where it becomes heated on its way to the boiler. The engine is placed on a sole-piece, 8$\frac{1}{2}$ feet long.

Condensing engines of moderate power are frequently made horizontal direct-acting. They are distinguished in appearance from the non-condensing engine by the addition of the air-pump and condenser on the same base-plate. Two examples are illustrated in Plate XXIII. The first is an engine of 20 nominal horse-power, by Messrs Barrett, Exall,

Direct Action Horizontal Engines.

and Andrewes, of Reading, with a cylinder 16 inches diameter, and 20-inch stroke, working with 50 lb. steam; number of revolutions, 80 per minute. The steam-ports are made as short as is practicable; there are two valves, for

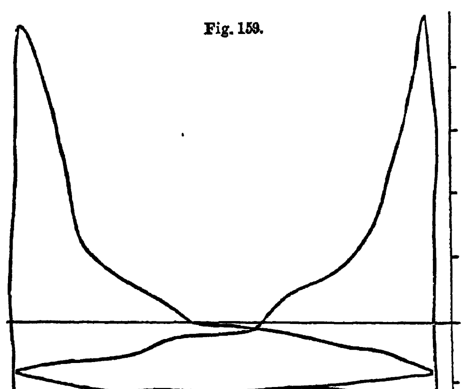


Figs. 157 and 158.

variable expansion, worked by two eccentrics, one to each; the expansion is varied by altering the position of the expansion-eccentric on the shaft, by means of a screw and hand-wheel moving the eccentric on a diagonal key fixed on the shaft. The piston-rod is extended through the bottom of the cylinder to force the air-pump rod, the air-pump being situated within the condenser, at the extreme left of the engine. The injection-water is discharged from the condenser through an overflow-pipe, and the injection-water rises to the condenser in virtue of the vacuum. The base-plate of the engine is $15\frac{1}{2}$ feet long.

An engine of this class was subjected to a ten hours' continuous trial by Messrs Barrett and Co., at their works. It had a 21-inch cylinder, 30-inch stroke, jacketed on the sides and ends; it cut off steam at $3\frac{1}{8}$ inches, or 9·4 per cent., or about $\frac{1}{11}$th of the stroke, besides a clearance of 1 inch of the stroke, with 50 lb. steam in the boiler. The boiler evaporated 9 lb. of water per lb. of coal, fed from the hot-well at a temperature of 82° Fahr., the cold water being supplied at 38° Fahr. The average speed of the engine was 60·03 revolutions, or 300 feet of piston per minute, and the power measured at the main-shaft, by the friction-dynamometer, was 40 horse-power. The indicator-diagrams (fig. 159) were taken from the two ends of the

Fig. 159.

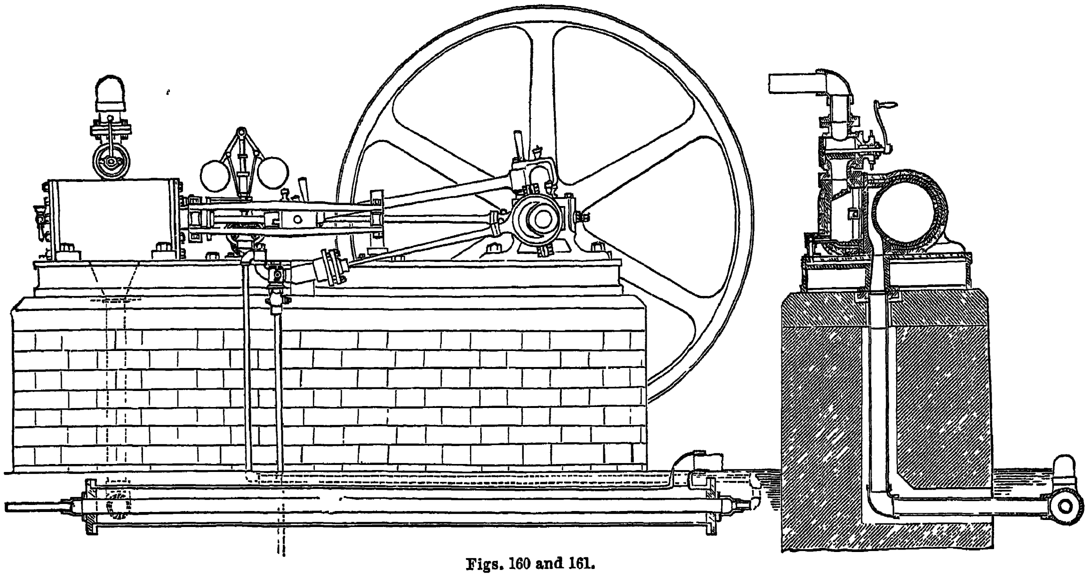


cylinder during the trial, and show an indicator-power

Direct Action Vertical Engines.

of 47 horse-power, from which it appears that the resistance of the engine consumed 7 horse-power, or 15 per cent. of the whole indicator-power. The fuel consumed was 3·06 lb. per dynamometric horse-power, or 2·6 lb. per indicator horse-power. The figure shows an average vacuum of nearly 12 lb. below the atmospheric line, whilst the vacuum in the condenser was 27 inches of mercury, or $12\frac{1}{4}$ lb. per square inch.

The compound-engine, by Messrs Carrett, Marshall, and Co., Leeds, Plate XXIII., comprises a variety of new and useful features. The high and low cylinders, $9\frac{1}{2}$ and 16 inches diameter respectively, with 20-inch stroke, are placed



Figs. 160 and 161.

side by side on one base-plate, and work to cranks, diametrically opposed on the same shaft. Thus the pistons do not, as is usual in compounded twin-cylinders, work together on the same cross-head, making their forward and backward strokes together; but they alternate, and by this means the steam is exhausted by the medium of a single slide, straight across from the high-pressure to the same end of the low-pressure cylinder, through the shortest possible passage. Thus, also, the reciprocating mechanism balances itself, and a perfectly steady motion is obtained. By the cross sections it is shown, that the valve-faces of the cylinder are at right angles to each other, connected by a single slide, and are at 45° with the horizontal plane of the cylinders. The air-pump, which is double-acting, and the condenser, are placed apart behind the low-pressure cylinder; the pump is within the condenser, and is worked by a prolongation of the low-pressure piston-rod. In this way, it is apparent, the weight of the heavier piston is carried in stuffing-boxes, and on slide-blocks, at both ends of the cylinder. The feed-water is heated in a simple, ingenious, and effective way, by injecting water from the hot well through a perforated pipe into the interior of the exhaust-pipe, from the low-pressure cylinder, where it acquires the temperature of the steam, and whence it is pumped into the boiler. The base-plate of the engine is about 10 feet long, and does not include the condenser.

Mr B. Goodfellow, of Hyde, constructs compound horizontal engines, working on cranks at right angles on the main-shaft, in which the high-pressure piston is worked at a higher speed than the low-pressure, by the expedient of giving it a longer stroke; and the air-pump and condenser are placed on the base-plate between the low-pressure cylinder and its crank, being worked by the continued piston-rod of the cylinder. The condenser and air-pump for horizontal engines are frequently placed beneath the base-plate, and worked by bell-cranks; but the arrangements illustrated are now generally preferred.

CHAP. V.—DIRECT ACTION VERTICAL ENGINES.

Where space is confined, and compactness an object, upright engines are serviceable. They are made variously; but the chief distinctions are—first, with the cylinder above and the crank below, near the ground; second, with cylinder below and the crank overhead. Of the first class, the engine (figs. 162 and 163) of 16 nominal horse-power, by

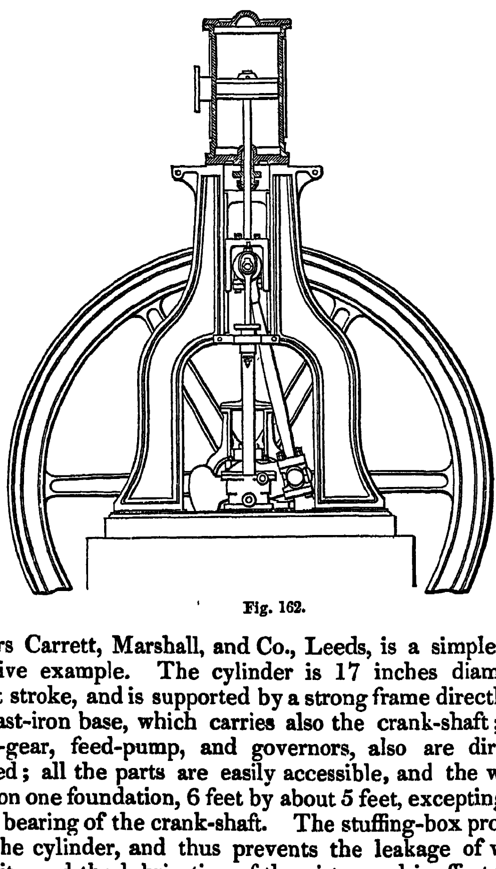


Fig. 162.

Messrs Carrett, Marshall, and Co., Leeds, is a simple and effective example. The cylinder is 17 inches diameter, 2 feet stroke, and is supported by a strong frame directly on the cast-iron base, which carries also the crank-shaft; the valve-gear, feed-pump, and governors, also are directly worked; all the parts are easily accessible, and the whole rests on one foundation, 6 feet by about 5 feet, excepting the outer bearing of the crank-shaft. The stuffing-box projects into the cylinder, and thus prevents the leakage of water from it; and the lubrication of the piston-rod is effected by a receptacle in the gland for lubricating packing, distinct from the ordinary packing. In addition to the ordinary

Direct Action Vertical Engines.

valve there is a sepa... expansion, or cut-off valve, on the back of it, worked by a separate eccentric, by means of which the steam may be advantageously cut off at any

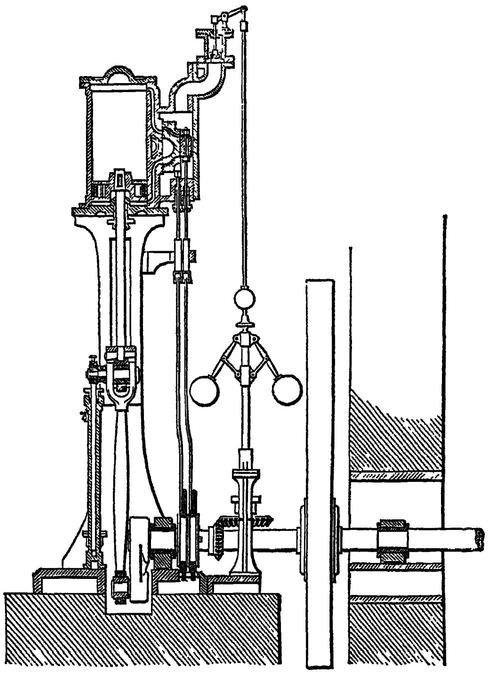


Fig. 163.

point, from $\frac{1}{10}$th to $\frac{8}{10}$ths of the stroke:—the lead remaining constant, and the exhaust unvarying. With heated feed-water, engines of this class work with from 3 to 4 lb. of good coal per indicator horse-power. In some cases this kind of engine is made with a condenser.

The vertical engine, by Messrs Williamson Brothers, of Kendal (figs. 164 and 165), exemplifies the reverse arrange-

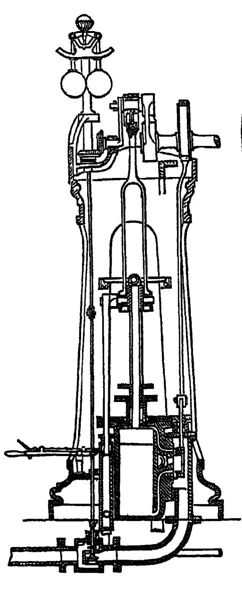


Fig. 164.

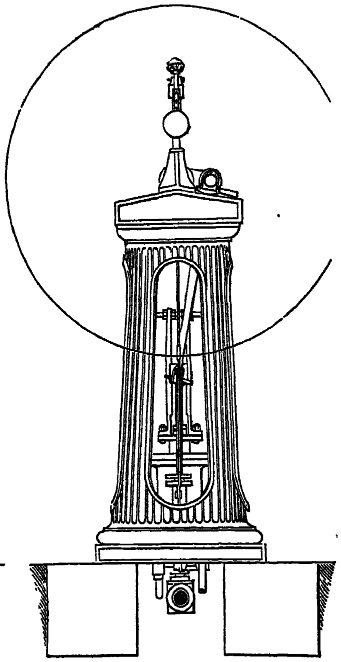


Fig. 165.

ment, where the crank is overhead and the cylinder below. Here a stiffer and more solid erection is needed for resisting the swing and action of the crank, and it is made in the form of a hollow pillar, equally stiff in every direction, and combining strength with lightness. The strain is confined to one casting, and there are few separate parts. The engine is fitted with an equilibrium-valve, controlled by the governor, designed without arms or rings, to prevent sticking in any part; the governor can be disconnected instantly by a lever, which shuts off the steam at the same time. The same form of engine is applied to underlying crank-shafts, when the engine is required to stand independent, and to drive only by a belt from the fly-wheel, or from a pulley on the main shaft.

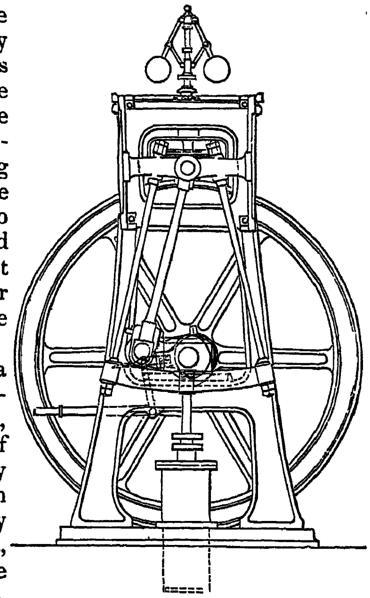


Fig. 166.

In situations where a medium level of crank-shaft is to be observed, the "steeple" form of engine is occasionally used, exemplified in fig. 166, as applied by Messrs Dunn and Co., Manchester, to the driving of sugar-mills. Here the cylinder is below, the cross-head and guide-bars at the top, and the crank-shaft is half-way up, worked by a connecting-rod depending from the cross-head. To effect this arrangement, the piston-rod must be united to a triangular frame, wide enough to clear the vibrations of the connecting-rod.

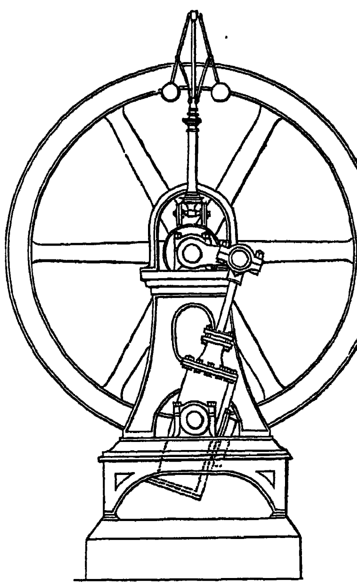


Fig. 167.

Oscillating engines, also, are occasionally applied vertically, so as to diminish the weight of the engine; and for small power they are useful and convenient. The Example (fig. 167), made by Mr Michie, of Nine Elms, London, has a $4\frac{1}{2}$-inch cylinder, 12-inch stroke, and makes 100 revolutions per minute. The slide-valve is not worked by an eccentric, but derives its motion from a fixed stud in the framing, to which is jointed a link and double lever, passing to the spindle of the slide in the side of the cylinder; thus the oscillation of the cylinder gives the action to the valve. Engines in this style are made up to 12 horse-power, and they work well, with few repairs.

Pumping-Engines.

CHAP. VI.—PUMPING-ENGINES.

Pumping water from mines, or for the service of towns, or for other purposes, has, until of late, been almost universally performed by direct lifts, after the style introduced

by Newcomen and Cawley, and adopted by Smeaton and by Watt (figs. 7 and 14). As the duty was simple—the lifting of a dead-weight—so was the engine, the steam cylinder at one end, the pump at the other, and the beam between to connect them, with no superfluous rotative or crank-motion. Lately, double-acting rotative pumping-engines, with crank and fly-wheel, have been introduced. They are more convenient and more compact than the direct-lift engines, but they are not so efficient. The "duty," as it is technically called, is inferior, owing to the greater internal friction of the rotative engine, and to the less nearly perfect adaptation of the action of the engine to the nature of the material to be dealt with and the work to be done. The term "duty" was first employed by Mr Watt to signify the net effect resulting from the consumption of a given quantity of coal; and was expressed by the product of the weight in pounds of water raised, by the height through which it was lifted in feet, divided by the weight in bushels of the fuel consumed in performing a given quantity of work. The duty of the best of Smeaton's engines was, in 1772, 9,450,000 foot-pounds per cwt. of coal. On the expiration of Watt's patent, about the year 1800, the highest duty of his engine amounted to 20,000,000, or more than double the former duty, which may represent the economic value of the improvement effected by Watt under his various patents. The reported duty of Cornish pumping-engines, by the consumption of 94 lbs. of coal, rose from an average of 19,500,000, and a maximum of 26,500,000 in 1813, to an average of 60,000,000 and a maximum of 96,000,000 in 1843. The average duty in 1856 was only 47,000,000, probably on account of inferior qualities of coals used.

It is necessary to bear in mind the distinction between the duty of a bushel of coals, 94 lb., and the duty of a cwt. of coals, 112 lb., both of which are employed as measures of fuel and of duty. In terms of 112 lb. of coal, the average duty of Cornish engines, in 1843, would be 71,500,000; and, in 1856, 56,000,000; and the maximum duty, in 1843, would be 114,500,000.

The functions of pumping-engines, for the supply of water to towns, &c., are chiefly distinguished from those of Cornish engines in the relatively shallow lifts, or depths from which the water is pumped, together with the height to which it is elevated, or the "head" of pressure against which the engine works. Thus Austin's engine, Fowey Consols, in Cornwall, in 1856, lifted the water through a height of 183 fathoms, or 1100 feet. In the London water-bearing district, the depth from the surface of the ground to the level of water does not exceed 100 to 120 feet. No water-works engines are employed to lift water from a greater depth than 15 or 16 feet below the pump; but at the East London Water-Works, the combined lift and head of pressure is about 140 feet. The extreme variety of duty of course involves a variety of proportions, chiefly in the ratio of the diameter of the cylinder to that of the "plunger-pole" of the pump. The Fowey Consols engine has an 80-inch cylinder, with 10 feet 4 inches stroke; the pump has 9 feet 3 inches stroke, drawing six lifts—that is to say, pumping by six successive stages: three of the plunger-poles are 15 inches, one 13½ inches, and two 12 inches diameter—the diameter of the plunger-poles being about ⅕th that of the cylinder. On the contrary, the pole of the "Victoria" pumping-engine at the East London Water-Works is 50 inches diameter, with 100-inch cylinder, being one-half the diameter. The obvious ruling element is the "head" against which the engine is to work; the greater the head, the smaller is the pole in proportion to the cylinder, other circumstances being alike.

The duty of a pumping-engine may be variously defined. Preliminarily, there is the gross work done by the steam in the cylinder, or the "total load," measured by the indicator, comprising the whole work done of whatever kind, useful and useless—water lifted, friction of pump, and friction of the engine itself. The "steam-duty" is the duty performed within the pump, measured by an indicator, comprising the whole work done in lifting the water into the pumps and expelling it into the mains—the steam-duty being equal to the gross work of the steam, minus the friction of the engine. The pumping, or effective duty, is the duty realised in the mains; this is measured by the head of pressure outside the pump, measured by the guage, and is equal to the steam-duty, minus the resistance of the pump. The effective duty is that which is usually understood to be signified by the "duty" of an engine.

At the East London Water-Works there are four engines, particulars of the working of which have been kindly contributed by the engineer, Mr C. Greaves. The leading dimension is respectively as follows for the four engines:—

Engine.	Diameter of Cylinder.
Ajax	72 inches.
Cornish	80 "
Wicksteed	90 "
Victoria	100 "

These engines are worked with 35 lb. steam in the boiler, and the initial pressure in the cylinder is 20 lb. to 25 lb. per square inch on the piston. The cylinders are steam-jacketed, and the steam is usually cut off at about ¼th of the stroke, and expanded during the remainder. The following are particulars of regular working results in 1857. The relative effective steam pressures per square inch on the piston, or the "total load," and the work done in the pump, reduced to the equivalent pressure on the steam-piston, being elements respectively of the total load, or gross work of the steam, and of the steam-duty, are as follow:—

Cylinder.	Total Load in lbs. per Square Inch.	Pumping Work done in lbs. per Square Inch.	Difference, or Friction of Engine in lbs. per Square Inch.
72-inch	15·00	14·00	1·00 or 6·64 per cent.
80 "	14·38	12·73	1·65 " 11·47 "
90 "	15·58	14·10	1·48 " 9·51 "
100 "	16·58	15·01	1·57 " 9·47 "
Mean......	15·38	13·96	1·42 or 9·23 per cent.

Showing a mean friction of engine equal to 1·42 lb. per square inch of piston, being 9¼ per cent. of the gross work of the steam; and showing that the steam-duty is 90¾ per cent. of the gross work of steam. The performance of three of these engines is as follows:—

Cylinder.	Usual Length of Stroke. ft. in.	No. of Strokes per Minute.	Duty per 112 lbs. of Fuel.	Effective H.P.
80-inch	9 9	6·48	86,576,976	104
		8·08	78,675,829	135·4
90 "	10 7	5·38	86,749,117	120·5
		5·97	93,595,265	133·9
100 "	11 0	4·75	78,667,331	165·5
		5·06	79,848,876	180
Mean	...	5·95	84,018,899	140

Showing that, with a mean of 6 strokes per minute, 140 effective horse-power was realised, with a duty of 84,000,000, the maximum duty being about 93,600,000. The horse-power developed at different points was as follows, that in the cylinder being estimated in terms of the friction-ratios previously deduced:—

Pumping-Engines.

Cylinder.	H.P. in Cylinder (estimated).	H.P. in Pump.	Effective H.P.
80	128·4	113·7	104·0
	...	...	135·4
90	150·3	136	120·5
	167·1	151·2	133 9
100	199·8	180 9	165·5
	219·2	198·5	180 0
Mean	173·0	156·1	140 0
Ratio to cylinder H.P.	...	90¼ per cent.	81 per cent.

Showing that the effective horse-power,—the "pumping duty," is 81 per cent., or about ⅘ths of the indicator horse-power exerted in the cylinder—the "total load;" and that the remaining 19 per cent., or ⅕th, is absorbed almost in equal proportions by the friction of the engine, including that of the pole on one part; and the friction and resistance of the pump on the other part, being each nearly 10 per cent. of the "total load."

The East London pumping-engines are supplied with steam from Cornish boilers, with single internal flue, of the following dimensions:—

Cylinder.	No. of Boilers.	Diameter of Shell.	Diameter of Flue.	Length.	Total Area of Fire Grate.
		ft. in.	ft. in.	ft. in.	sq. ft.
80	3	6 5½	3 10½	27 9	62· 5
90	3	6 6	4 0	34 0	74·25
100	4	5 9	3 6	30 0	76· 8
	5	...	...	...	116· 0

It is found from long-continued observation, that these boilers evaporate 10 lb. of water per lb. of gas coke, or Welsh coal, and the duty of the engines has already been stated according to this ratio. The following are the proportional consumptions of fuel:—

Cylinder.	Fuel per Hour.	Per Foot of Grate per hour.	Per H.P. Gross Load per Hour.	Per H.P. in Pump per Hour.	per H.P. Effective per Hour.
	lb.	lb.	lb.	lb.	lb.
80	266	4·25	2·07	2·34	2·55
	382	6·10	...	...	2·81
90	308	4·14	2·05	2·26	2·56
	317	4·26	1·81	2·09	2·37
100	467	6·07	2·34	2·58	2·82
	499	4·30	2·28	2·51	2·78
Means	373	4·19	2·11	2·36	2·65

The following are the proportional consumptions of water from the boilers:—

Cylinder.	Water per lb. of Fuel.	Water Per Hour.	Per Boiler per Hour.	Per Foot of Grate per Hour.	Per Stroke.
	lb.	Cubic ft.	Cubic ft.	Cubic ft.	lb.
80	10	42·7	14·2	·68	6·8
	10	61·1	20·4	·98	8 0
90	10	49·6	16·5	·67	9·6
	10	50·9	17·0	·67	8·9
100	10	75·0	18·7	·98	16·4
	10	80·1	16·0	·69	16·4
Means	...	60·0	17·1	·78	11·0

Showing that an average of 4⅕ lb. of fuel is consumed per square foot of grate per hour, and $2\frac{1}{10}$ lb. per cylinder horse-power per hour, or 2⅔ lb. per effective horse-power per hour; that an average of 60 cubic feet of water per hour is evaporated for each engine, and 17 cubic feet by each boiler, or about ⅘ cubic feet per square foot of grate per hour; and 11 lb., or above a gallon per stroke is consumed.

As the average cylinder or indicator horse-power is 173 horse-power, performed with an average of 3·6 boilers, the gross actual horse-power of one boiler averages only 47 horse-power. About ⅓ cubic foot of water is consumed per actual horse-power.

The air-space through the grates averages from ¼th to ⅙th of the area of the grate. The force of the draft at the base of the chimney varies from $\frac{7}{10}$ to $\frac{3}{10}$ inch of water. In the side-flues the draft was $\frac{1}{10}$th inch for the boilers of the 80 and 90 inch cylinders, and $\frac{2}{10}$ to $\frac{3}{10}$ inch for the 100-inch boilers. In the side-flues the temperature varied from 280° to 415° Fahr., according to the opening of the damper and the strength of the draft; and in the chimney, at a level 10 feet from the top, the temperature varied from 260° to 318°—the average for 24 hours being 274°. The temperature of 35 lb. steam, of 50 lb. total pressure, is 281°, which approaches the lower limit of temperature in the side-flues.

The condensation of steam in the jacket of the 90-inch cylinder, cutting off at ¼th, amounts to $\frac{1}{26}$th, or about 4 per cent. of the steam consumed in the cylinder, and would average about 2 cubic feet per hour for this engine. The steam-jackets are thickly clothed with sand or ashes, to prevent loss of heat by radiation, which, when the clothing is omitted, causes a loss of more than 10 per cent. of the efficiency.

The expenditure of fuel necessary to keep up the steam in one boiler—that is, to keep up the heat of one boiler and the surrounding building—was less than 1 cwt. of coke per day of 24 hours. To keep up the steam in the jacket additionally, the consumption was 2 cwt. per day.

The duty of double-acting rotative pumping-engines, having a crank and fly-wheel, averages from 40,000,000 to 50,000,000; and, in general, their efficiency is not above two-thirds of that of single-acting engines. A pair of rotative engines, with two fly-wheels, for pumping, were found to absorb about 30 per cent. of their power in driving themselves, leaving 70 per cent. for the interior of the pump, or the "steam-duty."

Single-acting pumping-engines are of two general classes:—beam-engines, represented by Plate XXIV., and direct-action, or bull-engines, represented by Plate XXV. In the former, the cylinder is at one end of the beam, the pump at the other; in the latter, the beam is dispensed with and the pump placed under the cylinder, and directly connected to it by the piston-rod. In the beam-engine, the steam from the boiler is admitted to the upper side of the piston and worked expansively, forcing it down, and lifting the weighted pole of the pump at the other end of the beam. The impetus communicated to the moving mass by the initial charge of steam, together with the expansive action of the steam, carries it through the remainder of the stroke,—the velocity of the piston being gradually retarded till the end of its course, while the resistance remains the same. The uplifting of the pole causes a vacuum in the pump into which the water flows. At the end of the steam-stroke the exhaust-valve closes, and the equilibrium-valve opens, admitting the steam above the piston to the under side, and the pressure is equalized above and below the piston; then the weighted pole descends and forces the water out of the pump; the piston ascends also to the top of the cylinder, and, just before reaching the top, the equilibrium-valve closes, and compresses the portion of steam left above the piston, forming a cushion, to bring the piston to a state of rest. The outlet-valve from the lower side of the piston to the condenser is then opened, and fresh steam from the boiler admitted above the piston, when the piston performs the next descending stroke. The speed of the engine is regulated by a "cataract," a mechanical appliance connected with the gearing, which is set in action at every stroke of the engine, and is adjusted to expend itself, and, at a suitable interval, to release the detents by which the

movements of the valve-gearing are controlled. The detents being disengaged, the steam-valve opens, by means of the action of the treadle-weights, and the steam is admitted for the next steam-stroke. All the valves fall open by means of the treadle-weights, and are closed by means of tappets.

The "Victoria" engine, made for the East London Water-Works, by Messrs Harvey and Co., to the specification of Mr Greaves, the Engineer of the company, is represented in Plate XXIV. It is a single-acting beam-engine. The cylinder A is 100 inches in diameter, and is capable of making a stroke of 12 feet. The beam B is 36 feet long and 7 feet 6 inches deep at the middle. The pole C is 50 inches diameter, same stroke as the piston; D is the pole-case, 68 inches diameter, with the water supply W, and the discharging main E, upwards of 4 feet in diameter; *p* is the piston; *i* the inlet valve; *o* the outlet valve; *t* the tappet rod, moved by the beam, having tappets to shut the valves, by means of levers and rods; *c* the condenser; *a* the air-pump; *h* the hot well; *f* the feed-pump; *w* inlet into water-pump; *x* exit from pump into mains; *v* air-vessel on the mains, to equalise the head of pressure; *d* detents, or cross-bars on the beam, to limit the stroke of the engine. For particulars of the boilers, the reader is referred to previous statements.

The direct-acting pumping-engine, made by Messrs Harvey and Co., for the Grand Junction Water-Works at Campden Hill Station (Plate XXIV.), has a 70-inch cylinder, with 10 feet stroke; pole 32½ inch diameter, with 3 feet water-pipes. The letters of reference are the same as for the beam-engine. The pump and valve-gear are worked by means of the lever L, actuated by connection with the pole. The engine is supplied with steam from six boilers *b*, *b*, shown in section longitudinally, and endwise in a separate view on the same plate. The boilers are 5 feet 9 inches diameter, with 3 feet 6 inches flues; and are expanded to 6 feet 1 inch, with 3 feet 10 inch fire-places at the furnaces; *s* is the steam-chest, to collect the steam from the boilers. The fire-grates are 6 feet long.

There are many varieties of pumping-engine on a small scale. Horizontal direct-action engines are in use. Upright

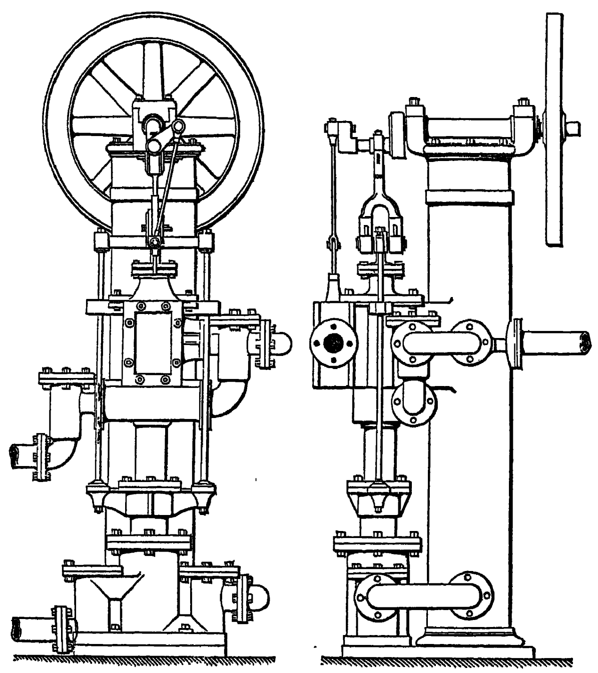


Fig. 168.

direct action-engines, by Messrs Carrett and Co. of Leeds, are also much in use, similar in general appearance to their ordinary upright engine. A new and good system, by Messrs T. Cowburn and Co., of Manchester (fig. 168), deserves notice. The steam-cylinder and the pump are fixed against a cast-iron pillar, which carries the crank-shaft on the top, and a fly-wheel, from which power may be taken off if wanted. The plunger is novel; it is hollow, so as to admit a second plunger, or ram, to work within it. Thus a continuous delivery of water is effected.

CHAP. VII.—PORTABLE ENGINES.

The term *portable engines*, formerly signifying self-contained engines, is now used to signify engines placed on wheels, capable of being moved from place to place, either by their own power of self-propulsion, or by horse-traction. They are in general use for agricultural purposes, and are carried on four broad wheels; they are made light enough to be handy and manageable by the staff of an agricultural establishment. Their boilers are of the locomotive type, with inside fire-box and flue-tubes, and the cylinder, or cylinders if two in number, are fixed on the top of the boiler at one end, and the shaft at the other. The 8 horse-power portable-engines, made by Messrs Clayton, Shuttleworth, and Co., of Lincoln, are shown in elevation and section in Plate XXVII., in two varieties, from which it is apparent that, practically, the boiler constitutes the foundation or basis of the whole structure. Small boilers are proportionally stronger than large ones; in the latter, independent frame-work, is needed. Messrs Barrett, Exall, and Andrewes, of Reading, formerly made their portable-engines on a bed-plate fixed to the boiler, which, with several advantages, had the disadvantage of increasing materially the weight of the engine, and was subsequently abandoned. In Clayton and Co.'s engine there is one cylinder A, 9 inches diameter, with 12-inches stroke; and B, the band-pulley on the crank-shaft is 5 feet in diameter. The boiler C has a fire-box 1 foot 6 inches long, 2 feet 7 inches wide inside, and 2 feet 1 inch in height above the grate. There are 30 flue-tubes 2⅜ inches outside diameter, 6 feet 4 inches long within the boiler. The following are the amounts of surface:—

Heating surface in the fire-box	18·5	square feet.
Do. do. tubes	124·5	„
Total inside surfaces	143·0	„
Area of grate	3·87	„

The cylinder is placed directly over the fire-box, from which it is supplied with steam, and the exhaust-pipe from the cylinder is carried through the boiler into the chimney. The chimney is made with a joint to fold back over the boiler, and rest in a crutch, when not required. In the whole design of this engine there is freedom of access to and inspection of all parts. Agricultural engines are, in general features, much alike.

Messrs Clayton and Co. make engines with the cylinders within the hot smoke-box, and jacketed, from which, no doubt, the cylinders derive benefit, leading to economy of fuel.

CHAP. VIII.—LOCOMOTIVE ENGINES.

The general features and characteristics of modern locomotive practice are represented in Plates XXVI., XXVII., and XXVIII., showing English and American engines. The passenger-locomotive, Plate XXVI., by Messrs Robert Stephenson and Co., is a type of the prevailing kind of engines used in this country for passenger-traffic; and it is specially adapted for drawing express trains at high velocity. It has two cylinders coupled to cranks at right angles on the driving-axle. They are 15⅝ inches diameter, and have 20 inches stroke. The driving-wheels are 6 feet 2 inches diameter; so that, at a speed of 50 miles per hour, the

Locomotive Engines.

piston would move at a mean speed of 760 feet per minute; and at 60 miles per hour, it would have a speed of 910 feet per minute, or three times as much as ordinary stationary engines. There are 170 flue-tubes 2 inches diameter, and 11 feet 4 inches long, and the heating surface is as follows:—

Inside heating-surface of tubes	915	square feet.
Do. do. fire-box	80	"
Total	995	"
Area of fire-grate	13·63	"

The goods-engine, with six coupled wheels, Plates XXVI. and XXVII., made by Messrs Beyer, Peacock, and Co., Manchester, represent in like manner the ordinary form of goods engine used in this country. The sections and plans show in detail the construction of the engine. The cylinders are 16 inches diameter, with 24 inches stroke; the wheels are 5 feet diameter. The fire-box is 4 feet 3 inches long, by 3 feet 6 inches wide; there are 191 flue-tubes, 2 inches diameter outside, and 11 feet 7 inches long. The following are the surfaces:—

Heating surface of fire-box	86·3	square feet.
Do. do. tubes	1052·4	"
Total	1138·7	"
Area of grate	14·9	"

The following literal references in Plate XXVII. will explain the details of the goods engine. A, the cylinder; B, the driving, or crank axle; C, the driving-wheels; D, the fire-box; E, the fire-box shell; F, the barrel of the boiler; G, the flue-tubes; H, the steam-pipe from the boiler, proceeding from the regulator *h*, in the dome I, to the smoke-box K, and thence by branches L to the cylinders; M, the blast-pipe; N, the chimney; O, the valve-gear, handled by the reversing lever P; Q, the regulator-handle; R, the safety-valves; S, the feed-pumps.

The following formulas, based on experimental data, have been given for the resistances of engines and trains on railways, at various speeds. Resistance is divided into two parts:—a fixed or constant quantity, and a variable quantity, increasing as the square of the speed. The conditions under which the formulas are applicable, are—

1. A good sound road.
2. A straight and level road.
3. An average side wind.
4. Engine, tender, and train, in good working order.

Let v = the speed of the train in miles per hour, and R the total resistance per ton of weight moved. Then, first, to find the total resistance per ton gross, of the engine, tender, and train, there is a constant resistance of 8 lb. per ton, and

$$R = 8 + \frac{v^2}{171}.$$

Second. To find the resistance per ton, R′, of the train alone, there is a constant of 6 lb. per ton, and

$$R' = 6 + \frac{v^2}{240}.$$

Third. For the resistance per ton (R″) of the engine and tender alone, including machinery-friction, let W = the weight of the engine and tender in tons, w = the weight of the train in tons, then

$$R'' = \left(6 + \frac{v^2}{240}\right) + \left(\left(2 + \frac{v^2}{600}\right) \times \left(\frac{W + w}{W}\right)\right),$$

in which the first member is the resistance of the engine and tender as carriages simply, and the second member is the whole machinery-friction, the amount of which varies with the weight of the train.

Note 1. On inclines, the resistance is increased or diminished by gravity, according to the ratio of the incline, and according as the train ascends or descends.

2. The results obtained by the above formulas must be increased one-half more, in order to find the resistance under the ordinary conditions of railways.

Classification of Steam-Boilers.

The following are examples of the tractive resistance per ton, gross, of engine, tender, and train, on a level, at various speeds:—

Speeds. Miles per hour.	Resistance under superior Conditions. lb. per ton.	Resistance under ordinary Conditions. lb. per ton.
10	8·6	13·0
20	10·3	15·5
30	13·2	20·0
40	17·3	26·0
50	22·6	34·0
60	29·0	43·5
70	36·6	55 0

The prevailing types of American locomotives are shown in Plate XXVIII. for passengers and for goods traffic in the United States. It is remarkable with what a degree of unanimity American engineers have matured the designs of their engines.

For an account of the history of locomotives, their peculiarities, their performances, and other information, see RAILWAYS.

The annexed cut (fig. 169) shows a simple design of balanced slide-valve, by Mr Gregory of Lisbon, for locomotives. The back of the valve is formed cylindrically with a groove, and a packing ring is let into the groove or circular channel, with an elastic tube of india-rubber between. By the partial compression of this tube the ring is pressed against the back of the valve-box, and steam-tightness is produced, preventing the steam from pressing on the protected portion of the back of the valve. This is an object of considerable importance.

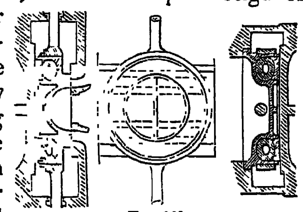


Fig. 169.

SECTION V.—CLASSIFICATION OF STEAM-BOILERS, WITH EXAMPLES.

In the course of the preceding section on steam-engines, a few examples of boilers have been illustrated and described, and performances recorded. It is the object of this section to complete the survey of steam-boilers. Boilers may be classed, generally, as horizontal and as upright boilers, in which the direction of the heating surface is respectively horizontal and vertical. Or they may be classed as open flue-boilers, and as multi-tubular boilers. But it is not necessary to follow any particular classification; a consecutive notice of each kind will suffice.

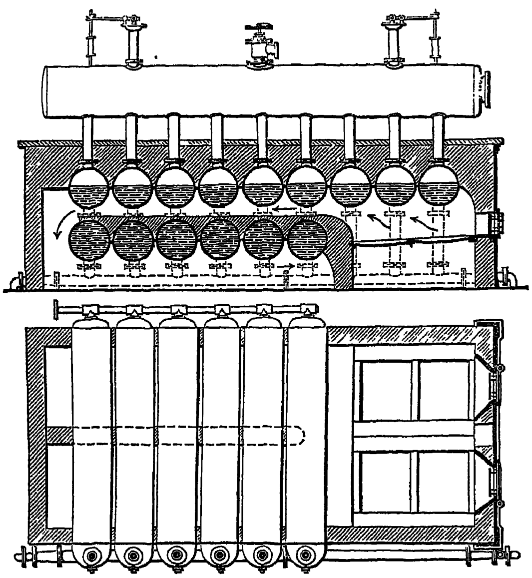
The Waggon Boiler.—This form of boiler has already been illustrated and described in PART I. It is suitable for low pressure only, and was for a long time the most generally used of all boilers.

The Cylindrical Egg-end boiler, fig. 65, has been in extensive use, but is now used chiefly at collieries, where simplicity is a particular object, and fuel of small value. This boiler is 4 feet 6 inches diameter, and 30 feet long. The grate is 6 feet 6 inches long, and 3 feet wide, and the flue proceeds direct to the other end. The form of this boiler is favourable for strength and safety, but it requires great length of boiler to provide sufficient heating surface. The steam is taken from the receiver at the centre, with a stop-valve above. There are two safety-valves towards the front, and a man-hole behind; and the feed-water is introduced at the far end.

The *Retort Boiler*, the production of Messrs Dunn and Co., Manchester, is composed of a series of independent cylinders placed side by side (figs. 170), about 19 inches in diameter, and upwards of 9 feet long, with cast-iron ends. They all communicate upwards with a steam-receiver above

Classification of Steam-Boilers.

the furnace. This class of boiler is undoubtedly safer than



Figs. 170.

the ordinary large boiler, and is equally efficient in evaporative performances. It is compact and portable.

The *Cornish Boiler* has already been illustrated and described in the previous section.

The *Cylindrical Double-Flue Boiler*, Plate XX., is in general use in the north of England. It has two fires, one in each flue *a*, *a*, which are fed with fuel alternately, so that the smoke from one furnace mixes with, and is consumed by, the hot gases and air from the other furnace. The products of combustion descend and pass through the flues *c*, *c*, twice along the whole length of the boiler, and thence by the tunnel T to the chimney. The steam is taken from a dome *d*, in order to insure its dryness, and is conveyed by the steam-pipe *s s* to the engine. The other arrangements are similar to those in the Saltaire boilers. *m*, man-hole; *k*, additional man-hole; *f*, safety-valves; *g*, spring-balance; *h*, glass water-gauge; *i*, blow-off cock; *r*, *r*, feed-pipe; *v*, *v*, *v*, gussets, or stays.

In this drawing the flues *a*, *a*, *a*, are represented with the strong ribs of angle iron *b*, *b*, *b*, *b*, as recommended by Mr Fairbairn, for obviating the dangers of collapse. The flue, as shown, is in accordance with the laws deduced in the experimental researches recently conducted by him, according to which the strength is three times that of the same flue constructed in the ordinary method without intermediate supports; and the light thrown upon the subject by these experiments is likely to cause a considerable

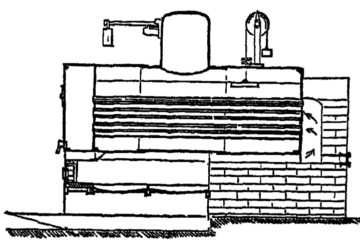


Fig. 171.

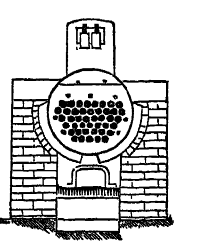


Fig. 172.

revolution in the construction of flues. (See *Experimental Researches on the Collapse of Boiler-Flues*, by Mr Fairbairn, 1858.)

Multitubular Horizontal Boilers.—Of these, the Saltaire boilers, introduced by Mr Fairbairn, Plates XVIII. and XX., and already described, are examples of one kind—the double flue in conjunction with the multitubular arrangement. An effective and compact plan of boiler, introduced and constructed by Messrs Smith and Coventry, Manchester, is shown in figs. 171 and 172, in which the boiler consists of a cylindrical shell, and furnace beneath, with return multitubular flues through the boiler, ending in a smoke-box at the front. The safety-valve of this boiler, detailed in fig. 173, is

Classification of Steam-Boilers.

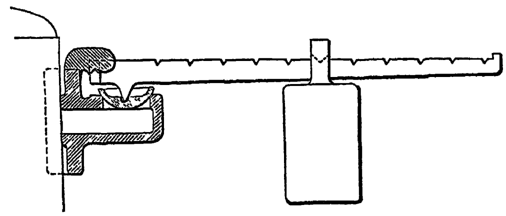


Fig. 173.

worthy of note. It is placed on knife-edges, and the valve, being spherical, is free to suit itself to the seat.

Agricultural boilers, and locomotive boilers, multitubular, have already been described.

The Butterly boiler, already described (figs. 79, 80), is frequently used.

Varieties of Boilers.—Galloway's boiler (fig. 174) is made

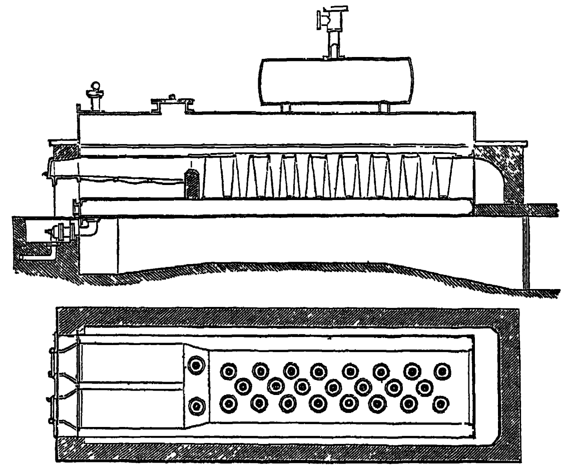


Fig. 174.

with a large oval flue within the boiler, having a number of vertical conical water-passages uniting the top and the bottom; so that a free circulation of water is maintained, and a considerable addition to the heating surface is effected. It is a species of "water-tube" boiler, and there is no doubt it produces good results. There is a double furnace, so as to allow of alternate firing, and the presence of the water-tubes in the thoroughfare of the draft promotes the mixture and combustion of the gases. A steam-reservoir is placed upon the boiler.

In Cowburn's cellular boiler (fig. 175), the internal flue

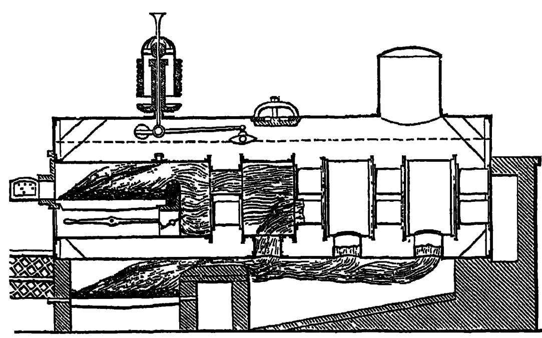


Fig. 175.

consists of a number of compartments or cells, connected by short wrought-iron pipes to each other, and to the lower

side of the boiler. There are two distinct furnaces, one within the flue, and one below the boiler, and the flame and smoke from the two furnaces commingle within the cells, and become effectually consumed. The flue, by being subdivided, as shown, yields to expansion elastically endwise; and as, in addition to this advantage, the boiler is more uniformly heated by the distribution of the fires inside and outside, the over-straining of joints is prevented, and the chances of leakage and rupture are diminished. The safety-valve of this boiler, detailed in figs. 176 and 177, is worthy of note. It is direct-acting, without levers; is freely suspended, so preventing adhesion or sticking to its seat, and readily adjusts itself to the seat, the bearing surfaces being spherical. The fusible plug, or valve (figs. 178, 179), to give warning in case of low water, is another good feature. It consists of an inverted brass cup, fixed on the top of the hottest part of the flue, with a cap screwed on, and numerously perforated, screwed, and filled with block-tin. When the water in the boiler falls, accidentally, below the level of the cap, the plugs are melted out by the heat, and the steam rushing into the furnace, gives the needful warning of danger.

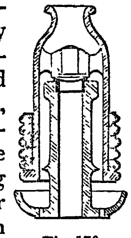


Fig. 176.

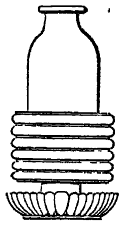


Fig. 177.

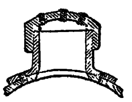


Fig. 178.

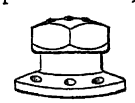
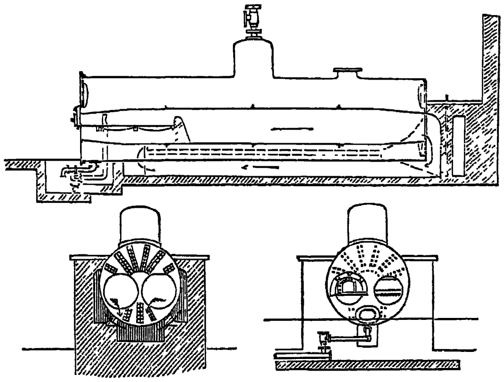


Fig. 179.

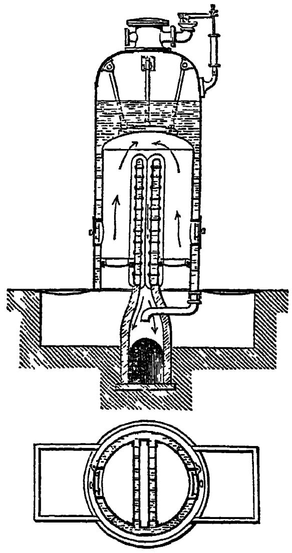
Mr Goodfellow of Hyde, in order to prevent the unequal expansion and straining of flue-boilers, contracts the flue at each end conically (figs. 180), so as to admit of elastic action. It is difficult to perceive how, with such a gentle taper, there can be sufficient scope for the elastic movement.

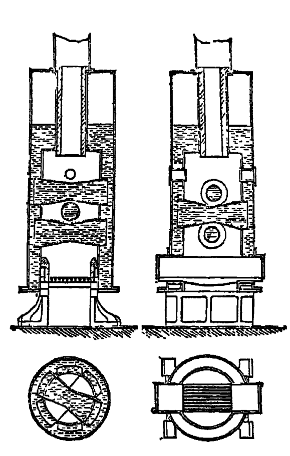

Figs. 180.

The steeper taper employed in the Cornish boilers, exemplified in Plate XXV., is more likely to be of service, as in fact it has been proved to be sufficient to prevent injurious overstraining of those boilers.

Upright Boilers.—The ordinary form of upright boiler is cylindrical, with the axis vertical. An internal fire-box is placed near the bottom, and a faggot of small tubes proceeds from the crown of the fire-box to the roof of the boiler, and thence to the chimney. The direct upward draft thus occasioned, though it quickens combustion, and excites a high temperature, is wasteful, inasmuch as the heat is too rapidly conveyed, and much of it is carried away into the chimney. Expedients for detaining or deflecting the current are found to operate with advantage. Messrs Dunn and Co. have produced an effective boiler (figs. 181), on the principle of down-draught; the boiler is cylindrical, with a plain domed fire-box within, divided transversely by two water-partitions; there are two grates, one on each side, and the gases ascending from them meet at the crown, are deflected, and descend through the vertical flue. The shell of the boiler is 4 feet 6 inches diameter, and 10 feet high; the fire-box is 3 feet 10 inches diameter, with a total height of 7 feet. The segmental grates have a versed sine of 15⅝ inches, and have a combined area equal to 7 square feet.

The upright boiler of Messrs Armstrong and Bowman, the former of whom is the well-known authority on boilers, contains a number of transverse double-cone steam-generators (figs. 182), within which water circulates, which baffle and divert the ascending hot currents; the ends of these generators project into the surrounding water space of the boiler, and so throw off the steam which is discharged from them, out of contact with the vertical sides of the fire-box. This boiler is found to work effectively.


Figs. 181.


Figs. 182.

An objection to ordinary conical safety-valves, directly weighted, fig. 183, or by a lever (fig. 184), is, that they do not rise with a sufficient degree of freedom to let escape the surplus steam, and the pressure in the boiler consequently rises considerably above that to which the valve is weighted. Mr R. Bodmer has removed this objection, in the design (fig. 185), by admitting water or steam, at the whole pressure in the boiler, under the valve, through an independent tube, free from the interference of the rushing steam. Thus the valve is lifted well off its seat, and a free exit provided for the steam. The valve is in the form of a hollow cylinder, fitting exactly, but easily, over a piston or plug, on which it slides vertically.

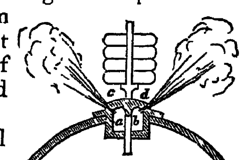


Fig. 183.

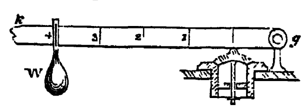


Fig. 184.

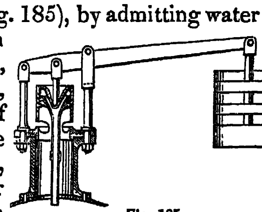


Fig. 185.

SECTION VI.—THE WORK OF STEAM IN THE STEAM-ENGINE.

CHAP. I.—PRINCIPLES OF THERMO-DYNAMICS.

The following general outline of the principles of thermo-dynamics—a science of recent origin, and underlying the whole theory of heat-engines—is abstracted from Professor Rankine's work on the *Steam-Engine and other Prime Movers*, which contains the first systematic exposition of the science.

Principles of Thermo-Dynamics.

Thermo-dynamics defined.—It is a matter of ordinary observation, that heat, by expanding bodies, is a source of mechanical energy; and, conversely, that mechanical energy, being expended either in compressing bodies or in friction, is a source of heat. The reduction of the laws, according to which such phenomena take place, to a physical theory, or connected system of principles, constitutes what is called the science of thermo-dynamics.

First Law of Thermo-dynamics.—Heat and mechanical energy are mutually convertible; and heat requires for its production, and produces by its disappearance, mechanical energy in the proportion of 772 foot-pounds for each British unit of heat (Joule's equivalent); the said unit being the amount of heat required to raise the temperature of one pound of liquid water by one degree of Fahr., near the temperature of the maximum density. This law may be considered as a particular case of the application of two more general laws, namely,—1. All forms of energy are convertible. 2. The total energy of any substance or system cannot be altered by the mutual actions of its parts.

Dynamical Expression of Quantities of Heat.—All quantities of heat, such as the specific heat of any substance, or the latent heat corresponding to any physical effect, or any other of the quantities of heat treated of, may be expressed dynamically, that is, in units of work, by multiplying their values in ordinary units of heat by Joule's equivalent. The following are examples of this mode of expressing quantities of heat, which is by far the most convenient in treating of thermo-dynamical questions:—

	Foot-Pounds.
Latent heat of evaporation of 1 pound of water, from and at 212°	745,812
Total heat of combustion of 1 pound of carbon	11,194,000

Total Actual Heat.—Let a substance, by the expenditure of energy in friction, be brought from a condition of total privation of heat to any particular condition as to heat. Then, if from the total energy so expended, there is subtracted, *first*, the mechanical work performed by the action of the substance on external bodies, through changes of its volume and figure, during such heating; *secondly*, the mechanical work due to mutual actions between the particles of the substance itself during such heating; the remainder will represent the energy which is employed in making the substance hot, and which might be made to reappear as ordinary mechanical energy, if it were possible to reduce the substance to a state of total privation of heat. This remainder is the quantity called the *total actual heat* of the substance, being the total energy, or capacity for performing work, which the substance possesses in virtue of being hot.

Second Law of Thermo-dynamics.—If the total actual heat of a homogeneous and uniformly hot substance be conceived to be divided into any number of equal parts, the effects of those parts in causing work to be performed are equal.

This law may be considered as a particular case of a general law, applicable to every kind of actual energy; that is, capacity for performing work, constituted by a certain condition of each particle of a substance, how small soever, independently of the presence of other particles (such as the energy of motion).

Absolute Temperature—Specific Heat, Real and Apparent.—*Temperature* is a function depending on the tendency of bodies to communicate the condition of heat to each other. Two bodies are at equal temperatures, when the tendencies of each to make the other hotter are equal. All substances absolutely devoid of heat are at the same temperature. Let this be called the *absolute zero of heat;* and let the scale of temperature be so graduated, that for a given homogeneous substance each degree shall correspond to an equal increment of actual heat. This mode of graduation necessarily leads to the same scale of temperature for all substances. The amount of actual heat expressed in units of work, which corresponds in a given substance to one degree of absolute temperature, is the *real dynamical specific heat* of that substance, and is a constant quantity for all temperatures. The total quantity of mechanical energy required to raise the temperature of unity of weight of a substance by one degree, generally includes, besides the real specific heat, work performed in overcoming molecular forces and external pressures. This is the *apparent dynamical specific heat*, and may be constant or variable. Joule's equivalent is the apparent dynamical specific heat of liquid water at and near its maximum density; and it is probably equal sensibly to the real specific heat of that substance. The real specific heat of each substance is constant at all densities, so long as the substance retains the same condition, solid, liquid, or gaseous; but a change of real specific heat, sometimes considerable, often accompanies the change between any two of these conditions. From the mutual proportionality of actual heat and absolute temperature there follows:—

The Second Law of Thermo-dynamics, expressed with reference to absolute temperature. If the absolute temperature of any uniformly hot substance be divided into any number of equal parts, the effects of those parts in causing work to be performed are equal.

The first and second laws virtually comprise the whole theory of thermo-dynamics.

Of Heat Potentially, and Thermo-dynamic Functions.—The second law of thermo-dynamics may also be expressed in the following form:—The work performed by the disappearance of heat during any indefinitely small variation in the state of a substance, is expressed by the product of the absolute temperature into the variation of a certain function, which function is the rate of variation of the effective work performed with temperature; that is to say, in Professor Rankine's notation, let U = the effective work performed, τ = the absolute temperature, J = Joule's equivalent, h = the quantity of heat in common thermal units, H = the same quantity of heat in foot-pounds, k = the real dynamic specific heat of the substance; and make $\frac{dU}{d\tau} = F$; then the work performed by the disappearance of heat is $\tau\, dF$. This function F has been called the *heat potential* of the given substance for the kind of work under consideration. Now, let the substance both perform work and undergo a variation of absolute temperature $d\tau$; then the whole heat which it must receive from an external source of heat to produce those two effects simultaneouly, is

$$J\, dh = dH = k\, d\tau + \tau\, dF = \tau\, d\phi;$$

in which

$$\phi = k \times \text{hyp. log}\ \tau + \frac{dU}{d\tau}.$$

ϕ is called the *thermo-dynamic function* of the substance for the kind of work in question, and sometimes the *heat-factor*. The above equation is the *general equation of thermo-dynamics.*

Principal Applications of the Laws of the Expansive Action of Heat.—The relation between the temperature, pressure, and volume, of 1 pound of any particular substance being known by experiment, the principles of thermodynamics serve to compute the quantity of heat which will be absorbed or rejected by 1 pound of that substance under given circumstances; and, conversely, in some cases, when the quantities of heat absorbed or rejected under given circumstances are known by experiment, the same principles serve to determine relations between the temperature, pressure, and density of the substances. The chief subjects to which the principles of the expansive action of heat are applicable are the following:—Real and

Principles of Thermo-Dynamics.

apparent specific heat, the heating and cooling of gases and vapours by compression and expansion; the velocity of sound in gases; the free expansion of gases; the flow of gases through orifices and pipes; the latent and total heat of evaporation of fluids; the latent heat of fusion; the efficiency of thermo-dynamic engines.

Analysis of the Efficiency of Heat-Engines.—The total heat of combustion of the fuel is expended in any given engine in producing the following effects, whose sum is equal to the heat so expended:—

1. The waste heat of the furnace.
2. The necessarily rejected heat of the engine, being the excess of the whole heat communicated to the working fluid by each pound of fuel burned, above the portion of that heat which permanently disappears, being replaced by mechanical energy.
3. The heat wasted by the engine, whether by conduction or by nonfulfilment of the conditions of maximum efficiency.
4. The useless work of the engine employed in overcoming friction and other prejudicial resistances.
5. The useful work.

Efficiency of the Fluid in an Elementary Heat-Engine.—An elementary engine is one in which the reception of heat by the fluid takes place wholly at one absolute temperature T_1, and its rejection wholly at another (lower) absolute temperature T_2. Consequently, in such an engine the change between those two limiting temperatures must be made entirely by compression and expansion of the fluid. Let H_1 = the heat received by the fluid from the furnace at each stroke, H_2 = the heat rejected at each stroke, and abstracted (as by a jet of cold water in the condenser of a steam-engine); then the efficiency of the engine is—

$$\frac{H_1 - H_2}{H_1} = \frac{T_1 - T_2}{T_1} = \frac{t_1 - t_2}{t_1 + 461^\circ{\cdot}2},$$

in which t_1 and t_2 are the higher and lower temperatures by Fahrenheit's scale. This equation expresses the law of the *efficiency of elementary thermo-dynamic engines*, viz.:—

The heat transformed into mechanical energy,—
Is to the whole heat received by the fluid,—
As the range of temperature,—
Is to the absolute temperature at which heat is received.

Heat-Engine of Maximum Efficiency.—Between given limits of temperature, the efficiency of a thermo-dynamic engine is the greatest possible when the whole reception of heat takes place at the higher limit, and the whole rejection of heat at the lower; that is to say, when the engine is an elementary engine, and the efficiency of the fluid in such an engine is independent of the nature of the fluid employed.

Heat Economiser, or Regenerator.—To fulfil strictly the above condition of maximum efficiency between given limits of temperature, the elevation of the temperature of the fluid must be performed wholly by compression, and the depression of its temperature wholly by expansion: operations which are, in many cases, impracticable from the great bulk of cylinders which their performance would require. This difficulty is almost entirely avoided by the following process, for producing alternate elevation and depression of temperature with a small expenditure of heat, invented about the year 1816, by Dr Robert Stirling, and subsequently improved and modified by Mr James Stirling, Captain Ericsson, Mr C. W. Siemens, and others. The fluid whose temperature is to be lowered is passed through the interstices of an apparatus, called an economiser or regenerator, formed by a number of thin plates of metal or other solid conducting substance, or by a network of wires, exposing a great surface within a small space. The material of the economiser becomes heated by the cooling of the fluid. When the temperature of the fluid is again to be raised, it is passed through the interstices of the economiser in the contrary direction, and the heat which it had previously given out is in part restored to it. It is impossible to perform this process absolutely without waste. In some experiments by Mr Siemens on air, the waste of heat at each stroke was about $\frac{1}{20}$th part of the heat ultimately abstracted from and restored to the air, and in the air-engines of the ship Ericsson about $\frac{1}{10}$th.

Air-Engines.—The ease with which air is obtained in any quantity, and its safety from explosion at high temperatures, have induced many inventors to devise engines in which it is the working fluid. Very few, however, of these engines have been brought into practical operation, owing chiefly to the difficulty of obtaining a sufficiently rapid convection of heat to and from the mass of air employed, and to the necessity for using a more bulky cylinder than is required for a steam-engine of the same power, and with the same maximum pressure.

Such, very summarily, are the principles and the scope of the modern science of thermo-dynamics, as propounded by Professor Rankine, and investigated by him at considerable length in his work on *Prime Movers*. His treatise embraces also, in detail, the applications of the power of steam in the steam-engine, and the results of his investigations will be referred to in the sequel as occasion may arise.

CHAP. II.—PRELIMINARY.

Preliminary.

In calculations of the duty of steam in a cylinder, the back-pressure on the piston, whether arising from the atmosphere or from a condenser, is an essential element. The piston of an engine, in fact, works between two pressures, and continues in motion, or has a tendency to do so, as long as the pressure in the boiler is greater than that in the condenser, or in the exhaust passage; and when steam is very greatly expanded in a condensing-engine, a low pressure in the condenser is no less necessary than a high pressure in the boiler. If all losses and difficulties incidental to, and perhaps in some degree inseparable from, the use of steam of very high pressure, be neglected, then it must be maintained that the highest pressure in the boiler, coupled with the lowest pressure in the condenser, would give the highest duty for a given quantity of heat, provided the steam is expanded in the cylinder from the greater pressure down to, or nearly down to, the lower pressure.

The term "vacuum," it may be remarked, is liable to a double interpretation, signifying either the absolute pressure in the condenser, or the difference between this and the atmospheric pressure. Now, in questions affecting the quantity of work of steam, and its efficiency in the steam-engine, there are the total pressures respectively in the two separate vessels which require to be considered; that is to say, the initial pressure in the cylinder, and the total pressure in the condenser, into which the exhausted steam is propelled by the superior pressure on the other face of the piston. If the pressure of the atmosphere were 10 lb. or 30 lb., in place of 14·7 lb. per square inch, as it is, it would not at all affect the action of a condensing engine, farther than slightly diminishing or increasing the force required to work the air-pump, and causing a greater or less weight to be placed upon the safety-valve, in order to obtain the same total pressure in the boiler. When the mercury in an ordinary barometer is observed to stand at a height of 30 inches, and the mercury in another tube communicating with the condenser of a steam-engine, at a height of 5 inches, instead of describing the conditions of the case as representing a vacuum of 25 inches of mercury, it would afford a clearer conception of the matter to consider that the total pressure in the condenser is equal to 5 inches of

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mercury, while the total pressure in the boiler is equal to 30 inches of mercury plus the load on the safety-valve. In short, the operations of a condensing engine are practically independent of the incidental variations of atmospheric pressure.

Again, the operations of a non-condensing engine, exhausting into the atmosphere, are referable to the atmospheric pressure, as it affords the datum or base line to which the expansive and exhaust pressures should be approximated, and below which they cannot be extended. It is usual, therefore, in dealing with non-condensing engines, to designate the pressure of steam by the difference or excess of its pressure above that of the atmosphere,—14·7 lb. absolute pressure per square inch being adopted for the zero of the non-condensing scale. The round number, 15 lb., is occasionally adopted.

CHAP. III.—THE WORK OF STEAM WITHOUT EXPANSION.

The development of heat into pressure and motion by the media of the water in the boiler and the piston of the engine may, sinking details, be thus concisely illustrated. Let *a b c d* (fig. 186) be a tall cylindrical upright vessel, open at the top, and having one square foot of area of base or cross section; and *e* a piston or disc, without weight, exactly fitting the vessel, and capable of moving up and down without friction. Let there be 1 pound weight of water at the bottom of the vessel, with the piston resting upon it. If a fire be lighted beneath the vessel, and heat communicated to the water, the temperature of the water will be raised to 212° Fahr. before any steam is generated, being subject to the atmospheric pressure on the piston, of 14·7 lb. per square inch. When the temperature reaches 212° Fahr., the heat of the fire being continued, it will not rise higher, but, instead of an ascending temperature, steam will be formed and disengaged under the piston; the piston will be raised, with its atmospheric load of 14·7 lb. per square inch, or 2116·8 lb. on the 1 square foot area of the piston, through successive stages, 1 foot high, to the positions e', e'', e''', until it reaches an elevation of 26·36 feet above the bottom of the cylinder, when the whole of the pound of water will be evaporated, having a constant elasticity throughout the process, of 14·7 lb. per square inch, and a temperature of 212°. In this instance, the boiler and the engine are represented by one vessel, in which the piston and the water are brought into direct contact, and the intervention of pipes or passages for the steam is dispensed with. The work done or duty performed is the raising of a weight of 2116·8 lb, through a height of 26·36 feet, equal to 55,799 foot-pounds, by 1 pound of saturated steam at atmospheric pressure.

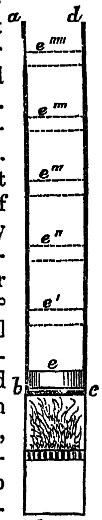

Fig. 186.

Work of Steam without Expansion and without Condensation.—This duty or work done is performed by the steam pushing its way into space, and repelling or pushing aside whatever resisting medium is opposed to its development,—the resistance in the case under consideration being the pressure of the atmosphere. Suppose the experiment to be repeated, with the addition of a weight on the piston equal to the pressure of the atmosphere, making, say, in round numbers, a total incumbent pressure of 30 lb. per square inch, or 4320 lb. absolute weight on the square foot, the area of the piston. On the application of heat, the temperature of the water will be gradually raised to 250·4° Fahr., when the temperature will become stationary, and evaporation will commence, and will proceed until the whole of the water is evaporated. At this stage, the piston, with its load, will have been raised to a height of 13·46 feet; and the work done will be the raising of a weight of 4320 lb. though a height of 13·46 feet, equal to 58,147 foot-pounds, by 1 pound of saturated steam at a total pressure of 30 lb. per square inch, of which about a half is only atmospheric resistance, or exactly 14.7 lb. × 144 × 13·46 feet = 28,492 foot-pounds, having a balance of 29,655 foot-pounds of tangible work done, which will be all the available useful duty of the pound of steam, supposing it then to be discharged. Generally, whatever be the load imposed on the piston, a deduction must be made from the total duty of an amount necessary for repelling the atmosphere, to find the available useful duty.

Such are precisely the conditions of a non-condensing steam-engine worked without expansion, the steam being admitted behind the piston throughout the whole of the stroke, and then discharged into the atmosphere. The cylinder of a steam-engine, it is true, is placed at a convenient distance from the boiler, and not immediately over the water, as in the experimental apparatus; the difference is, however, only circumstantial, the steam is generated at one end of the boiler, and it goes out simultaneously at the other.

To find how much of the whole quantity of heat consumed in generating the steam, is, by this non-condensing non-expansive process, converted into useful effect, let it be assumed that the water is supplied to the boiler at a boiling temperature, 212° Fahr.; then, according to the formula for the total heat of steam, of 30 lb. pressure per square inch, and 250·4° Fahr.

$$H = 1113{\cdot}4 - 212{\cdot}9 + {\cdot}305t = 900{\cdot}5 + {\cdot}305t;$$

and the total heat given to the boiler for 1 pound of water evaporated, is 976·9 degrees, or units of heat. On the contrary, the tangible work done, or useful effect, has been found to amount to 29,655 foot-pounds, or to 29,655 ÷ 772 = 38·4 units of heat. The loss of heat, that is to say, the unappropriated heat, is therefore 976·9 − 38·4 = 938·5 units thrown away, and the proportion of heat utilised is only about $\frac{1}{25}$th of the total heat expended.

The amount of heat expended in repelling the atmosphere, expressed in force, was found to be 28,492 foot-pounds; or, expressed in units, it is 28,492 ÷ 772 = 36·9 units. If this be added to the heat utilised, the sum 36·9 + 38·4 = 75·3 units, expresses the total exertion of the steam in forcing its way into existence behind the piston. Of course, the generation of the steam demands the same exertion, whether it takes place behind a piston, or under a safety-valve loaded to the given pressure, through which the surplus steam escapes; and the whole amount of heat supplied to the boiler in the formation of 1 pound of steam of 30 lb. total pressure per square inch, must, therefore, be distributed as follow:—

	Units of Heat.
1. In overcoming the molecular attraction, and separating the particles, 696,020 foot-pounds ÷ 772 = ...	901·6
2. In repelling the incumbent pressure; in other words, to raise a load of 4320 pounds through a height of 13·46 feet = 58,147 foot-pounds ÷ 772 = ...	75·3
The total heat expended........	976·9

Of all this heat, there is, as already estimated, only about a half of the second and smaller portion utilised by a common non-condensing non-expansive steam-engine. Even this twenty-fifth part of the total is too favourable an estimate, as applied to engines in ordinary condition, because there is usually a portion of the steam condensed in the cylinder, or, it may be, burdened with priming, and a back-pressure is caused which still further diminishes the efficiency. The annexed indicator-diagram, fig. 187, was taken from a small non-condensing steam-engine, from which it

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appears that, of the whole sensible pressure, 20 lb. above the atmosphere, exerted on the piston, 5 lb. was destroyed by back-pressure, leaving only an effective pressure of 15 lb. on the piston, or only three-fourths of the whole sensible pressure.

Fig. 187.

If, under the same conditions, steam of 45 lb. total pressure be raised from water supplied at 212°, and worked at that pressure in the cylinder, it is found, by a similar calculation, that for each pound of steam consumed, 77 units of heat are absorbed in repelling the incumbent pressure; of this only 25 units are expended on the atmospheric resistance, and the remainder, 52 units, may be utilised on the piston, being one-third more than with 30 lb. steam, and constituting one-nineteenth of the whole of the heat, 984·2°, supplied to the water in generating steam.

Again, with steam of 60 lb. total pressure, by the same calculation, 78·5 units of heat are absorbed in repelling incumbent pressure, of which only 19 units are expended on the atmospheric resistance, leaving 59·5 units for useful work, or a little over one-half more than with 30 lb. steam.

There is a common notion, that in proportion as steam of higher pressure exceeds the atmospheric pressure, the efficiency for useful work increases in the same ratio. This is true only of the capacity of a cylinder of given dimensions for delivering useful work. But it is very far from the truth if applied to the efficiency of a given weight of steam; for, in the examples above, it has been found approximately that—

For 1 pound weight of steam of	30,	45,	60	lb. total pressure.
The effective useful pressures are	15,	30,	45	„
In the ratio of	1,	2,	3	„
But the useful quantities of work are only	38·4,	52·0,	59·5	units of heat.
Only in the ratio of about	1,	1·3,	1·5	„

Showing, that with three times the excess of pressure above the atmosphere, there is only one and a half times the useful work, with equal weights of steam. And, in order to get double the useful work from the same weight of steam, worked, of course, in the manner which has formed the subject of this chapter, it would be necessary to introduce high-pressed steam of 180 lb. absolute pressure per square inch, compared with steam of 30 lb. per inch.

Work of Steam without Expansion, but with Condensation.—That is to say, the steam is supposed to be condensed within the cylinder (fig. 186), after the piston has been raised through the height due to its volume, against the resistance of the atmosphere; and the development of useful duty from the steam, heretofore terminated on having raised the piston with its incumbent load, comprising the unprofitable atmospheric resistance, may be further promoted. Let the material weight placed on the piston be removed, and the piston be attached to a rising weight over a pulley nearly equal to the amount of atmospheric pressure on the piston, or 2116·8 lb.; then, if an absolute vacuum be established within the cylinder, the piston will descend to the bottom, and the suspended weight will rise through a height equal to the descent. This weight may, for present purposes, be supposed to equal the atmospheric pressure, and the additional work done will be equal to 2116·8 lb., multiplied by the descent of the piston, or the ascent of the weight, in feet; being, in fact, equal to the work before unprofitably expended in opposing the atmosphere. The work thus redeemed was found to be, for 1 pound weight of 30 lb. steam under the piston, 28,492 foot-pounds, or 36·9 units; for 45 lb. steam, 25 units of heat; for 6 lb. steam, 19 units.

These reclaimed quantities of work being added to the useful work previously done in raising the piston, the total useful work done would be—

For 30 lb. steam	75·3	units.
For 45 lb. steam	77·	„
For 60 lb. steam	78·5	„

Work of Gaseous Steam with Expansion.

being, in any case, just about one-thirteenth of the heat supplied to the boiler.

The above conclusions are directly applicable to the steam-engine; and it appears, that when steam is worked in a common steam-engine, in direct continued connection with the boiler, non-expansively, that is to say, without applying its inherent expansive energy, there is only a small fraction, about a thirteenth, of all the heat given to the boiler, converted into useful work on the piston, with the advantage of a perfect vacuum behind the piston; and the proportion of useful work is still less than that if the steam be exhausted into the atmosphere. These deductions are based on otherwise favourable conditions.

CHAP. IV.—THE WORK OF GASEOUS STEAM WITH EXPANSION.

The action of gaseous or superheated steam, maintained at a constant temperature within the cylinder, is based on comparatively simple conditions. The total pressure of gaseous steam, when the temperature is constant, falls in proportion as the volume by expansion is increased, the pressure being inversely as the volume; and, consequently, the product of the diminishing pressure by the increasing volume, at all points of the stroke, is constant; and, for 1 pound weight of steam, it is equal to 85·4 times the absolute temperature; or, $PV = 85{\cdot}4\ T$. This constant relation of the pressure and volume of expanding steam may be represented diagrammatically on a base line A B (fig. 188), representing volume, which is supposed to be developed in a straight line, in a cylinder, of which A B is the length of stroke. Neglecting clearance for the present, let steam be admitted into the cylinder at a total pressure of 10 lb., represented by the ordinate A C, and for a space of 1 foot in length represented by A D, then the rectangular area A C E D represents the product of the pressure and volume of the steam admitted into the cylinder.

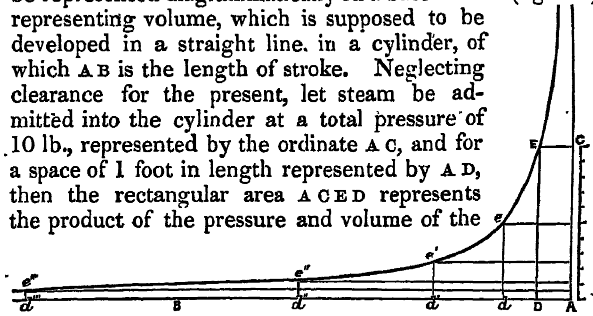

Fig. 188.

Let the steam be expanded at a constant temperature into double the volume A d, and to half the pressure $d\,c$; the area of the elongated rectangle A $d\,e\,c$, will be equal to that of the initial rectangle A E. Expanding, further, to three volumes A d', and to the third part of the initial pressure $d'e'$, the still more extended rectangle A e' is equal to each of the others. The expansion may be further extended to four and five volumes, and to a fourth and a fifth of the pressure, constituting the rectangles A e'' and A e'''; and while the products of the pressure and volume are always the same, represented by the successively elongated rectangles, the elevations $d\,e$, $d'\,e'$, &c., will correctly represent the successively reduced pressures for the several increments of expansion. It is obvious, that any number of intermediate pressures may be interpolated by the simple process of dividing the product of the initial pressure and volume by the distance traversed by the piston, and that they may be joined by a curve E e''', traced through their summits, representing the continuous expansion curve of the steam, which would be traced by the pencil of an indicator applied to the cylinder. This curve of expansion is, according to the principle of its construction—the equality of the rectangles—a portion of a hyperbola; and it may be indefinitely extended at either end, to embrace on the one part intense pressures and small volumes, and, on the other part, very low pressures and large volumes. In the extension upward of the curve into

Work of Gaseous Steam with Expansion.

the higher pressures, it would only be correct as an exponent of the mutual relation of pressure and volume, on the understanding that a proportionally high uniform temperature should be adopted, to ensure the gaseous condition of the steam. A curve constructed on this principle, though indefinitely extended in either direction, does not meet or touch the base line A B, or the vertical A C.

As the rectangular area A E, in the foregoing figure, expresses the work done by the steam in entering and occupying the cylinder, the hyperbolic area D E $d''' e'''$ likewise expresses the work done by the steam by expansion against the piston. This area, and consequently the quantity of work done, may be computed from the known relations of hyperbolic superficies with their base lines, according to which, if the base lines A D, A d, A d', &c. (fig. 188), extend in a geometrical ratio, the successive areas D e, D e', &c., increase in an arithmetical ratio. If, for example, the lines or volumes A D, A d, &c., are as 1, 2, 4, 8, 16, &c., the areas D e, D e', &c., are as 1, 2, 3, 4, &c. On the principles of logarithms, which represent, in arithmetical ratio, numbers naturally in geometrical ratio, special tables of hyperbolic logarithms are compiled, to facilitate the calculation of areas of power due to various degrees of expansion,—such logarithms being, in fact, direct expressions of the proportion borne by the expansive duty pertaining to different degrees of expansion, to the work done by the initial volume of steam. If, for example, the initial volume be expressed by 1, and the total volumes by expansion to different degrees be represented by

2, 4, 8, 16, &c.,

the hyperbolic logarithms of these numbers are,

·693, 1·386, 2·079, 2·772,

which are in arithmetical proportion thus—

1, 2, 3, 4,

and express the actual ratios of the entire expansive duties successively to the initial duty of the steam in entering and occupying the cylinder previous to expansion. The logarithms, it will be noted, are, in each case, the logarithm of the number expressing the ratio of expansion, or the number of times the initial volume is expanded.

It is needful, of course, to make a deduction for the unavoidable back-pressure in the condenser, to find the effective duty of the steam. Suppose a cylinder 5 feet long, with 1 square inch area of piston; steam being admitted, as before, at 10 lb. pressure; let the back-pressure be taken as a uniform resistance of 2 lb. throughout the stroke, and applied to the diagram of duty, constructed as before, as in fig. 189, where the 2 lb. zone of resistance is shaded. It is plain, in the first place, that if the steam, after following the piston through the first foot of the stroke A D, be exhausted into the condenser, with a residual pressure of 2 lb., the effective pressure is $10-2=8$ lb., and the work done is equal to 8 foot-pounds. But let the steam be expanded through the remaining four-fifths of the stroke; then—

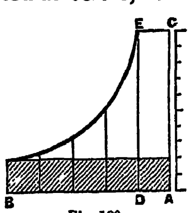

Fig. 189.

At the end of the...............	1st,	2d,	3d,	4th,	5th	foot of stroke	
The total pressures would be	10	5	3⅓	2½	2 lb.	per sq. inch.	
The back-pressures.............	2	2	2	2	2 lb.	do.	do.
The effective pressures.........	8	3	1⅓	0½	0 lb.	do.	do.

Then the total work done by expansion up to the end of each foot of stroke is represented by the hyperbolic logarithm of the ratio of expansion, when the work done during admission is represented by unity, thus—

At the end of the...........	1st,	2d,	3d,	4th,	5th	foot of stroke
The steam is expanded into		2	3	4	5	volumes.
Of which the hyp. logs. are	0	·69	1·10	1·39	1·61	
The initial duty being as...	1	1	1	1	1	unity.
And the total duty as.......	1	1·69	2·10	2·39	2·61	

showing that the total duty of the steam, by expanding it to five times the initial volume, is increased to fully 2½ times the initial duty without expansion, if no deduction be made for back-pressure. To make this necessary deduction at the rate of 2 lb. per square inch, and also to express the relative duty in foot-pounds, the whole initial duty is, as already said, 10 foot-pounds on a piston of 1 square inch area, moved through 1 foot, with a pressure of 10 lb.; the total work done in the first and second feet of the stroke is $10 \times 1·69 = 16·9$ foot-pounds; and so on. Then there is a drawback of 2 foot-pounds on each foot of the stroke. The relations of the work of the same weight of steam in the cylinder are therefore as follows:—

At the end of the.........	1st,	2d,	3d,	4th,	5th	foot of stroke
The total work done is...	10,	16·9,	21·0,	23·9,	26·1	foot-pounds.
The total resistance is....	2,	4,	6,	8,	10	do.
The total effective work is	8,	12·9,	15·0,	15·9,	16·1	do.
And the gain by expansion is.................	0	61	87	99	101	per cent.

Here it is to be observed, that by expanding the steam five times, the effective work is doubled, that is, it is increased from 8 foot-pounds to 16·1 foot-pounds; and that when the expansion is extended to the utmost useful limit—to the point at which the pressure of the expanded steam becomes equal to the back-pressure—the total resistance of the back-pressure in foot-pounds amounts to as much as the total work, which is done by the steam previous to expansion,—namely, 10 foot-pounds. It follows, therefore, that the total effective work of the steam expanded down to the pressure in the condenser is just equal to the total work developed by expansion alone,—that is, 16·1 foot-pounds is equal to $26·1-10$ foot-pounds. The initial performance of the steam may be said, conventionally, to go for nothing, being balanced by the resistance, and the whole of the useful work may be said to be accomplished by the residual expansive force alone. This conclusion applies generally wherever the steam is expanded down to the pressure in the condenser. It may further be concluded, that the utmost ratio of expansion, or limit to which expansion can be carried efficaciously,—regard being had simply to the operations of the steam, as indicated in the cylinder,—is measured by the number of times which the total pressure of the vapour in the condenser is contained in the total initial steam in the cylinder.

For further illustration, let the total initial pressure A C of the steam in the cylinder (fig. 189), during the first foot of stroke be 75 lb. per square inch, and suppose it to be expanded five times as before, and then exhausted into the atmosphere, with a back-pressure of 15 lb. per square inch throughout the stroke, indicated by the shaded zone. Then, as before, if the steam be maintained at a uniform temperature, the pressure at the end of the stroke will be $75 \div 5 = 15$ lb. per square inch, or down to atmospheric pressure, beyond which it would be useless to expand it. On a piston of 1 square inch area, the ratios of work done will be as before—

At the end of the......	1st,	2d,	3d,	4th,	5th	foot of stroke
The total work done is as................	1	1·69	2·10	2·39	2·61	
The total work done is actually..........	75	51·7	157·5	179·2	195·7	foot-pounds.
The total resistance is	15	30	45	60	75	do.
The total effective work is............	60	48·7	112·5	119·2	120·7	do.
And the gain by expansion is.........	0	61	87	99	101	per cent.

The proportions of work, in this case, where steam of five atmospheres is expanded five times, and exhausted into the atmosphere at a pressure of one atmosphere, are the same as when steam of 10 lb. pressure per inch is also expanded five times, and exhausted at a pressure of one-fifth, or 2 lb. per inch; and they indicate an equal efficiency of the steam in the way it is applied.

Work of Gaseous Steam with Expansion.

It is observable from the foregoing illustration, that when the opposing pressure is not less than one-fifth of the initial pressure in the cylinder, or, say in the boiler, there is no material extra duty gained by expanding to more than four volumes; in further expanding to five volumes, the proportion of further gain is only 0·2 upon 15·9, or $1\frac{1}{4}$ per cent.

The clearance which must be allowed between the piston and the end of the cylinder, for safety of working, and also the space or passage from the valve to the cylinder, must necessarily be filled with steam of the initial pressure, at the commencement of every stroke, which, doing no work, must be reckoned as entirely non-effective in non-expansive engines, and, in that respect, as wasted. Where the steam, however, is expanded within the cylinder, the clearance-steam contributes its quota of effect by expansion; and, therefore, in estimating the work done by steam, a distinction must be drawn between the quantity of steam effectively engaged in the cylinder before the suppression or cut-off, and the quantity after suppression—that is to say, before expansion and during expansion. For simplicity of calculation, the volume of the clearance may be expressed in units of the stroke, and added to the period of suppression, in order to express proportionally the initial volume of the steam submitted to expansion.

In the construction of a formula for the relative efficiency of gaseous steam worked expansively, viewed simply as a problem of absolute duty, irrespective of drawbacks on account of the resistance in the condenser and otherwise, the length of the stroke, the clearance, the period of admission, and the absolute initial pressure, are essential elements; and whereas the ratio of expansion is commonly expressed by the number of times the period of admission is contained in the length of stroke, or otherwise by the fraction of the stroke at which the steam is cut off, the actual ratio for the calculation of efficiency must be formed upon the addition of the amount of the clearance.

Let the duty of steam, without expansion, when the clearance is neglected, be expressed by unity, or 1; then the additional duty by expansively working it, is expressed by the hyperbolic logarithm of the ratio of expansion, and the entire duty is expressed by 1 + hyp. log. ratio of expansion. When the clearance is added, the initial duty is proportionally less than unity, as the clearance adds to the volume consumed; and the duty is expressible by the period of admission divided by itself plus the clearance. The ratio of expansion also is less, inasmuch as the clearance augments the initial volume proportionally more than it does the expanded volume, and is, in fact, equal to the initial volume plus the clearance, divided by the final volume plus the clearance. Let L = the length of stroke, l = the period of admission, and c = the clearance. Then the relative expression of the entire duty, neglecting clearance, is $1 + \text{hyp. log.} \frac{L}{l}$.

If the clearance be added, the expression becomes

$$\frac{l}{l+c} + \text{hyp. log.} \frac{L+c}{l+c};$$

in which the first fraction expresses something less than 1, or unity (which is the assumed datum or measure of the entire non-expansive duty of steam without clearance), being the depreciation caused by the presence of clearance; and the second fraction is the modified ratio of expansion.

Now, the period of admission plus the clearance, or $(l+c)$, is the measure of the volume of steam actually admitted to the cylinder for the performance of work, to which the foregoing general expression of entire duty is related; and if it be multiplied by the area of the piston (a), the product will be the volume of the steam admitted, or $a\,(l+c)$. The entire duty of which the steam actually expended would be capable, without expansion and without clearance, would be equal to this volume multiplied by the pressure (p) per unit of surface, or to $a\,p\,(l+c)$; and it is to this standard measure of duty that the general expression of entire duty must be applied by multiplying the one by the other, in order to show how the work of steam is affected by the clearance. If W = the actual entire duty, then

$$W = a p\,(l+c) \left\{ \frac{l}{l+c} + \text{hyp. log.} \left(\frac{L+c}{l+c} \right) \right\}.$$

For non-expansive engines, the actual entire duty is expressed by the equation—

$$W = a p\,(l+c) \frac{l}{l+c} = a p l,$$

in which l becomes equal to L, and signifying that the actual duty is, of course, equal to the product of the volume described by the piston, or the area multiplied by the stroke, and the pressure per unit of surface.

To indicate the importance of the clearance as an element in the efficiency of steam, take a locomotive-cylinder 15 inches in diameter and 20 inches stroke, with a clearance of $\frac{1}{4}$ inch off each end of the cylinder, and steam-passages 10 inches wide by $1\frac{1}{4}$ inch broad, and brought up in the usual manner to a single valve-face in the middle of the cylinder. Taking each passage at 12 inches in length, its cubic contents are $10 \times 1\frac{1}{4} \times 12 = 150$ cubic inches, which, divided by the area of piston, gives $\frac{3}{4}$ inch as the equivalent length of cylinder; and $\frac{3}{4} + \frac{1}{4} = 1$ inch, or one-twentieth of the stroke, is the total clearance or steam-room at each end of the cylinder. Now, if the steam were cut off at one-fifth, or 4 inches, and expanded to the end of the stroke, it would not properly be expanded so much as five times; for there are 5 inches of steam to be expanded into 20 inches, and the real expansion would be only four times. In cylinders, of course, where higher ratios of expansion are practised, the influence of clearance is still greater; and if, with a clearance of one-twentieth of the stroke, the steam be cut off at a twentieth, the volume admitted would be two-twentieths, and the steam would only be expanded into ten volumes, and not twenty. The advantages in this respect of short and direct passages from the valve-chest to the cylinder are obvious:—insuring a higher initial pressure, a higher ratio of expansion, and a less proportion of inactive steam in the cylinder than with long passages.

Professor Rankine proposes the following formula for the work U of 1 pound of gaseous steam, or "steam-gas," in which p_1 and v_1 are the initial pressure and volume, r is the ratio of expansion, and p_3 is the back-pressure:—

$$U = p_1\, v_1 \left(4{\cdot}29 - 3{\cdot}29 \frac{1}{r^{\cdot 304}} \right) - p_3\, r\, v_1.$$

He estimates that the gain of efficiency by superheating steam, of 34 lb. total pressure, in an ordinary engine, cutting off at one-fifth, by the heat of the furnace, is about 15 per cent., and that if the heat for this purpose be derived from the flues, which would otherwise be wasted, the saving is about 23 per cent. The latter result agrees very nearly with the general results of recent practice.

The preceding discussion comprehends the ordinary hypothesis on which the work of steam by expansive working is usually estimated. It assumes too much, however:—that steam, as used in practice, is entirely gaseous; and it does not consist with the true ratio of expansion in a steam-cylinder. The exemplifications of its application, in estimating the particular gains by expansive-working, are, nevertheless, important, as they measure, with a sufficient degree of exactitude, the value of expansive-working generally, in various degrees, as a means of increasing the efficiency of steam, and they point to the special significance of back-pressure in neutralising in an important degree the

Work of Gaseous Steam with Expansion.

Work of Dry Saturated Steam with Expansion.

expected benefit of prolonged expansion. In the following chapter is treated the work of dry saturated steam,—the condition in which steam exists in actual good practice.

The "regenerative steam-engine" of Mr C. W. Siemens is worked with gaseous steam, maintained at a nearly constant temperature, by placing the cylinder over a furnace; but the steam on its way to and from the space below the plunger of the cylinder traverses a "regenerator," the effect of which is, that nearly the whole of the heat employed to raise the temperature of the steam above the boiling point corresponding to its pressure is obtained at each stroke from the regenerator in which that heat has previously been stored by steam leaving the hot end of the cylinder. Mr Siemens states, that in some of his experiments with this engine, the consumption of fuel was only 1·5 lb. per indicator horse-power per hour.

CHAP. V.—THE WORK OF DRY SATURATED STEAM WITH EXPANSION.

The pressure of saturated, or ordinary steam, expanding in a jacketless or unheated cylinder, it has already been stated, falls more rapidly than that of steam of equal temperature, during the first stages of expansion; but ultimately less rapidly, if the expansion be sufficiently prolonged. This has been proved by the writer, from his observations on locomotive-engines, and by others on stationary-engines, to arise from the evaporation of water from the heated sides of the cylinder, when the expanding steam has fallen to a relatively low pressure and temperature—on the same principle as the spontaneous ebullition of hot fluids in vacuo—the water having been formed by the precipitation of steam during the admission to the cylinder, and in the first stages of expansion, upon the relatively cold surface of the cylinder.

There is another, but secondary source of the production of water in the cylinder,—the condensation of ordinary steam during the process of expansion behind the piston, owing to the conversion of part of the heat into work, and the precipitation of the water thus forsaken. This is a species of condensation which arises independently of the relative temperature of the cylinder, and would exist even if the material of the cylinder were a perfect non-conductor. Its existence was originally demonstrated, contemporaneously and independently, by Professor Rankine and Professor Clausius, in 1849.

This condition of things supplies an explanation of the whole mystery of expansive-working of steam. It fully accounts for the failure of attempts to economise fuel by expansive-working, without any provision for preventing the condensation of the steam within the cylinder, arising from the extreme alternations of temperature of the steam itself, during a double stroke of the piston, and the sympathetic condition of the cylinder, heated and cooled by the steam. In ordinary practice, the higher the initial pressure in the cylinder, and the greater the extent of expansive-working to which the steam is subjected, the more difficult it is to prevent the pressure in the condenser from rising, because, as before stated, if the cylinder be exposed, and the integrity of the steam be affected by the alternations of temperature within, there is a considerable amount of supplementary evaporation of water within the cylinder towards the end of the steam-stroke, as well as during the return stroke, when the cylinder is open to the condenser, which partially overpowers the latter, and excites additional back-pressure; and yet, if the back-pressure be not subdued, the gain by expansive-working is neutralised. The loss of expansive efficiency from this cause is important also in non-condensing engines.

The means of preventing the existence of water in the cylinders, thus caused, is provided by supplying heat to the cylinder from an independent source—an external jacket of hot steam, for example—in virtue of which the cylinder is not only maintained at a temperature as high as that of the steam within it, but may also communicate a portion of its heat to the expanding steam. And the question arises, is it sufficient that the steam should be simply preserved from being diminished in quantity by condensation during expansion: being supplied from the jacket while expanding, with just sufficient heat to prevent condensation? Or, is it preferable that the steam should be superheated into the gaseous condition, either within the cylinder from the jacket, or by other means, before it is admitted, so as to act as a perfect gas, considerably removed from the state of saturation? It can be shown that the best result is obtainable when there is just a sufficient supply of heat communicated to the steam in the cylinder, to prevent the precipitation of any portion of it as water. If the steam be discharged from the cylinder in a superheated state, it carries with it a greater quantity of rejected heat than if discharged at the saturation-point.

The liquefaction of steam in the cylinder, by the legitimate process of the conversion of heat into work, is not in itself a loss; it is, in fact, an expenditure of steam representing its equivalent of duty, and if the water of condensation thus precipitated could be instantly removed from the cylinder as soon as formed, so as to leave the cylinder dry at the end of the stroke, a still better result would be obtained per unit of heat expended, than when heat is absorbed from the jacket to prevent its condensation. But the objection to this liquefaction of steam in the cylinder is a practical one, as water in the cylinder, by whatever cause it may be formed, cools the cylinder by evaporation from its surfaces:—an evaporation doing but little good for the time, that is to say, during the remainder of the steam-stroke, and otherwise positive harm.

It is believed that, practically, the use of the steam-jacket does not extend materially beyond the maintenance of the steam in a state of dry saturation while expanding; the steam in the cylinder receiving just enough of heat from the steam in the jacket to prevent any appreciable part of it from condensing without superheating it. Professor Rankine, in adopting this view of the case, bases the assumption on the fact, "that dry steam is a bad conductor of heat, as compared with liquid water, or with cloudy steam; and that after cloudy steam has received enough of heat to make it dry, or nearly dry, it will receive additional heat very slowly. The assumption," he adds, "is justified by the fact, that its results are confirmed by experiment." Professor Rankine investigated, and published in 1859, exact and also approximate formulas for the work of dry saturated steam, under such conditions, and for the expenditure of heat in producing and using that steam. Adopting his notation, let T=absolute temperature in degrees of Fahrenheit = temperature measured from the ordinary zero + 461·2°; p=pressure in pounds on the square foot; v = volume of 1 pound of steam in cubic feet; t_1, p_1, v_1, refer to the admission of steam into the cylinder; t_2, p_2, v_2, to the end of the expansion; let $r = v_2 \div v_1$ the ratio of expansion; p_3, the pressure of exhaustion, or back-pressure; t_4, the absolute temperature of the feed-water; J=Joule's equivalent, or specific heat of 1 pound of liquid water, = 772 foot-pounds per degree of Fahrenheit; W=work of 1 pound of steam in foot-pounds; H= expenditure of heat per pound of steam in foot-pounds; a=1,109,550 foot-pounds; b=540·4 foot-pounds per degree of Fahrenheit; efficiency of steam, $W \div H$.

Let the curve B C K (fig. 190) be the expansion-curve of a body of dry saturated steam. Let $OA = p_1$, and $AB = v_1$, represent the pressure and volume of admission; also let $OD = p_2$, and $DC = v_2$, represent the pressure and volume at the end of the expansion; and let $OF = p_3$ the pressure of exhaustion; then $v_2 \div v_1 = r$ is the ratio of expansion,

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and $\frac{v_1}{v_2}=\frac{1}{r}$ is the period of admission or effective cut-off. The following are the exact formulas :—

$$W = a \text{ hyp. log. } \frac{t_1}{t_2} - b\,(t_1 - t_2) + v_2\,(p_2 - p_3).$$

$$H = a\,(1 + \text{hyp. log. } \frac{t_1}{t_2}) - bt_1 + J\,(t_2 - t_4).$$

The approximate formulas are founded on the facts, that for total initial pressures of steam from 30 to 120 lb. per

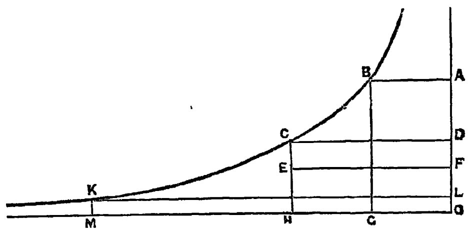

Fig. 190.

square inch, and for ratios of expansion up to sixteen times, the pressure of saturated steam varies nearly as the seventeenth power of the sixteenth root of its density, or of its volume inversely; and that the expenditure of heat in an engine in which dry saturated steam is used, expressed in units of work, is nearly equal to $15\frac{1}{2}$ times the product of the initial pressure and volume of steam expended. If p and v represent relative pressures and volumes, then, as aboved stated,

$$p \text{ varies as } \frac{1}{v^{\frac{17}{16}}}.$$

The ratio of the mean total pressure to the initial pressure of the steam, for different values of the ratio of expansion, r, is given by the expression—

$$\frac{17}{r} - \frac{16}{r^{\frac{17}{16}}}.$$

Then,

the final pressure, $p_2 = \frac{p_1}{r^{\frac{17}{16}}}$;

the mean total pressure $= p_1 \left(\frac{17}{r} - \frac{16}{r^{\frac{17}{16}}}\right)$

the mean effective pressure $= p_1 \left(\frac{17}{r} - \frac{16}{r^{\frac{17}{16}}}\right) - p_3$

the work of 1 pound of steam, exerted on the piston (area, ABCFA, fig. 190), =

$$W = v_2\,\{p_1 \left(\frac{17}{r} - \frac{16}{r^{\frac{17}{16}}}\right) - p_3\}.$$

The work per cubic foot of the space swept through by the piston, is

$$W \div v_2 = p \left(\frac{17}{r} - \frac{16}{r^{\frac{17}{16}}}\right) - p_3.$$

It is evident that if the pressure of exhaustion be given, and any two of the three quantities, namely, the initial pressure, the mean effective pressure, the ratio of expansion,—the fourth quantity can be calculated directly, except it be the ratio of expansion, which can be found by trial and error.

The approximate formula for the expenditure of heat per pound of steam, when the feed-water is supplied at a temperature of from 100° to 120° Fahr., is as follows :—

Expenditure of heat per pound of steam—

$$H = 15\tfrac{1}{2}\, p_1\, v_1.$$

The heat expended per cubic foot is—

$$H \div v_2 = \frac{15\frac{1}{2}\, p_1}{r}.$$

The efficiency of the steam, W÷H, is by reduction,

$$\frac{17 - \frac{16}{r^{\frac{1}{16}}}}{15\frac{1}{2}} - \frac{r p_3}{15\frac{1}{2}\, p_1}.$$

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By efficiency is meant the proportion which the actual useful effect bears to the whole expenditure of heat communicated to the steam.

In the foregoing formulas, the initial volume for the effective cut-off is measured to the point at which the curve of expansion, if produced upwards, intersects the horizontal line of admission. It is thus that the action of wire-drawing is accounted for, and an example of the operation is shown in fig. 134, where, by an extension of the expansion-line upwards, the shaded area D is enclosed, and the point of effective cut-off is placed 2 inches in advance, at 5 inches of the stroke, instead of 7 inches, to which the valves are set.

There is a small loss of effect by the release of the steam from the cylinder before the end of the stroke, shown also by shaded spaces in fig. 134. The compression or cushioning of the exhaust steam, though it reduces the area of the diagram, and the work done, does not, unless excessive, reduce the efficiency of the steam.

The clearance, as before mentioned, adds to the space to be filled with steam for each stroke, and reduces the ratio of expansion. This effect is more or less counterbalanced by the wire-drawing, the influence of which is to increase the ratio of expansion.

When the feed-water is delivered at other temperatures than 104° Fahr., or thereabouts, for which temperature the approximate formula for the expenditure of heat was obtained, an allowance must be made for the greater or less expenditure of heat, in proportion to the total heat of the steam generated. For example, if the water be heated to 204° Fahr., 100° higher than assumed in the formula; and if the steam be generated at 100 lb. total pressure, having 1181·4° total heat, the addition of 100° to the temperature of the feed-water reduces the expenditure of heat by $\frac{100}{1181{\cdot}4}$ or $\frac{1}{11{\cdot}8}$; and the co-efficient of the formula $H = 15\frac{1}{2}\, p_1\, v_1$ is reduced by $15\frac{1}{2} \div 11{\cdot}8 = 1{\cdot}3$, to 14·2; and the expression becomes $H = 14{\cdot}2\, p_1\, v_1$.

The following example of the application of the formulas to actual engines, and of the comparison of their results with those of experiment, is given by Professor Rankine :—

Example.—Double-cylinder engines of 744 indicator horse-power, calculated by the exact formulas :—

Data.

	Bottom of Cylinders.	Top of Cylinders.
Pressure of admission, $p_1 \div 144$	33·7	34·3
Back-pressure, $p_3 \div 144$	4·0	4·0
Ratio of expansion, r	$4\frac{1}{3}$	$6\frac{1}{4}$

Ordinary temperature of feed-water, 104° Fahr.

Calculated Results.

	Bottom.	Top.
Final volume of 1 pound of steam, $v_2 = rv_1$	50·375	74·4
Final pressure, $p_2 \div 144$	7·367	4·867
Work of 1 pound of steam,	109562	117338
Mean effective pressure in pounds on the inch	15·1	10·95
Mean of both results	13·03	
Mean effective pressure, as observed	13·1	
Difference	−0·07	

	Bottom, foot-pounds.	Top, foot-pounds.
Available heat expended per pound of steam	906989	925678
Pressure in lbs. per square inch, equivalent to heat	125	86·4
Mean	105·7	
Efficiency	0·121	0·127
Mean, 13·03÷105·7	0·123	

Work of Dry Saturated Steam with Expansion.

The same example calculated by the approximate formula:—

Data.

	lbs. per inch.
Mean pressure of admission, $p_1 \div 144$	34
Mean back-pressure, $p_3 \div 144$	4

$$\text{Mean cut of } \frac{1}{r} = \frac{0\cdot24+0\cdot16}{2} = 0\cdot2$$

Results.

Mean gross pressure, $34 \times \cdot505$	17·17
Mean effective pressure, $17\cdot17-4$	13·17
Observed	13·10
Difference	+0·07
Pressure equivalent to expenditure of heat	105·4
Efficiency	0·125

Both the exact and the approximate formulas appear to possess a great degree of accuracy in their practical application.

Mr Brownlee, in July 1859, published the following formulas for the work and heat of dry saturated steam, founded, like Rankine's approximate formula, on the fact of the uniform variation of the density, with a constant power of the pressure; in fact, the ·941 power. (See STEAM.) Conversely, the pressure varies as the $\frac{1}{\cdot941}$ power of the volume inversely, or as the $\frac{17}{16}$ power, or as the 1·0627 power inversely, which are equivalent expressions of the power; and

$$p_2 = p_1\left(\frac{v_1}{v_2}\right)^{\frac{1}{\cdot941}} = p_1\left(\frac{v_1}{v_2}\right)^{1\cdot0627}$$

If the steam be discharged after expansion at the same terminal pressure p_2, as the pressure at which the steam is condensed or exhausted, the total available work done, in foot-pounds, including clearance, and other drawbacks, is

$$W = \frac{1\cdot0627}{\cdot0627} P_1 \, v_1 \left\{1 - \left(\frac{v_1}{v_2}\right)^{\cdot0627}\right\}$$

$$= 16\cdot949 \, P_1 \, v_1 \left\{1 - \left(\frac{v_1}{v_2}\right)^{\cdot0627}\right\}$$

Let H_1 = the total heat of the initial steam, and H_2 = the total heat at the end of the expansion; then the heat required to be supplied from the jacket to prevent condensation, while the steam expands from p_1 to p_2

$$= \frac{W}{J} - (H_1 - H_2),$$

in which $J = 772$, Joule's equivalent.

If, again, the steam is permitted to flow into the condenser, or any space in which the pressure is less than that, p_2, at which expansion is terminated, and the pressure in the cylinder is thereby reduced to p_3, at which pressure the remaining vapour is finally expelled, there is obtained the additional work $v_2\,(p_2 - p_3)$; and the whole available work of the steam is

$$W = 16\cdot949 \, p_1 \, v_1 \left\{1 - \left(\frac{v_1}{v_2}\right)^{\cdot0627}\right\} + v_2\,(p_2 - p_3).$$

The exhaustion from the cylinder to the lowest pressure p_3, has a slightly cooling effect on the cylinder, as the exhausted vapour falls in temperature, and partially condenses while expanding and expelling that portion which flows off. Neglecting, in the meantime, this small expenditure of heat, Mr Brownlee takes for illustration the case of 1 pound of steam at 100 lb. total pressure per square inch, or 14,400 lb. per square foot, expanded to ten volumes, and maintained in a state of dry saturation by the addition of heat from the jacket. The terminal pressure will be

Work of Dry Saturated Steam with Expansion.

$$p_2 = 100 \times \left(\frac{1}{10}\right)^{1\cdot0627} = 8\cdot656 \text{ lb. per square inch,}$$

with a temperature of 185·5°; $p_1 = 14{,}400$ lb. per square foot; $v_1 = 4\cdot3351$ cubic feet; $\frac{v_1}{v_2} = \frac{1}{10}$, and $1 - \left(\frac{1}{10}\right)^{1\cdot0627}$ = ·1344. If the back-pressure be equal to the pressure of final expansion p_2, the whole available work will be $W = 16\cdot949 \times 14400 \times 4\cdot3351 \times \cdot13441 = 42200$ ft.-pounds.

Then, assuming the water to be supplied at 100°, the total heat H_1, of 100 lbs. steam, reckoned from this temperature, will be 1113·4° (see STEAM), whilst at 185·5° and 8·656 lb. pressure, the total heat H_2 will be, $1013\cdot4 + (\cdot305 \times 185\cdot5) = 1070\cdot2°$; and $H_1 - H_2 = 1113\cdot4 - 1070\cdot2 = 43\cdot2°$. Also, $\frac{W}{J} = \frac{142200}{772} = 184\cdot2$ units. Therefore, the heat absorbed from the jacket, necessary to prevent condensation, is $184\cdot2 - 43\cdot2 = 141$ units of heat. Hence, with water supplied at 100°, the total heat necessarily expended per pound of steam $= 1113\cdot4 + 141 = 1254\cdot4$ units, and the work done for each unit of heat expended, is

$$\frac{142200}{1254\cdot4} = 113\cdot4 \text{ foot-pounds.}$$

But, further, let the steam, after expanding to 8·656 lb. pressure per inch, be exhausted to 2 lb. back-pressure in the cylinder during the return-stroke. To find the additional work, $v_2\,(p_2 - p_3)$, thus done, $v_2 = v_1 \times 10 = 43351 \times 10 = 43\cdot351$ cubic feet; and $p_2 - p_3 = 6\cdot656$ lb. per square inch; then the additional work is

$$43\cdot351 \times 6\cdot656 \times 144 = 41540 \text{ foot-pounds;}$$

and the total available work is $142200 + 41540 = 183740$ foot-pounds for 1 pound of steam; or, for each unit of heat expended, it is

$$\frac{183740}{1254\cdot4} = 146\cdot4 \text{ foot-pounds.}$$

It appears that, in this case, nearly $11\frac{1}{4}$ per cent. of the whole heat consumed within the cylinder would be supplied to the steam while expanding, to maintain it in a state of dry saturation; and the efficiency of the engine is measured by the fraction $\frac{146\cdot4}{772} = \frac{1}{5\cdot3}$, or 18 per cent., showing that 82 per cent. of the heat expended is rejected.

Formulas have been constructed for the work of high-pressure steam, worked expansively by means of the link-motion, based on the indicator-power of locomotives, detailed in the work on *Railway Machinery*. The cylinder from which the data were obtained, was 18 inches diameter, 24 inches stroke, and had 1·8 inches total clearance, or $\frac{1}{13}$th of the stroke at each end, with steam-ports 13 by 2 inches, or about $\frac{1}{10}$th of the piston-area. The cylinders were placed in the smoke-box, and the steam maintained in good condition. The maximum pressure in the cylinder varied from 70 to 90 lb. per square inch above the atmosphere. The volume of steam admitted was estimated in terms of the indicator-pressure at the point of suppression, and is now recalculated from the most recent investigations of relative volume. The formulas give the nett performances, allowing for drawbacks of every kind, as clearance, back-pressure, wire-drawing; and it is remarked that the incidental advantage by the increased wire-drawing of steam at greater speed during admission, is practically equivalent to the loss by increase of back-pressure. Thus, the formulas are applicable with accuracy for all the different observed speeds of piston, from 200 to 800 feet per minute. Let r = the percentage of the stroke at which the steam is cut off, then the consumption of steam in lbs. per horse-power per hour

$$= 24r + 15\,;$$

and dividing the result by the evaporative ratio of the fuel,

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the quotient is the consumption of fuel in lbs. per indicator horse-power per hour.

Again, as one actual horse-power is equal to 1,980,000 foot-pounds per hour, the work of 1 lb. of steam

$$=\frac{1,980,000}{(\cdot 24r+15)}.$$

The effective mean pressure in lbs. per square inch in the cylinder, for a given maximum pressure P, and percentage of admission, r, is

$$\text{Eff. mean pressure} = P \times \cdot 135\sqrt{r} - \cdot 28.$$

The above three formulas are applicable without material error for periods of admission from 10 to 80 per cent., and for pressures of 60 lb. to 150 lb. per square inch. For high pressures, the results they give are slightly under the actual results,—a negative error. The effective mean pressure, by the last equation, is slightly too small for the lower speeds, and slightly too great for the higher, but is exact for a speed of piston of 560 feet per minute.

CHAP. VI.—THE WORK OF SATURATED STEAM UNDER NORMAL CONDITIONS, WITH EXPANSION.

In the two preceding sections the work of steam in a cylinder has been considered, first, as gaseous steam, where the steam has been super-heated above its temperature of saturation, and maintained at a uniform temperature; second, as dry saturated steam, where it receives, during expansion, just as much heat as is sufficient to prevent the condensation of any portion of it. It remains to consider the action of steam, when it neither parts with nor receives heat during any part of the stroke. This condition supposes a normal state of things, and implies that the material of the cylinder is a perfect non-conductor, and that the water of condensation during expansion is discharged with the steam at the end of each stroke. Such a condition of things does not, and perhaps cannot, exist in practice, but the consideration of it as an elementary question will be useful.

It has been stated that, whatever the fluid employed, the proportion of heat utilised, in working over the same range, or between the same pair of temperatures, is the same, whatever the fluid employed, when all the heat derived from the heater or boiler is communicated to the fluid at the maximum temperature, and when the entire fall of temperature is effected by the useful expansion of the fluid. On these principles it is necessary, first, that the substance should be raised from the temperature of the condenser to that of the boiler, without directly abstracting heat from the source of heat,—for example, the feed-water should be heated independently to the temperature in the boiler; second, that the fluid should be expanded down to the temperature of the condenser. Under these circumstances, the ratio $\frac{T_1 - T_2}{T_1}$ expresses the efficiency of the heat expended, or the proportion of heat utilised, and the remainder, $T_1 - T_2$, being the measure of the heat utilised, and T_2 the measure of the heat rejected, the relative proportion of the latter can never, under any conceivable circumstances, be less than $\frac{T_2}{T_1}$. For example, let the absolute temperature of the condenser, $T_2 = 600°$, and that of the boiler $T_1 = 800°$, then the heat utilised cannot be more than $800 - 600 = 200°$, or the fraction $\frac{2}{8}$, and the heat rejected cannot be less than 600°, or the fraction $\frac{6}{8}$. The ultimate maximum of work, in foot-pounds per unit of heat expended, would, with any vapour or gas, equal $772 \times \frac{T_1 - T_2}{T_1}$; and suppose, again, $T_1 = 718°$, and $T_2 = 563°$; the heat utilised would be $718 - 563 = 155°$, and there would be $\frac{155}{718}$ parts of the heat converted into work, and $\frac{563}{718}$ parts rejected, or transferred to the condenser. The work done for each unit of heat expended would be $772 \times \frac{155}{718} = 166 \cdot 6$ foot-pounds. This is for a perfect heat-engine.

Now, reverting to the steam-engine, whilst the maximum of duty is obtained by the expansion of the steam within the cylinder down to the pressure in the condenser, prior to its being discharged, it is obviously impossible to comply with the first condition of a perfect engine, namely, the heating of the feed-water to the temperature in the boiler, without abstracting heat from the furnace, or from the boiler itself; the only other source of heat is in the condenser, which is only at the temperature due to the pressure—that is, for, say 1 lb. absolute pressure, the sensible temperature is 102° Fahr., and the feed-water supplied from the condenser cannot exceed this temperature. The heat expended, under such circumstances, must therefore be increased by a quantity arising from the inferiority of the sensible temperature of the feed-water at 102°, to that of the steam in the boiler, expressed by $T_1 - T_2$ degrees; so that, if the water at 102° be converted into saturated steam at 102°, and the temperature and pressure of the resulting steam be raised to those of the saturated steam in the boiler, though $T_1° - T°_2$, or 155°, the quantity of heat thus absorbed is measured by $\cdot 305\,(T_1 - T_2)$, or, say, to allow for the varying specific heat of water, $\cdot 3\,(T_1 - T_2)$. The denominator of the ratio of efficiency must therefore be increased by this quantity; and putting h = the greatest proportion of the heat expended, it is possible to convert into work, by expanding the steam down to a temperature of 102°, with the condenser at this temperature, and an absolute pressure of 1 lb. per square-inch. Then we have Mr Brownlee's formula,—

$$h = \frac{T_1 - T_2}{T_1 + \cdot 3(T_1 - T_2)}$$

Let, for example, as before, $T_1 = 718°$, for a total pressure of 33·7 lb. per square inch; then T_2 being 102° sensible, or 563° absolute, $(T_1° - T_2°) = 155°$, and

$$h = \frac{155}{718 + (\cdot 3 \times 155)} = \frac{155}{764 \cdot 5} = \cdot 2027,$$

or about one-fifth, being the ratio of efficency; and the work done for each unit of heat expended is $772 \times \cdot 2027 = 156 \cdot 5$ foot-pounds.

The comparison, in the particular cases under consideration, between the efficiency of the most perfect engine conceivable, and that of an ordinary condensing engine, working under the conditions specified, may thus be stated:—

	Extreme absolute temperatures.	Extreme total pressures.	Work done per unit of heat expended.
Perfect engine,...	718° to 563°	33·7 lb. to 1 lb.	166·6 foot-pounds.
Ordinary do.,...	718° to 563°	33·7 lb. to 1 lb.	156.5 „

It would appear, then, that the ordinary engine would yield 10·1 foot-pounds, or only 6 per cent. less duty than the perfect engine, when working over the same range, or between the same pairs of temperatures.

It has been said that, in a perfect engine working between the same temperatures, the total work performed for a given expenditure of heat is the same, whatever the substance or vehicle of the heat may be. But in ordinary working,—confining the comparison to condensing engines for the present,—the liquid is supplied directly from the condenser at a lower than the initial temperature; and the work done with different liquids is not the same for equal quantities of heat expended, although working similarly between the same pair of temperatures, and regularly expanding from the highest to the lowest. A steam-engine, for instance, with the boiler at 212°, and the condenser at

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104°, the steam expanded in the cylinder from the former to the latter temperature, and the feed-water supplied at 104°, would convert into work ·1526 of the heat expended, represented by unity. With a sulphuric ether engine, under the same conditions, the maximum utility would be expressed by ·1406. In an air-engine, let the air be supplied to the heater at the constant temperature 104°, and therein raised at constant pressure from 104° to 212°; thence admitted to and expanded upon a piston till the temperature falls to 104°, and then discharge at this temperature, then it cannot utilise more than ·09 of the heat expended.

In order to compare, by an example, the action of steam in an ordinary engine, where it neither gains nor loses heat while expanding with its action in a jacketed cylinder,—being supplied with just as much heat while expanding as to prevent condensation of any kind in the cylinder—the example already detailed, in illustration of Mr Brownlee's formula for the action of steam in a jacketed cylinder may be assumed. It was found in that case, that 121·6 foot-pounds of work was done for each unit of heat expended, with initial steam of 100 lb. total pressure per square-inch expanded to 10 volumes, with a final pressure in the cylinder of 8·656 lb., and the same pressure in the condenser. The initial and final absolute temperatures due to the pressures were 788·8° and 646·5°; then $T_1 - T_2 = 142·3$, and

$$\frac{T_1 - T_2}{T_1 + ·3\,(T_1 - T_2)} = \frac{142·3}{831·5} = ·1711; \text{ and } 772 + ·1711 = 131$$

foot-pounds of work per unit of heat expended, when heat was neither given to nor taken from the steam in the cylinder, to be compared with 121·6 foot-pounds in the jacketed cylinder. Again, for 1 pound of steam, the expenditure of heat in the act of expansion was found to be 1028 units, exclusive of the heat derived from the jacket; and 1028 × 131 = 134,700 foot-pounds would be the total action of 1 pound of steam in the unjacketed cylinder, to be compared with 142,200 foot-pounds, which comprises the additional work arising from the absorption of heat from the jacket. Hence it appears that, in the unjacketed non-condensing cylinder, there was less work per pound of steam, but more work per unit of heat expended, than in the jacketed cylinder. Of course this comparison, though just, is hypothetical, as it supposes that no part of the heat of the steam is absorbed or wasted through the cylinder, which is not a state of things that can be said ever to occur in practice. The jacketed cylinder, then, is not essentially better than the unjacketed, but is so only because of practical imperfections arising from the conducting power of metals, in the latter case, and the consequent precipitation and unprofitable re-evaporation of steam.

SECTION VII.

CHAP. I.—COAL:—ITS COMPOSITION AND DECOMPOSITION. COKE.

The combustion of fuel consists in the chemical union of the combustible elements with atmospheric oxygen, and the practical management of the process consists, therefore, in so disposing of the fuel in layers on the grate, and so administering the air as to effect their intimate mixture in order to effect their final combustion. The process is simple or complex, according to the composition of the fuel. Coke consists, substantially, of but one combustible, carbon, and the whole process is comprised in the union of the carbon with oxygen in the proper saturating proportion. But coal is not a homogeneous substance; the combustible matter of it is found, by analysis, to consist mainly of carbon and hydrogen:—carbon, dull and unevaporable;—hydrogen, the most elastic gas known:—at the extreme of the scale of existence. The question of the prevention of smoke is intimately associated with that of the combustion of coal. They are, indeed, essentially one question; for, if coal be completely burnt, there cannot be any smoke; and, otherwise, if there be smoke, the coal is certainly not completely burnt. Now, as coke and anthracite coal give no smoke during combustion, although composed of the very matter of smoke—carbon,—it follows that the property of smoke-making is in some way associated with the hydrogen of the coal, which is at the same time the most perfect type of gaseity known in chemistry. The constituent hydrogen is associated in chemical union with a portion of the carbon, forming with it a complex group of compounds, known collectively as hydro-carbons, which present themselves in various forms, when separated or distilled, by the application of heat. At the lowest temperature, the products obtained are chiefly oils, resins, and like distinctive compounds, vaporizable at temperatures under red heat. A somewhat higher temperature brings off fluids of volatile character, as naphtha. A higher still, the third stage of temperature, produces the rich illuminating gas, olefiant gas, or bi-carburetted hydrogen. The fourth stage discharges the common gas, carburetted hydrogen, which continues to be given off after the coal has reached low red heat. But as the temperature rises, pure hydrogen also is given off; until, finally, in the fifth and last stage, hydrogen gas alone is discharged. What remains is the fixed or solid carbon of coal—the coke; with earthy matter—the ash of the coal.

These hydro-carbons, especially those which are given off at the lowest temperatures, which are richest in carbon, constitute the flame-and-smoke making part of the coal; and the greater their entire weight, as compared with that of the fixed carbon, the more highly is this character developed. When subjected to degrees of heat much above the temperatures required to vaporize them, they become decomposed, and pass successively into more and more permanent forms, by precipitating portions of their carbon. At the temperature of low redness, none of them are to be found, and the olefiant gas is the densest type that remains, mixed largely with carburetted hydrogen and free hydrogen. It is in these transformations that the great body of smoke is produced, when the precipitated carbon passes off uncombined; even olefiant gas, at a bright red heat, deposits half its carbon, changing to carburetted hydrogen, and this gas may deposit the last remaining equivalent of carbon, at the highest furnace-heats becoming pure hydrogen.

Throughout all the primary and secondary conditions of the hydro-carbon compounds, raised by distillation from coal, the hydrogen maintains the first claim to the oxygen present above the fuel; until it is satisfied, the precipitated carbon remains unburnt.

There are very great individual differences in the chemical composition and properties of coals, and their varieties are very numerous. The proportion of fixed carbon in coal ranges from 30 to 93 per cent.; of hydro-carbons, from 5 to 58 per cent.; of water, or oxygen and hydrogen, in the proportions to form water, from a mere trace to 27 per cent.; and of ash, from 1½ to 26 per cent. The varieties of coal may be arranged into five classes:—

1. Anthracite, or blind coal, consisting almost entirely of free carbon. 2. Dry bituminous coal, having from 70 to 80 per cent. of carbon. 3. Bituminous caking coal, having 50 to 60 per cent. of carbon. 4. Long flaming or cannel coal, differing from the last in containing more oxygen; and in some varieties it does not cake. 5. Lignite, or brown coal, containing 27 to 50 per cent. of carbon.

The following summary presents the mean composition and characteristics of English, Welsh, and Scotch coals, derived from the *Report on Coals suited to the Royal Navy*, by Dr Playfair and Professor De La Bèche:—

Coal, its Composition and Decomposition.

Table of the Mean Chemical Composition of Coals.

Locality.	Constituent elements, by weight.						Coke left by Distillation.	Water evaporated per pound of Coal.
	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ashes.		
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	lbs.
Wales, 36 samples	83·78	4·79	4·15	0·98	1·43	4·91	72·60	9·05
Newcastle district, 18 samples	82·12	5·31	5·69	1·35	1·24	3·77	60·67	8·37
Lancashire, 28 samples	77·0	5·32	9·53	1·93	1·44	4·88	60·22	7·94
Scotch, 8 samples	78·53	5·61	9·69	1·0	1·11	4·03	54·22	7·70
Derbyshire, 7 samples	79·68	4·94	10·28	1·41	1·01	2·65	59·22	7·58
Gross means	80·22	5·20	7·87	1·33	1·25	4·05	61·40	8·13

It appears from this summary that the composition of British coals averages about 80 per cent. of carbon, 5 per cent. of hydrogen, 8 per cent. of oxygen, $1\frac{1}{3}$ per cent of nitrogen, $1\frac{1}{4}$ per cent. of sulphur, and 4 per cent. of ashes. Also, that the coke, or fixed carbon, as distinguished from the volatilized carbon, averages a little over 60 per cent. of the weight of the coal; the volatilized carbon averaging 20 per cent. Of the volatile portions of coal, then, generated in the preliminary stage of decomposition and distillation, prior to combustion, those which arise in chemical combination are, say,

Carbon	20	per cent.
Hydrogen	5	„
Oxygen	8	„

One part of the hydrogen is united to the 8 parts of oxygen, in the chemically combining proportions forming steam, and of the remaining 4 parts of hydrogen, $3\frac{1}{3}$ parts unite in chemical proportion with the 20 parts of carbon, forming carburetted hydrogen, and $\frac{2}{3}$ of one part passes off as pure hydrogen. The elements of the decomposed fuel, prior to combustion, may thus be summarised:—

100 *lbs. of Coal.*

	lb.		lb.	
Fixed carbon	60	forming	60	fixed carbon.
Volatilized ditto	20		$23\frac{1}{3}$	carburetted hydrog.
Hydrogen	5		9	steam.
Oxygen	8		$\frac{2}{3}$	hydrogen.
Nitrogen, ash, &c.	7		7	nitrogen, &c.
	100		100	

Coke exists in various degrees of purity. The purest coke contains about $97\frac{1}{2}$ per cent. of carbon, according to the following analysis of the best Newcastle coke:—

Carbon	97·6	per cent.
Sulphur	0·85	„
Ashes	1·55	„
	100·00	

Coke is classified into three kinds: good, middling, bad; of which the good contains an average of 94 per cent. of carbon; the middling 88 per cent.; and the bad 82 per cent. Coke usually contains more sulphur than coal, and that is the most injurious element in its effects on the metallic substances exposed to the products of combustion.

Peat, or turf, is in considerable use in Ireland. Perfectly dry peat, of the best quality, contains, in 100 parts—

Carbon	58	per cent.
Hydrogen	6	„
Oxygen	31	„
Ash	5	„
	100	

In its ordinary state of dryness, it contains 25 to 30 per cent. of water.

CHAP. II.—THE CHEMISTRY OF THE COMBUSTION OF COAL.

One pound of hydrogen unites with and requires 8 lb. of oxygen for its combustion; measuring by volume, 1 cubic foot of hydrogen requires just half a cubic foot of oxygen for combustion; the product being steam, aqueous vapour, or water. Oxygen is sixteen times as weighty as hydrogen, and so hydrogen combines with eight times its weight, and but half its volume, of oxygen. In round numbers, 1 pound of hydrogen is 200 cubic feet in bulk, at 62° Fahr., and the combining volume of oxygen is 100 cubic feet.

One pound of carbon unites with $2\frac{2}{3}$ lb., or 32 cubic feet, of oxygen for its complete combustion, forming carbonic acid.

Atmospheric air is composed of oxygen and nitrogen, in the proportion of 1 lb. of the former to $3\frac{1}{2}$ lb. of the latter; or, by volume, 1 cubic foot of oxygen to 4 cubic feet of nitrogen. Nitrogen is a neutral gas in combustion, and is present as a diluent simply; and for every cubic foot of oxygen required in combustion 5 cubic feet of air must be supplied.

It follows, that for the combustion of 1 lb. of hydrogen 500 cubic feet of air are required; and for the complete combustion of 1 lb. of carbon, 160 cubic feet of air are required.

These are the combining proportions of hydrogen and carbon with oxygen, and air, in combustion. In practice, the presence of an excess of oxygen above that which is chemically appropriated, is essential to the completeness of the combustion of the volatilised portions; but the amount of excess necessary becomes less as the general temperature in the furnace becomes greater. It is not needful, for present objects, to entertain the question of excess of air specifically, nor the relative demands of the varieties of hydro-carbons generated from coal. It suffices to show, generally, the proportions of air required for full chemical union with the volatile and the solid portions of the fuel; and thus illustrate the relative importance of the claims of the gases upon the general oxygen fund. It was shown that the average proportion of volatilised hydrocarbons was $23\frac{1}{3}$ per cent. by weight of the whole body of coal, of which the hydrogen constituted $3\frac{1}{3}$ per cent. and the carbon 20 per cent.; and there remained 60 per cent. as solid carbon. For illustration, take 100 lb. of coal; then the relative quantities of air chemically consumed in completely burning the combustible elements are as follows:—

Volatile	Hydrogen,	4 lbs. consumes		2000 cubic feet of air.		
	Carbon,	20 do.	do.	3200	do.	do.
				5200		
Fixed	Carbon,	60 do.	do.	9600	do.	do.
		85 do.	do.	14,800	do.	do.

It may be assumed, in round numbers, that, for the complete combustion of 100 lb. of coal, that is, of its combustible elements, 15,000 cubic feet of air is chemically consumed, or 150 cubic feet for 1 lb. of coal. And, of this supply of air, the volatile and fixed elements consume respectively, for the volatile, about one-third, and for the fixed, two-thirds.

If allowance be made for the excess of air practically

Heat of Combustion of Coal and Coke.

required for the complete combustion of the gases, say double the chemical equivalent, the total supply of air required for the combustion of 100 lb. of coal would be as follows:—

Volatile elements,	10,400, or say, 10,000	cubic feet of air.
Fixed element,	9,600, or say, 10,000	do, do.
Total for 100 lb. of coal,	20,000	cubic feet of air.

Thus, finally, it is estimated, that for the complete combustion of 100 lb. of coal of average composition, 15,000 cubic feet of air are chemically consumed; and that 20,000 cubic feet of air are required in practice, or 200 cubic feet of air for 1 lb. of coal, of which one-half is devoted to the fixed portion of the fuel, and one-half to the volatile portion.

The importance of the share in the business of the furnace, taken by the volatilised parts of the fuel, evinced by the large proportion of air allotted to it, is enhanced by the reflection, that the development of heat by combustion is generally in the ratio of the quantity of oxygen chemically combined in the process; and that thus the heat developed by the complete combustion of the volatile elements is one-third of the entire quantity of heat generated. There is, then, scope for the economization of fuel, as well as for the prevention of smoke; but, as there is no doubt that much of the air consumed in burning the volatile elements is drawn through the grate, in company with that which is devoted to the solid portion, there remains so much the less fresh air to be thrown in above or beyond the fuel. There are, doubtless, empiricists who do not believe in the increase of economy by smoke-prevention. Unquestionably, however, when the prevention of dense smoke is not accompanied by a material saving of fuel, there must be a want of adjustment of the appliances, and necessarily imperfect combustion, or waste of means. Carbon, as already stated, may combine with oxygen in one of two proportions, forming carbonic oxide and carbonic acid, of which both are colourless; but, in the production of the former of these, much less heat is developed than in that of the latter.

Besides the combustibles, hydrogen and carbon, the other elements of coal—oxygen, in union with its equivalent of hydrogen, with nitrogen and sulphur—are driven off in the gaseous form. Ammonia is the product of the union of hydrogen and nitrogen, and may possibly be driven off direct from the coal. However the chemical details of combustion may be developed, it is certain that hydrogen from coal practically monopolises a considerable portion of atmospheric oxygen; for the supply of which, therefore, to the hydrogen, provision must be made without prejudice to the requirements of the fixed carbon, in order to effect complete combustion.

CHAP. III.—THE HEAT OF COMBUSTION OF COAL AND COKE.

The total heat of combustion of the elements of coal, simple and compound, has been the subject of elaborate experiment by several physicists, amongst whom are MM. Favre and Silbermann, who employed in their observations the mercurial calorimeter, an instrument from which great accuracy may be expected. The following table of the results arrived at by the above-named experimentalists shows the total heat of combustion with oxygen, of one pound of each of the substances named, in British thermal units, and also in pounds of water evaporated from 212° Fahr., with the weight of oxygen required to combine with one pound of each of the combustibles.

The result arrived at by MM. Favre and Silbermann, as the total heat of combustion of carbon, is higher than that of Dulong, 12,906 units, and that of Despritz, 14,040 units; but it is preferred, as the highest result in experiments of this kind is the most likely to be correct.

Table of the Total Heat of Combustion of the Constituents of Coal and other Fuels.

Combustible (1 pound).	Weight of Oxygen consumed per pound of combustible.	Total heat in British units.	Evaporative power in weight of water, from 212° Fahr.
	lbs.	units.	lbs.
Hydrogen gas	8	62,032	64·2
Carbon, imperfectly burned, so as to make carbonic oxide	$1\frac{1}{3}$	4,400	4·55
Carbon, completely burned, so as to make carbonic acid	$2\frac{2}{3}$	14,500	15·0
Olefiant gas	$3\frac{3}{7}$	21,344	22·1
Various liquid hydro-carbons	...	21,000 to 19,000	22 to 20
Coal (average)	$2\frac{9}{20}$	14,081	14·57
Coke (average)	$2\frac{1}{3}$	12,760	13·2

It is to be observed, that the imperfect combustion of carbon, making carbonic oxide, produces less than one-third of the heat yielded by the complete combustion of it; also, that the heating power of hydrogen gas is $4\frac{1}{4}$ times that of carbon. It may be deduced, further, that the total heat of combustion of any compound of hydrogen and carbon is the sum of the quantities of heat which the hydrogen and carbon contained in it would produce separately by their combustion. It has also been inferred from other experiments, that the presence of oxygen and hydrogen in fuel, in the proportion to form water or steam, does not affect the total heat of combustion; and that it is only the excess of hydrogen that can be made serviceable as a source of available heat. It would appear, however, that one essential element in the question of the total heat of combustion of coal has not yet been determined, namely the quantity of heat absorbed from the general stock, or rendered latent, in gasifying the hydro-carbons, which is to be charged against the hydrogen, as the evaporative efficiency of the hydrogen must be measured by the quantity of heat developed in its union with oxygen, minus the heat absorbed in the preliminary gasification of it. As Professor Rankine concisely puts it, "the heat obtained is the excess of the heat produced by the combinations, above the heat which disappears in consequence of the decompositions. Sometimes, also, the heat produced is subject to a further deduction, on account of heat which disappears in melting or evaporating some of the substances which combine, either before or during the act of combination." One thing is clear, that in order to make the best of it, the hydrogen, once volatilised, should be oxidized, as well as the carbon associated with it, in order to realize the large measure of heat generated by their combustion. There is a favourite theory, having at least the merit of simplicity, that the heating power of coal is just equal to that of the coke derived from it, which is manifestly absurd. It would be nearer the truth to say, that the heating power of coal is measured by that of its constituent carbon. The evidence of the evaporative powers of coals, abstracted in the table, page 629, appears to support this mode of estimation, in so far as the evaporative efficiency varies generally with the percentage of constituent carbon. The percentages of constituent hydrogen vary within narrow limits, and do not afford data for any marked comparison; but it may be suggested, that generally, the evaporative efficiency is less, as the constituent hydrogen is greater in quantity. Neither the variations of the hydrogen nor those of the carbon, however, suffice to account for the comparatively wide differences of efficiency; but, on referring to the next column, of the constituent oxygen, it is remarkable, that the efficiency of the fuel decreases regularly as the percentage of oxygen in the fuel increases.

Physical Conditions of the Combustion of Coal.

Welsh coal, with about 84 per cent. of carbon, and 4 per cent. of oxygen, evaporates 9·05 lb. of water per lb. of fuel; whilst Derbyshire coal, with about 80 per cent. of carbon and 10 per cent. of oxygen, evaporates only 7·58 lb. of water per pound of fuel. The difference of carbon does not sufficiently account for the difference of evaporative efficiency; nor does the difference of hydrogen, which is practically the same in both cases. The prime cause, apparently, is the oxygen, which is in great excess in the inferior coal; and an explanation readily occurs. All this oxygen must, in the first place, be volatilised, and it must absorb a portion of heat, which is thus diverted from the business of evaporation; and, though, no doubt, it may subsequently restore the heat thus temporarily abstracted in combining with the hydrogen as a gas, yet, as compared with the atmospheric oxygen, which, in the absence of solid oxygen, supplies its place, the solid oxygen is at a disadvantage, in so far as atmospheric oxygen is yielded at once in the half converted, desirable condition of a gas.

It appears, then, that the evaporative efficiency of coal varies directly with the quantity of constituent carbon, and inversely with the quantity of constituent oxygen; but that it varies, not so much because there is more or less carbon, as, chiefly, because there is less or more oxygen. The percentages of constituent hydrogen, nitrogen, sulphur, and ash, are practically constant, with individual exceptions, of course, and their united influence should be so also. Practically, then, treating the question as one of evaporative efficiency, the solution of it lies between the carbon and the oxygen.

The theoretical estimate of the calorific value of coal of average quality, namely, the evaporation of 14·57 lb. of water, from and at 212°, is confirmed by the results of an apparatus constructed by Mr Wright of Westminster; so contrived, that a portion of coal is burned under water, and the products of combustion actually passed through the water, so that the whole of the heat generated is absorbed. By means of this apparatus, the following calorific values, or total heats of combustion, were obtained, the particulars of which were published in the *Reports on the Use of the Steam Coals of the Hartley District of Northumberland*, by Messrs Armstrong, Longridge, and Richardson:—

Welsh coal	14·30 lb. from 212°
Hartley coal	14·63 „
Mean (by experiment)	14·46 lb.
By theoretical estimate	14·57 lb.

The total heat of combustion of coke is deducible directly from that of carbon, which constitutes the combustible matter of coke. The percentage of carbon in coke determines the percentage of its heating power. Thus:—

Coke.	Constituent Carbon.	Total heat of Combustion of one pound.	Total Evaporative power in pounds of water from 212°
Good	94 per cent.	13,620 units	14·0
Middling	88 „	12,760 „	13·2
Bad	82 „	11,890 „	12·3

CHAP. IV.—PHYSICAL CONDITIONS OF THE COMPLETE COMBUSTION OF COAL.

It has been seen that coal undergoing combustion is exhibited in two forms, solid and gaseous, of which the solid (coke) rests on the grate, and the gaseous (hydro-carbons and hydrogen) rise from the solid portion. To get the air into immediate contact and mixture with these elements, so as completely to burn them individually and in detail, is the important problem, the solution of which has been the study of engineers. The mode of so introducing and mixing the air depends on the circumstances of the furnace. If the grate be very large, and the combustion very slow and uniform, as is usual in the practice of Cornish pumping-engines, all or nearly all the air needed for effecting the complete combustion of the fuel may be passed through the grate. If, on the contrary, the grate be small, and the combustion rapid and irregular, as in locomotive practice, a large proportion of the air needed to accomplish the entire combustion of the fuel must be introduced above the fuel, there to mix with and consume the gases. The introduction of air through the grate is, in ordinary practice, the fundamental condition; the admission of air otherwise above the fuel is auxiliary or supplementary to it, supplying just the additional quantity of air requisite to complete the combustion.

Again, the temperature should be maintained at a sufficient elevation, or, more correctly, it should not be lowered by external causes, during the combustion of the hydro-carbon gases, in order to effect the union of the carbon element with its full proportion of oxygen. In chemical order, the hydrogen discharges the associated carbon, and unites with oxygen; by this union intense heat is generated, which envelopes the separated carbon-particles, and raises them to a white heat. Becoming thus luminous, and being the matter of flame, the carbon, in its intensely heated state, is prepared to unite with its saturating proportion of oxygen, and the union is effected the instant they meet, should the carbon retain its temperature until it gets into contact with oxygen. Upon this contingency depends the final condition of the precipitated carbon, whether as unburnt, uncombined particles, the colouring matter of smoke, or as the product of combustion, carbonic acid. Should the carbon-particles miss the opportunity of uniting with oxygen whilst yet at the high temperature which qualifies them to unite, it becomes practically impossible to restore them to the combining condition, and they inevitably pass away as smoke.

It follows, further, as a condition essential to the complete combustion of coal, that the combustible gases should be thoroughly mixed with their supply of air. When the streams or columns of hydro-carbon gases rise, undisturbed or unbroken, from the body of the fuel, they are decomposed in bands or films at what may be conceived as their surfaces of contact, when the oxygen of the surrounding air unites, in the first place, with the hydrogen of the decomposed distillation, and, in the second place, with the carbon-particles. So far the combustion is complete. Watery vapour and carbonic acid are generated as the results of the union of the distilled gases and the oxygen. At this stage, however, a contingency arises, and a partial re-action may ensue; for in the ordinary course of the circulation of the gases, the film or stratum of burnt gas mixes with and loses itself amongst the neighbouring hydro-carbon gases, and should there not be present a sufficiency of fresh atmospheric oxygen to continue the combustion in that quarter, the newly formed carbonic acid would be attacked by the hydrogen of the hydro-carbon, and resolved into its elements, of which the oxygen would be appropriated by the hydrogen, and the carbon would be re-precipitated simultaneously with the carbon separated from the newly formed hydrogen. It may be observed, however, that notwithstanding such occasional action and re-action to which the carbon is subjected, and chargeable to the superior affinities of the associated hydrogen, the carbon may be in condition, as at first, to again unite with oxygen, and to be ultimately and completely burned:—in the condition, namely, of a sufficiently elevated temperature. It is clear that a continuous process of intermixture is necessary to the completion of the combustion of coal, bringing together successively fresh portions of the combining elements, and throwing the separated carbon in the way of fresh oxygen for its own proper combustion.

The complication that usually characterizes the burning of coal is, then, both physical and chemical; physical, be-

Physical Conditions of the Combustion of Coal.

cause an intimate mixture, and a suitable proportion of the elements concerned, is essential to the completeness of their conversion; chemical, because, unfortunately for the special object of the furnace, which is to generate heat, the least important element, hydrogen, is precisely that which commands the preference, and must have its share of oxygen before the claims of the staple element, carbon, can be really entertained and satisfied. The hydrogen must be driven off before the main business of the furnace commences. The occasional presence of oxygen and nitrogen in considerable quantity further complicates the process, as they must be volatilised and driven off in the due course of distillation.

Nevertheless, both coal and coke are, in good practice, effectually burned in furnaces properly formed. The completeness of the combustion of coke in locomotive boilers has been proved by chemical and by mechanical analysis. The combustion of coal has been for many years diligently studied and practised by Mr Charles Wye Williams, and has been by him reduced to successful and varied practice. His leading principle, as published in his *Treatise on the Combustion of Coal*, is the introduction of air above the fuel, to mix with and consume the combustible gases, on the principle of the argand lamp, through a great number of small orifices in the furnace-door, or at the bridge, or otherwise. In its application, of course, the details are various, and in some classes of furnace having powerful draught, as locomotive fire-boxes, it has not been found necessary to subdivide the air so minutely as Mr Williams' practice indicates.

On the system of steam-inducted air-currents, the air is introduced in several streams, which, when necessary, are propelled into the furnace amongst the smoke, by means of jets of steam properly directed through the apertures, which are quite efficient in effecting the object.

There is an opinion that there is advantage in burning fuel in furnaces with long flues, slightly moist, and that ash-pits should be supplied with water, from which steam may be generated by the radiant heat from the fire, and passed through the grate. There is no actual gain of heat by this expedient; but it may be that the radiant heat, otherwise lost, is utilised in making steam, which may increase the efficiency of the fuel. The access of water to the fuel lessens the "glow-fire" or flameless incandescent fuel, and increases the quantity of flame by forming carbonic-oxide and hydrogen gases in its decomposition into its elements, oxygen and hydrogen, and the reduction by the oxygen of the carbonic acid already formed in the furnace. The presence of moisture, even in coke, creates flame, and reduces the intensity of the heat in the "glow-fire;" on the same principle of deferred or distributed combustion, moist bituminous coal is found to be most effective in furnaces with long flues, as in Cornish boilers, where they are 100 or 150 feet in length. These considerations point to the distinctive qualifications of coke and coal in furnaces. Whilst, under steam-boilers, coal and coke may be rendered equally efficient in the generation and communication of heat, per pound weight; on the contrary, it has been found, as recorded by Mr Apsley Pellatt, who gives the results of many years' practice, that in glass furnaces, where intense local heat is required, 13 cwt. of coke is practically equivalent to 21 cwt. of coal. Coke is of the most effective value where local intensity of heat is needed, as in glass furnaces, and in others with short flues and rapid draft, where the flame cannot be used. Coal is generally more effective where carried heat is in demand, the process of combustion being deferred and distributed, and the active development of flame and heat being sustained in the flues; and the benefit of a limited proportion of moisture in the coal depends upon the length of the flues and the time allowed for combustion, when the heat taken up in the glow-fire is given out again in the flame.

Efficiency of Steam-Boilers.

The circumstances under which coal is burned under steam-boilers are as various as the qualities of coal itself. The rate of combustion varies from 2 lbs. to 120 lbs. of fuel per square foot of fire-grate surface per hour; the combustion may be equally perfect for all rates, and in good practice it is so. The rate depends chiefly on the strength of the draught, which, if by chimney, does not, at its best, enable the furnace to consume above 30 lbs. of coal per square foot of grate per hour. For higher rates of combustion, the blast-pipe or the fan is employed. The rates of combustion in boiler furnaces may be thus classified:—

	lbs. per Square Foot per Hour.
1. The slowest rate of combustion in Cornish boilers with Welsh coal	2 to 2½
2. The slowest rate of combustion in Cornish boilers with Newcastle coal	4
3. Factory boilers	12 to 16
4. Marine boilers	16 to 24
5. Dry coal, quickest rate	20 to 23
6. Caking coal, „	24 to 27
7. Locomotives	40 to 130
8. Do. ordinary variations	50 to 100

The temperature of the products of combustion at the instant of their formation varies of course with the quantity of cold air in dilution. Professor Rankine estimates the temperature to be as follows:—

	Carbon.	Olefiant Gas.
Fuel, undiluted with air	4580°	5050°
If diluted with an excess of half the air consumed	3215°	3515°
If diluted with an excess equal to all the air consumed	2440°	2710°

The temperature of the escaping products of combustion in the chimney does not usually exceed 600° Fahr.; it is frequently lower, occasionally not above 300°, and at times barely sufficient to boil water. But this sort of excellence is not to be found except with the largest class of boilers and the slowest combustion. In passenger-locomotives on ordinary duty, the temperature usually rises to 600° and upwards, and in goods locomotives it probably reaches to 1000°.

CHAP. V.—THE EFFICIENCY OF STEAM-BOILERS.

Of the total heat of combustion of fuel, perfectly consumed in the furnace, a portion is absorbed through the heating surface of the boiler, and the remainder passes off without being utilised in the formation of steam. The proportion of utilised heat, or the efficiency of the boiler, varies with every circumstance, but it is regulated chiefly by the area of the fire-grate, the area of the heating surface, and the rate of combustion per unit of grate-surface, say per square foot of grate. If the grate be large and the combustion slow, a greater extent of heating surface is necessary to insure the same efficiency, than if the grate were small and the combustion quick, supposing in the two cases the same total quantity of fuel be consumed per hour. The reason is, that the intensity of combustion increases with the rate at which it proceeds per square foot of grate, the general temperature is higher, as there is a less excess of air in dilution, the radiant heat is also greater, and consequently there is a more rapid absorption of heat into the boiler. The importance of the last condition as to radiant heat is proved by the experiments of Peclet, who found that more than half of the heat of incandescent fuel is radiated from the mass. The relative proportions of the grate area, the heating surface, and the rate of combustion, constitute a question of great practical importance. It was investigated with respect to locomotive-boilers, and the results published in *Railway Machinery*, in 1852, and also in the *Proceedings of the Institution of Civil Engineers*, in 1853, when it was shown that, in order to insure the same efficiency, the following rela-

Efficiency of Steam-Boilers.

tions must be observed:—1*st*, For a given area of grate, the total hourly consumption of fuel should vary as the square of the total heating surface; that is to say, for example, if the heating surface were doubled, the total consumption of fuel might be increased to four times, whilst the same evaporative efficiency would be maintained. 2*d*, For a given extent of heating surface, the total hourly consumption should vary inversely as the area of grate; for example, if the grate-surface were increased to twice the area, the total hourly consumption of fuel should be absolutely reduced to one-half, in order to maintain the same efficiency. 3*d*, For a given hourly consumption of fuel, the area of fire-grate will vary as the square of the heating surface, in maintaining the same efficiency; for example, if twice the heating surface be employed, the grate may be extended to four times; conversely, if half of the heating surface be removed, the grate must be reduced to one-fourth of its area.

The mutual relations of heating surface, grate-area, and consumption of fuel, thus announced, are remarkable; and they bear upon the well-known sensitiveness of furnaces to superfluous enlargement of grates, in the reduction of efficiency. For it appears, that if a grate be doubled in area, only half the fuel can be burned on it, and only half the steam generated, if the same degree of efficiency, or evaporative power of the fuel, is to be maintained; so that only a fourth of the fuel can be, with equal utility, burned upon a square foot of the enlarged grate. It is apparent, then, that a superfluous size of grate is detrimental to the power of the boiler, unless at a sacrifice of fuel. On the contrary, an extension of heating surface adds in a still greater proportion to the power of the boiler, whilst the same efficiency of fuel is maintained. The general equation embodying these relations is,

$$F = C\frac{H^2}{G},$$

in which F=the quantity of fuel consumed per hour, H= the area of heating surface, G=the area of fire-grate, and C=a co-efficient, which is constant for similar boilers, but may vary for different kinds of boilers. Let the fuel be expressed in pounds, and the areas in square feet, and let the efficiency be represented by the evaporation of 9 pounds of water per pound of fuel, then the constant for locomotive-boilers, burning good coke, is equal to ·0154, and the formula becomes

$$F = \cdot 0154\frac{H^2}{G}.$$

Assuming 10 square feet area of grate, the hourly consumption of fuel, for different heating surfaces, capable of evaporating 9 lb. of water per pound of coke, are as follow:—

Area of Grate.	Area of heating surface.	Consumption of coke per hour. Efficiency=9 lb. of water per lb. coke.
Square feet.	Square feet.	lb.
10	450	312
10	500	385
10	600	554
10	700	755
10	800	985
10	900	1247

If the consumption be expressed at per unit of grate area, one square foot, the expression in the general formula becomes

$$F_1 = C\frac{H^2}{G^2} = C\left(\frac{H}{G}\right)^2 = Cr^2,$$

in which r = the ratio of the heating surface to the grate, and showing that the consumption of fuel, for constant efficiency, per square foot of grate, varies as the square of that ratio; in which case the formula for locomotives, as before, is

$$F_1 = \cdot 0154\, r^2.$$

The relative consumption of water evaporated is nine times the weight of coke, or $\cdot 0154\, r^2 \times 9 = \cdot 1384\, r^2$. The following are examples of the relative quantities, reduced to units of measure:—

Ratio of heating surface to fire-grate.	Consumption of coke per square foot of grate per hour.	Evaporation of water per square foot of grate per hour.		Evaporation of water per square foot of heating surface per hour.
Grate=1.	lb.	lb.	Cubic feet.	lb.
45	31	280	4·5	6·2
50	38	346	5·6	6·9
60	55	498	8·0	8·3
70	75	678	10·9	9·7
80	98	886	14·0	11·1
90	125	1121	18·0	12·5

This statement shows how very much the active value of the heating surface, per unit of its area, in evaporating water with the same degree of efficiency, may be increased by relatively reducing the grate, or by extending the heating surface itself. These results are based upon the conditions of the ordinary locomotive-boilers, with fire-box and small flue-tubes, about 2 inches diameter, and with sufficient clearance between the tubes, say ⅝ or ¾ inch for 160 tubes, and, of course, under good management. The same proportions stand good for coal in the locomotive. The evaporative standard of 9 lb. of water per pound of fuel is assumed, which would be equivalent to the utilisation of, say, 10,000 units of heat per pound of fuel, or about ⅘ths of the total heat of combustion. For other evaporative standards, though, no doubt, the same general equation is appropriate, different co-efficients would be required; and with respect to locomotive-boilers, it may only now be remarked, that, generally, within certain limits, the greater the rate of combustion on a given area of grate, with a given heating surface, the less is the evaporative efficiency. In locomotive boilers, an evaporative efficiency of above 10 lb. of water per pound of fuel has been attained. It must be admitted, however, that in general practice, an evaporation of only 8 lb. of water per pound of fuel is effected; and the efficiency fluctuates within the ordinary limits of 7 lb. and 9 lb. per pound of fuel. In locomotive practice the fuel is very commonly consumed at a rate varying from 60 lb. to 80 lb. per square foot of grate; but it descends as low as 40 lb. per foot of grate, with passenger-trains, and amounts to 100 lb., 120 lb., and even above that, per foot of grate per hour, in working goods-trains.

It follows, that the "long-boiler" type of locomotive-boiler, introduced and made by Messrs Robert Stephenson and Co., with a moderate grate, and long flue-tubes, is in general the most efficient in evaporative performance.

The general equation of efficient evaporative power is applicable to all classes of boilers, the value of the co-efficient probably differing for each class, and, of course, for each sort of fuel. The doctrine is powerfully illustrated in the practice of Cornish boilers, in which, with very large grates, the rate of combustion, as practised in Cornwall, is only from 2 to 4 lb. of fuel per square foot of grate. It is by slow combustion, they say, that they obtain their economical results, namely, a high evaporation of water—about 10 lb. per pound of coal. The system, of course, demands immense boilers, with long flues and extensive heating surface, to absorb at leisure the heat produced so languidly from the grate. The very low rate of combustion practised is in accordance with the nature of the fuel, commonly in small pieces, and in the form of dross; it requires to be deposited in layers on the grate and left undisturbed, so as to burn off gradually and uniformly. If forced, or disturbed, the smoke is disengaged, and there is a loss of efficiency.

Strength of Steam Boilers.

Thus there is a necessity for a large grate, in order to effect the complete combustion of the fuel; and there is a necessity for a large boiler and extensive surface, in consequence of the large grate, in order to absorb the heat.

Professor Rankine has announced the following approximate formula for expressing the efficiency of a furnace:—

$$\frac{E'}{E} = \frac{BS}{S + AF},$$

in which E denotes the theoretical evaporative power, and E′ the available evaporative power of 1 pound of a given sort of fuel; S the area of heating surface in square feet per square foot of grate, and F the number of pounds of fuel burned per foot of grate per hour; A, a constant, which is to be found empirically, probably proportional approximately to the square of the quantity of air supplied per pound of fuel; B, an empirical constant. In applying the formula to different classes of boilers, different values of A and B are proposed; for locomotive-boilers Professor Rankine computes the values of S and F from Mr Clark's formula, and arrives at near approximations for rates of consumption of about 60 lb. of fuel per square foot of grate per hour.

With respect to forcing a boiler, that is, urging the fire by frequent stirring and poking, discharging smoke and wasting fuel—a practice strongly deprecated by Mr Fairbairn—Professor Rankine justly observes that "the economy of fuel depends very much on the proper adjustment of the rate of combustion per square foot of grate to the draught of the furnace;" and that "it is best, in practice, to make the grate-area at first rather too large, and then to contract it by means of fire-bricks, until the smallest area is obtained upon which the required quantity of coal can be burned without incomplete combustion."

CHAP. VI.—STRENGTH OF STEAM-BOILERS.

English boiler-plates of iron are usually classed as Yorkshire plates, and Staffordshire, indicating the localities where they are manufactured. Cast-steel plates, also, are successfully manufactured of great strength, tenacity, and toughness; and good boilers may be made of that material. American boiler-plate appears to be made generally of superior quality. The following are the average ultimate tensile strengths of boiler-plate; that is to say, the weights necessary to tear the material asunder, per square inch of section:—

	Per square inch.	
Yorkshire iron plate, best quality	25	tons.
Staffordshire iron plate, do.	20	„
American iron plate, do.	31	„
Do. do. ordinary	27	„
Cast-steel plates	40	„

The breaking or ultimate tensile strengths of welded and riveted joints, making that of the solid plate = 100, are as follow:—

1. The solid plate	100
2. Scarf-welded joint	100
3. Double-riveted double-welt joint	80
4. Double-riveted lap-joint	72
5. Lap-welded joint	66
6. Double-riveted single-welt joint	65
7. Single-riveted lap-joint	60

It thus appears that scarf-welded joints are equal in strength to the solid plate, and that lap-welded joints, or such as have the edges of the plates merely superposed, have only $\frac{2}{3}$ds of the strength. Double and single riveting, as the terms imply, signify the union of two plates by two rows or by one row of rivets, respectively. A welt is a band of metal applied over the seam on one side; a double-welt is applied on both sides. The above proportions are to be accepted as correct, for plates not exceeding $\frac{3}{8}$-inch in thickness; for thicker plates the relative strengths are smaller, and in some cases thicker plates are positively weaker at the joints than thinner ones. The "working strength" is measured by the maximum strain prescribed by cautious engineers for practice, and does not usually exceed one-sixth of the ultimate strength, though occasionally one-fifth.

To apply these data for finding the strength of a cylindrical boiler—for example, one of 6 feet in diameter, and Staffordshire plates $\frac{3}{8}$-inch thick; the strength is to be expressed in lbs. per square inch. The united thickness of two opposite sides of the boiler is $\frac{3}{8} \times 2 = \frac{3}{4}$-inch, and there is $\frac{3}{4}$ square inch sectional area of metal to resist the strain on 1 inch length of the boiler. The ultimate strength of Staffordshire plate is 20 tons per square inch, or 15 tons on $\frac{3}{4}$ square inch. In 6 feet diameter there are 72 inches, and 15 tons $\div$ 72 = 466 lb. per square inch, the ultimate strength of the solid metal of the boiler expressed in steam-pressure; and 466 $\div$ 6 = 78 lb. per square inch, the working strength of the solid metal. If the plates be united by single-riveted lap-joints, of which the strength is only 60 per cent. of that of the solid plate, then $78 \times \frac{60}{100} = 47$ lb. per square inch is the working pressure per square inch.

Large iron tube flues are not capable of resisting so great a pressure externally against a collapse as they can bear internally, and they require careful staying to prevent collapse. Mr Fairbairn has worked out that question successfully, and he finds that the power of resistance of a plain tube to external pressure varies inversely on the unsupported length of the tube, inversely on the diameter, and inversely on the square of the thickness. The application of angle-iron ribs for stiffening long flues, recommended by Mr Fairbairn, is shown in his double-flue boiler, already described, Plate XX.

Ruptures and Explosions of Boilers.

CHAP. VII.—RUPTURES AND EXPLOSIONS OF BOILERS.

A steam-boiler fails, when the internal pressure of the steam overpowers the strength of the boiler to withstand the pressure. The boiler is said to rupture when the failure is not accompanied by a sudden or extraordinary development of elastic force; the material of the boiler giving way, by cracking or splitting open, and affording an outlet for the contained water and steam. The boiler is said to explode when the failure is accompanied by an extraordinary development of elastic force; the boiler being rent and torn asunder at strong places and weak places, frequently without distinction. When merely ruptured, a boiler rests in its place; when exploded, it is usually torn from its bed and projected—more or less entire, or in fragments—to considerable distances from its bed, carrying with it, or repelling, whatever opposes its progress, moving large masses, and affording other evidences of the enormous power suddenly developed as a consequence of the failure of the boiler. Various theories of explosions have been proposed; but though, to a greater or lesser extent, they serve to explain special phenomena, yet, by none of those hitherto proposed has the essential distinction between ruptures and explosions been accounted for. Many of them are based upon considerations derived from the sciences of electricity, magnetism, and chemistry:—electrical discharges, and the decomposition of steam into its elementary gases, oxygen and hydrogen; and the subsequent explosion of the hydrogen. Suffice it for the present to say, that discharges of electricity have only been proved to take place outside boilers, not inside; that steam can only be decomposed at a temperature equal to that of iron at a white heat, and that when decomposed, the oxygen unites with the material of the boiler, forming a metallic oxide, and the hydrogen alone remains. But without a sufficient combining equivalent of free oxygen, which is nowhere to

Ruptures and Explosions of Boilers.

be had within a boiler, an explosion of hydrogen cannot take place.

The ordinary explanation of explosions assign them to original weakness of boilers; to weakness produced by gradual corrosion of the material of which the boiler is made; to wilful or accidental obstruction or overloading of the safety-valves; to the sudden production of steam of a pressure greater than the boiler can bear, in a quantity greater than the safety-valve can discharge, of which the primary cause is said to be the overheating of a portion of the plates of the boiler, uncovered by water, and exposed to the intense heat of the furnace, so that a store of heat is accumulated, which is suddenly expended when water is suddenly placed in contact with the overheated plates, in the production of a large quantity of steam at a high pressure. These arguments, of course, point generally to the existence of overpressure—excessive with relation to the strength of the boiler to resist it, as the general cause. Mr Fairbairn, in his *Useful Information for Engineers*, takes the same view of the causes of the failure of boilers. The argument of simple overpressure, however, backed by the weighty authority of Mr Fairbairn, fails to explain the generic distinction between the causes of ruptures and those of explosions.

The essential distinction appears to be indicated by the symptoms, namely, the non-production of extraordinary elastic force in the case of ruptures, and the obvious production of it in the case of explosions. The phenomena of explosions are to be ascribed *to the projectile force acquired by the particles of water and steam within the boiler*, by reason of the suddenly developed expansive force of the steam, spontaneously generated in the boiler, concurrently with the sudden fall of pressure produced by the sudden escape of steam from the boiler, at the locality of the original failure; or by its enlargement of volume from any cause, as the collapse of a flue, for example. The particles of water and steam are projected against the shell of the boiler at an enormous velocity, like as many bullets, or small shot, making up in velocity what they want in mass or weight; and they communicate their centrifugal momentum to the material of the boiler, necessarily straining it, and when powerful enough, tearing it asunder, and thus effecting an explosion. Space, or latitude, is required for the generation of such projectile velocity, and the momentum due to the velocity; and if the water were confined within tubes entirely filled by it, there would be no projection of particles, and no explosive momentum, until the level of the water descended below the point of rupture, which explains the fact of the greater safety of water-tube boilers. The action of the projectile force in question is manifested by the bulging outwards of the flue-tubes usually to be observed in exploded locomotive boilers, due to the sudden generation of steam amongst the tubes; and the new theory affords an explanation of the frequent explosions of boilers that occur immediately after the starting of the engine, when, in the first place, the pressure in the boiler is lowered by the sudden admission of steam to the engine, and its rapid consumption by condensation in blowing through condensing engines, succeeded by the immediate spontaneous generation of fresh steam, and a discharge of projectiles within the boiler. The famous explosion on board the Great Eastern steamship may be similarly explained: the feed-water heater consisted of a cylinder surrounding the chimney, forming an annular space, filled with water and steam at a high temperature and pressure. The chimney, being unstayed, collapsed like a flue, under the pressure on its outer surface, and thus occasioned a sudden enlargement of volume within the heater, and a simultaneous reduction of pressure; the steam suddenly and spontaneously generated, expanded against the collapsed flue, and rebounded on the casing, projecting water with it; the moving mass of steam and water thus suddenly arrested, expended its momentum on the casing, and rended it asunder.

Explosions are probably in many cases preceded by ruptures. Circumstances determine whether a rupture shall be followed by an explosion. The limits of this article forbid the extended discussion of such circumstances, but perhaps the occurrence of an explosion, in ordinary cases, mainly depends upon the locality of the rupture, *under water*, or *above water*. If under water, water only is expelled, causing very little enlargement of volume, reduction of pressure, or internal commotion, and therefore unlikely to incur explosion. If, on the contrary, the rupture takes place above water, steam issues with the enormous velocity due jointly to its comparative lightness and its tension—1800 to 2000 feet per second—which, of course, would cause the evacuation of the steam-room of an ordinary boiler instantaneously through a very small opening, and, therefore, an instant fall of pressure and an instant generation of steam, and the projection of water and steam at the rate of many hundred feet per second within the boiler.

This new theory, which may be called *the projectile theory of explosions*, is susceptible of a variety of illustrative, collateral, and confirmatory evidence; and whilst it is compatible with other and more partial theories, it serves to account for much that remains otherwise unexplained, with respect to the various forms of the failure of boilers.

For the prevention of explosions, proper precaution must be exercised in the choice of materials, and the design and construction of the boiler. It should be subjected to frequent and careful inspection, and should have a sufficiently free action of the safety-valves, one or more of which should be placed beyond the control of attendants, and should suffice to liberate surplus steam sufficiently freely to prevent an excessive rise of pressure, under all ordinary circumstances. The sudden production of steam, in excess of the ability of the safety-valves to discharge the surplus, is most likely to be prevented by avoiding the forcing of the fires, which makes the boiler produce steam faster than the rate suited to its size and surface; by a regular, constant, and sufficient supply of feed-water; and by abstaining from the sudden introduction of feed-water, should the plates have become overheated, which would produce an explosion, and by drawing the fires, so as to allow the boiler and its contents to cool down, before refilling it with water.

CHAP. VIII.—DEPOSITS IN BOILERS.

Deposits in Boilers.

The impurities of the feed-water are precipitated and deposited on the internal surface of a boiler; sometimes as a hard crust of the minerals contained in the water, chiefly sulphate of lime; sometimes as mud or sediment, which settles loosely. Hard deposits, by resisting the conduction of heat, impair the efficiency of the boiler, as well as its durability and safety; and they may be prevented, either by administering chemical re-agents with the water, neutralising the ingredients of the water, or converting them into innocuous or loose compounds, which fall as sediment; or, what is better, by purifying the water before it is admitted into the boiler. The practice of surface-condensation in steam-engines, by which the condensed steam may be collected and returned to the boiler, insures a supply of pure water. (D. K. C.)

(Besides the authorities mentioned in the body of the foregoing article, the following have been consulted:—*The Engineer; Proceedings of the Institution of Mechanical Engineers;* Bourne's *Catechism of the Steam-Engine.*)

STEAM NAVIGATION.

Steam Navigation.

Of all the triumphs of man's ingenuity for which this age is so remarkable, none, perhaps, has conduced more to the wellbeing and happiness of the human race than the art of Steam Navigation. This is apparent when we consider the vastly extended means of communication which we now enjoy with the most distant parts of the globe; the fresh impulse given to commercial undertakings by the rapidity, the safety, and the certainty of steamships, as compared with sailing-vessels; and the increasing spread of civilization and Christianity attendant upon our intercourse with distant and semi-barbarous nations. It is not wonderful, therefore, that the merit of having invented an art so pregnant with interest to mankind should be claimed for many different individuals; and we accordingly find the names of ingenious men of all countries associated, more or less, with its origin.[1]

Paddle-wheels used by the ancients.

The use of paddle-wheels, propelled by manual or animal power, dates back to a very remote period, these having been employed by the ancient Egyptians, the Romans, and other nations of antiquity, for propelling their war-galleys; but it is doubtful whether any advantage was thus obtained in economy of labour, as compared with the use of oars. It is not, therefore, until the gradual development of the steam-engine, and its introduction as a motive power, that we can hope to find any advancement in the long-sought-for art of navigating ships against adverse winds and currents. The first historical notice we meet with of such a combination—a steam-engine placed on board a vessel to act as the propelling agent—occurs in the year 1543, when we are informed that Blasco de Garay, a sea-captain in the service of Charles V. of Spain, succeeded in propelling a ship of 200 tons burthen in the harbour of Barcelona, at the rate of a league (or three miles) an hour. No information is afforded us of the nature of his apparatus, except that it comprehended a boiler, which, it is stated, was liable to burst; that the power was transmitted through paddle-wheels, and that the vessel could be turned with much facility by means of the apparatus. We can only speculate as to the nature of this mysterious engine, but it seems probable that it owed its efficacy to the reaction of a jet of high-pressure steam, on the same principle as that famous classical toy, the Æolipile of Hero, invented B.C. 120. Notwithstanding that the scheme was commended by the emperor and his ministry, and its author promoted, we do not read of any second experiment being made, or of any further notice being taken of the invention. We may assume, therefore, that in this case the propelling power was found to be insufficient and unsatisfactory, and the experiment was worthless in its result.

Blasco de Garay, 1543.

In the year 1630, David Ramsey, "page of the king's bed-chamber," obtained a patent "*To make boats, ships, and barges goe against the wind and tyde*," but we do not hear of any experiments having been made by him. The patent office contains records of various similar suggestions made between the years 1630 and 1681, but nothing of any practical value appears to have been effected. At the latter date the ingenious Dr Papin, a Frenchman, described a method of propelling a vessel by steam. The only engine then known, however, being itself so crude and imperfect, the doctor experienced so much difficulty in reducing his scheme to practice, that it is believed no actual trial of it ever took place. His principal difficulty lay in obtaining the required rotatory motion from the reciprocating one of the piston, for which purpose he proposed to employ two cylinders, the piston of one of which should be ascending, while that of the other should be descending, the continuous rotative motion being obtained by means of racks attached to the extremities of the piston-rods, working *alternately* into a pinion on the paddle shaft. Although Dr Papin's schemes can only be viewed in the light of theoretical suggestions, he still deserves much credit both for his idea of the atmospheric engine, and for his proposal to employ it for working the paddles of a boat. Savery, on the other hand (who published his *Miner's Friend* in the year 1698), although a great actual improver of the steam-engine, and famous in his day as a clever mechanician, appears to have doubted the applicability of his engine to the propulsion of ships, since he only alludes cursorily to the possibility of such a thing.

Dr Papin, 1681.

Newcomen, 1705.

In the year 1705 Newcomen, having adopted Papin's suggestions of the cylinder and piston, and Savery's method of condensation, first completed the atmospheric engine, and made it *capable* of becoming, in practical hands, an efficient propelling power; and it is worthy of remark, that even at the present day, we have several excellent paddle-wheel steamers which are most satisfactorily propelled by modern atmospheric engines, constructed by the late Mr Seaward. The great engineering difficulty at this period was how to convert the reciprocating motion of the piston into the rotary motion of the shaft; for although, to our eyes, the *crank* may appear a very simple and almost self-evident expedient for this purpose, it was not till long afterwards that we find it introduced.

In the year 1730, Dr John Allen proposed to propel a vessel by the re-action of a jet of water forcibly expelled from the stern—a scheme which has been repeatedly revived since his time, and which has recently been attended with a considerable amount of success in the hands of Mr Ruthven of Leith. Six years after Dr Allen's proposal, Jonathan Hulls obtained a patent for his "*Invention of a machine for carrying ships and vessels out of or into any harbour or river against wind and tide, or in a calm.*" His idea of a steam-boat was as follows; and however we may now be inclined to smile at his rude mechanism, in comparison with the beautiful machinery of a steamship of our own times, Jonathan Hulls undoubtedly deserves much credit for his ingenuity. In his boat two paddle-wheels were suspended in a frame projecting from the stern. In the body of the boat were two steam cylinders, whose pistons acted on the atmospheric principle; that is to say, they were impelled in one direction only, by the pressure of the atmosphere acting against a vacuum. To each piston one end of a rope was fastened; the rope was then carried round a grooved wheel or pulley on the corresponding paddle-wheel, the other end of the rope being allowed to hang free, with a weight attached to it. When one of the pistons descended in its cylinder by the pressure of the atmosphere, it pulled its rope, and consequently moved round the paddle-wheel in a degree due to the length of the stroke and the diameter of the pulley. While the piston was ascending in the cylinder, on the re-admission of the steam, the counter-balance weight at the end of the rope dragged the pulley round in the contrary direction; but the pulley being attached to the paddle-wheel by

Jonathan Hulls, 1736.

[1] The historical portion of this article is indebted to Professor B. Woodcroft's *Sketch of the Origin and Progress of Steam Navigation* for some valuable facts.

Steam Navigation.

ratchet-work, it was so arranged that the paddle-wheel remained stationary during the retrograde motion of the pulley. There being two cylinders and two paddle-wheels in the boat, one would be in motion whilst the other was stationary, and thus a continuous progressive movement was given to the boat. It is uncertain whether this plan was ever put in practice.

James Watt, 1780.

We now arrive at the era of James Watt, whose inventive genius removed most of the obstacles which had hitherto prevented the steam-engine from being effectively employed for propelling vessels. His main improvement, after his invention of the separate condenser, was the substitution of the double-acting in place of the single-acting or atmospheric engine, by which means the power of an engine of given size and weight was at once doubled, while the motion was at the same time rendered more uniform. About this time also (1780) the crank and fly-wheel were first patented by James Pickard. Although Watt's improvements rapidly paved the way for the successful adaptation of the steam-engine to the purposes of navigation, we do not find that he himself devoted much attention at first to this subject, confining his views to perfecting the rotatory-engine, and increasing its economy. Accordingly, we find that it was not till after the expiry of their patent in 1800 that Boulton and Watt's engines were applied to this use.

In the year 1781, the Marquis de Jouffroy constructed a steamboat at Lyons of the following dimensions:—140 feet long, 15 feet beam, and 3·2 feet draught of water. His experiments, which were made in the river Soane, were probably unsuccessful, as the subject was allowed to drop.

Leaving undescribed some abortive attempts of Ramsay and Fitch in America, and Serrati in Italy, which were attended with no practical result, we pass on to the first really successful attempts at steam navigation, which were made in 1788 by a Scottish gentleman, Patrick Miller of Dalswinston, in Dumfriesshire. Having previously experimented with boats propelled by the power of men and horses applied to paddle-wheels, he resolved to make the steam-engine do this work; but neither he nor Mr James Taylor, who resided in his family as tutor, and assisted him in his experiments, could devise a plan for applying the engine. In this dilemma Taylor suggested that they should call to their assistance an old schoolfellow of his, Mr William Symington, an engineer, at that time employed in endeavouring to adapt the steam-engine to wheeled carriages. Mr Miller accordingly saw Symington in Edinburgh, and, after examining the model of his locomotive carriage, was convinced of the perfect applicability of a similar engine to drive the paddle-wheels of a boat, and gave orders for one to be made under the direction of Symington and Taylor. This engine was accordingly made in Edinburgh, sent to Dalswinton, and put together by them in October 1788. The engine, in a strong oak frame, was placed on one side of a twin, or double pleasure-boat, on Dalswinton loch; the boiler was placed on the opposite side, and the paddle-wheels in the middle. In the same month of October the machine was put in motion, and the inventors had the gratification of witnessing the perfect success of their efforts. Although the cylinders of their engine were but 4 inches in diameter, this first steamboat attained a speed of 5 miles an hour on the waters of the lake.

Miller of Dalswinton, Taylor, and Symington, 1788.

Mr Miller, being now desirous of trying the experiment on a larger scale, commissioned Mr Symington to purchase one of the canal-boats employed on the Forth and Clyde Canal, and to have suitable engines constructed for her at Carron Ironworks. When this new machinery was ready, a trial took place on a straight reach of the canal of about 4 miles in length, on the 26th of December 1789, when the vessel moved at the rate of about 7 miles an hour. Many other experiments followed with a similar result, and the following notice of them was sent by Lord Cullen to several of the Edinburgh newspapers:—

"It is with great pleasure I inform you that the experiment which some time ago was made upon the great canal here by Mr Miller of Dalswinton, for ascertaining the powers of the steam-engine when applied to sailing, has lately been repeated with great success. Although these experiments have been repeated under a variety of disadvantages, and with a vessel built formerly for a different purpose, yet the velocity acquired was no less than from $6\frac{1}{2}$ to 7 miles an hour. This sufficiently shows that, with vessels properly constructed, a velocity of 8, 9, or even 10 miles an hour may be easily accomplished, and the advantages of so great a velocity in rivers, straits, &c., and in cases of emergency, will be sufficiently evident, as there can be few winds, tides, or currents which can easily impede or resist it; and it must be evident that, even with slower motion, the utmost advantages must result to inland navigation."

Although these experiments were thus partially successful, and their value well understood and appreciated, we find that Mr Miller's boat was soon afterwards dismantled and laid up at Carron, and nothing further was at that time attempted. This apparent apathy can only be accounted for by the fact (which was afterwards acknowledged by Mr Miller himself), that Symington's machinery at this time was not equal to the task of propelling a boat with the degree of certainty and regularity necessary to insure commercial success. Hence, although the great principle of the possibility of steam navigation was thus apparently settled by Mr Miller's experiments in 1788 and 1789, it was not till the year 1801 that a really practical steamboat was first produced in Scotland. In this year Thomas Lord Dundas, who was well acquainted with Miller's experiments, and who was a large proprietor in the Forth and Clyde Canal, engaged Mr Symington to undertake a series of experiments on this subject, with the view of employing steamboats for towing on the canal in place of horses. The result was the production of the Charlotte Dundas, named after his lordship's daughter, and which, from the simplicity and practical nature of its machinery, may be justly considered as the "first practical steamboat." The superiority of this boat over its predecessors lay in Symington's more judicious arrangement of the machinery, which consisted of Watt's double-acting engine, working a connecting-rod and crank, which turned a single paddle-wheel, revolving in a well-hole near the stern of the vessel. This engine had one horizontal cylinder, 22 inches in diameter and 4 feet stroke. In March 1802 Lord Dundas, Mr Speirs of Elderslie, and several other gentlemen, being on board, the Charlotte Dundas "took in drag," says Mr Symington, "two loaded vessels, each upwards of 70 tons burthen, and with great ease carried them through the Long Reach of the Forth and Clyde Canal to Port-Dundas, a distance of $19\frac{1}{2}$ miles in six hours (being at the rate of $3\frac{1}{4}$ miles per hour), although it blew so strong a gale right ahead that no other vessel on the canal that day attempted to move to windward." Notwithstanding this favourable result, the scheme was doomed a second time to disappointment, in consequence of some of the proprietors of the canal becoming alarmed at the destructive effects of the wash of the steamboat upon the banks. The boat was therefore laid up in a creek of the canal, where it remained an object of curiosity merely for several years. It may be remarked, that this production of Symington's possessed every necessary qualification which is considered requisite, even at the present day, to make a good and useful steamer; and in proof of the confidence it inspired in its own time, we may observe that the Duke of Bridgewater actually ordered eight steamers from Symington for use on the Bridgewater Canal, to be built on the model of the Charlotte Dundas. His grace dying, however, shortly afterwards, this order was never executed.

The Charlotte Dundas, 1801.

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We now arrive at the period when American enterprise stepped in to avail itself of the painful and laborious results of these costly experiments, which although made and perfected in this country, had not yet been turned to good account. About a year after Symington's experiment with the Charlotte Dundas, Fulton, the American engineer, made a similar though less successful experiment on the Seine, for the weight of his engine broke the vessel in two, and the whole went to the bottom. He persevered, however, and in August 1803 he completed another vessel with its machinery. This boat was 66 feet long and 8 feet wide, and moved so slowly that his experiment is described as having been a failure. He afterwards came to Scotland, and saw Symington's steamboat on the Forth and Clyde Canal, his visit being thus recorded by Mr Symington:—

Fulton, 1803.

"When engaged in these experiments I was called upon by Mr Fulton, who told me he was lately from North America, and intended returning thither in a few months, but having heard of our steamboat operations, could not think of leaving this country without first waiting upon me, in expectation of seeing the boat, and procuring such information regarding it as I might be pleased to communicate, observing that, however advantageous such an invention might be to Great Britain, it would be still more valuable in America, where there were so many great navigable rivers. In compliance with his earnest request, therefore, I caused the engine-fire to be lighted up, and, in a short time thereafter, put the steamboat in motion, and carried him 4 miles west on the canal, returning again to the point from which we started in one hour and twenty minutes (being at the rate of 6 miles an hour), to the great astonishment of Mr Fulton and several gentlemen, who, at our outset, chanced to come on board. During the trip Mr Fulton asked if I had any objection to his taking notes regarding the steamboat, to which I made no objection, as I considered the more publicity that was given to any discovery, intended for general good, so much the better; and, having the privilege secured by letters-patent, I was not afraid of his making any encroachment upon my right in the British dominions, though in the United States I was well aware I had no power of control. In consequence, he pulled out a memorandum-book, and, after putting several pointed questions respecting the general construction and effect of the machine, which I answered in a most explicit manner, he jotted down particularly every thing then described, with his own observations upon the boat during the trip."

Fulton having thus obtained what information he could, returned shortly afterwards to America, and, in conjunction with Mr Livingstone, obtained a patent securing to them the prospective advantages of steam navigation in America, by what they were pleased to call "their invention of steamboats." They very wisely got all their machinery from England; so that in the year 1807 the first steamboat in America was launched, and fitted with a pair of engines constructed by Boulton and Watt.

The Clermont, 1807.

This vessel, called the Clermont, though probably fitted with superior machinery to that in Symington's boat, was barely as fast, making under five miles an hour. Her dimensions were 130 feet long, $16\frac{1}{2}$ feet beam, and 7 feet deep; the boiler 20 feet long, 7 feet deep, and 8 feet broad; the steam-cylinder (one only) was 24 inches in diameter, and 4 feet stroke; burthen 160 tons. Her paddle shaft was of cast-iron, with no outer support beyond the sides of the ship. The diameter of the paddle-wheels was 15 feet, the boards being 4 feet long, and dipping two feet in the water. She was subsequently lengthened to the extent of 140 feet keel. In the beginning of the year 1808 the Clermont was placed for regular work on the Hudson River, between New York and Albany, a distance of 125 geographical miles, and was crowded with passengers, her speed after the alteration being at the rate of 5 miles an hour. This was, therefore, the first steamboat that ever ran continuously for the accommodation of passengers, and the first that ever remunerated her owners, and to this the Americans may justly lay claim; but that Fulton was the "inventor" of the present system of steam navigation, as asserted by some American authors, cannot be admitted; nor, indeed, did he "invent" any single improvement in the construction either of the machinery or the vessel. The success of their first steamer induced Messrs Fulton and Livingstone to build two other vessels, the Car of Neptune, of 300 tons, and the Paragon, of 350 tons, also supplied with Boulton and Watt's engines.

Stevens, 1808.

The first person who ever took a steamer to sea was also an American, R. L. Stevens of Hoboken, who had been associated with Livingstone previously to the connection of the latter with Fulton, and had brought his experiments to a successful issue nearly as soon. As Fulton, however, had secured to himself the exclusive privilege of navigating by steam in the state of New York, Stevens boldly took his vessel round by sea from the Hudson to the Delaware. To him are due many of the present peculiarities of American steamers. He it was who first adopted the long stroke; the upright guides for the piston-rod; the beam overhead, raised on a high framework of wood, working above the deck; and the connecting-rod, descending thence to the paddle-shaft, all characteristic of American steamers to the present time. He also improved the form of the American boats, by substituting a fine entrance and run for the old bluff bow and stern, as well as by increasing their relative length to eight or ten times the beam. Stevens is believed to have been the first engineer who constructed a "tubular" boiler, though these did not come into general use till long after his time.

Comet, 1812.

Although steam navigation had been thus early introduced on the American waters, it was not till the year 1812 that the first regular passenger-steamer made its appearance in this country on the Clyde. This was the Comet, built for Mr Henry Bell, the proprietor of the Helensburgh Baths on the Clyde, and who had long been a most zealous advocate of steam propulsion. This little vessel was 40 feet long on the keel, and 10 feet 6 inches beam, propelled by a steam-engine of three or four horse-power, with a vertical cylinder, and working on the bell-crank principle—the engine being placed on one side of the vessel, and the boiler (of wrought iron) on the other. The Comet made her first voyage in January 1812, and continued to ply regularly between Glasgow and Greenock, at a speed of about 5 miles an hour. She was propelled by two small paddle-wheels on each side, each wheel having four boards only. She was afterwards transferred to the Forth, where she ran for many years between the extremity of the Forth and Clyde Canal and Newhaven, near Edinburgh. The distance is 27 miles, which is stated by Mr Bell to have been performed, on the average, in $3\frac{1}{2}$ hours, being at the rate of above $7\frac{1}{2}$ miles an hour.

Henry Bell.

Mr Bell had on several occasions brought his projects for steam navigation under the notice of the British government, but always without success; and it was not till the year 1819 that the admiralty of the day became impressed with the importance of steam-power for towing men-of-war, chiefly through the representations of Lord Melville and Sir George Cockburn. The first steam-vessel in the royal navy was then built, and was also named the Comet. She is still in existence, and measures 115 feet in length, 21 feet in breadth, and draws 9 feet water, being propelled by a pair of engines, by Boulton and Watt, of 40 horse-power each.

But to return to Mr Bell's steamers on the Clyde. The Comet was so successful, that two other steamers, of increased size and power, were constructed; and, in 1814, Mr Cook, of Glasgow, built a fourth, called the "Glasgow," which, in point of power and efficiency, became the standard at that time for river-steamers. The marine engines hitherto constructed had all been applied *singly* in the vessel; but in 1814 Messrs Boulton and Watt first applied *two*

Steam Navigation.

condensing engines, connected by cranks set at right-angles on the shaft, to propel a steamer on the Clyde. This was found to be a great improvement, and thenceforward almost all steamers have been fitted with two engines.

In the year 1815 a small vessel, with a side lever-engine of 14 horse-power, by Cook of Glasgow, made a voyage from Glasgow to Dublin, and thence round the Land's End to London. It then ran with passengers between London and Margate with some success, though encountering great opposition from the Thames watermen.

David Napier, 1818.

In 1818 Mr David Napier, to whom we owe the introduction of British coasting steamers, as well as of steam-packets for our post-office service, first established between Greenock and Belfast a regular steam communication by means of the Rob Roy, a vessel of about 90 tons burthen and 30 horse-power, built by Mr William Denny of Dumbarton. For two winters she plied with great regularity and success between these ports, and was afterwards transferred to the English Channel, to serve as a packet-boat between Dover and Calais. Soon after this Mr Napier had the Talbot built for him by Messrs Wood. She was 120 tons burthen; and when fitted with two of Mr Napier's engines, of 30 horse-power each, this vessel was in all respects the most perfect of her day. She was the first steamer that ran between Holyhead and Dublin. About the same time, also, he established the line of steamships between Liverpool, Greenock, and Glasgow, for which traffic he built the Robert Bruce, of 150 tons, with two engines, of 30 horse-power each; the Superb, of 240 tons, with two engines of 35 horse-power each; and the Eclipse, of 240 tons, with two engines of 30 horse-power each. All these were established as regular coasting traders before the year 1822.

The James Watt, &c., 1822.

In the latter year the steamer James Watt was built by Messrs Wood, to ply between Leith and London. She was the largest steamer that had yet been built, being 448 tons measurement, and fitted with two engines of 50 horse-power each, by Messrs Boulton and Watt. The Soho followed on the same line, and was equally successful. The next great advance made was in 1826, when the United Kingdom was constructed, this vessel having been regarded in her day with as much wonder and interest, from her (so-called) gigantic proportions, as were afterwards the Great Western, the Great Britain, and, more recently, the Great Eastern. The United Kingdom was 160 feet long, $26\frac{1}{2}$ feet beam, and 200 horse-power; the ship being built by Mr Steele of Greenock, and the machinery by Mr David Napier. Prior to this time many improvements had been made in the arrangement and construction of the marine engine by Boulton and Watt, Maudslay and Field, Penn, and others of our eminent mechanical engineers; the expansive action of steam in the cylinder having already been taken advantage of by Messrs Maudslay and Field in their engines, which were also fitted with escape-valves on the cylinders, and other improvements.

The Savannah, 1819.

The first steamer which crossed the Atlantic was the "Savannah," an American vessel, of 300 tons burthen, which arrived at Liverpool in the year 1819, direct from the United States, in 26 days, partly steaming and partly sailing. Being fitted with engines of small power, and the vessel being otherwise unsuited for ocean navigation, this must be regarded rather as a bold experiment (and not a very successful one) than as establishing the practicability of a rapid and regular steam communication between this country and America; for it is only in the combination of these two qualities that the steamship excels the sailing vessel. In 1829 the Curaçoa, an English built vessel, of 350 tons and 100 horse-power, made several successful runs between Holland and the Dutch West Indies. Men of science, however, plainly demonstrated, to their own satisfaction, that the navigation of the Atlantic by steam-power alone was impracticable; and it was not till the Sirius and the Great Western had shown the fallacy of their reasoning, that the public mind was disabused of this idea. The Sirius was not built expressly for transatlantic navigation; she belonged to the St George Steam-Packet Company, and had run with a good reputation between London and Cork. Her tonnage was about 700 tons, and her horse-power 320. She started from London on the morning of the 4th of April 1838, with 94 passengers. Though first in the race, she was only three days in advance; for on the 7th of the same month the Great Western, built and fitted at Bristol expressly for the purpose, followed her. The Sirius arrived at New York on the 22d, being 17 days clear on the passage, and the Great Western (sailing from Bristol) on the 23d, being 15 days. The Sirius again sailed on her homeward passage on the 1st of May, and the Great Western on the 7th of May, and they arrived, the first on the 18th, and the second on the 22d, being 16 and $13\frac{1}{2}$ days respectively. The average speed of the Great Western on this voyage was thus 8·2 knots on her outward passage, and nearly 9 knots on her homeward, reckoning the distance at 3125 knots for the one, and 3192 for the other. She consumed 655 tons of coal going out, having still 205 tons remaining in her coal-boxes upon her arrival at New York. Coming home her consumption was 392, having 178 tons remaining on her arrival at Bristol. Her average daily consumption varied from 27 tons, with expansive gear in action, to 32 tons without it. As the Great Western possesses considerable historical interest, some of her principal dimensions are here subjoined. She was designed and built by Mr Paterson of Bristol, and fitted with machinery by Messrs Maudslay, Sons, and Field of London. She is 212 feet long between the perpendiculars, 35 feet 6 inches beam, and 23 feet 3 inches depth of hold, drawing from 16 to 18 feet of water. Her tonnage is 1340 (builders' O.M.), and her engines (on the side-lever construction) are 440 horse-power. Her cylinders are $73\frac{1}{2}$ inches in diameter, and 7 feet stroke, making 12 to 15 revolutions per minute. Her complete success was doubtless mainly attributable to the fact, that she was especially fortunate both in her designer and in her engineers, who are still, perhaps, the most eminent of the present day in their respective departments.

The Sirius and Great Western. 1838.

The practicability of transatlantic steam navigation being thus triumphantly established, the British Queen, the President, and other large steamships, were built in rapid succession, as well as many steam-vessels of war.

The screw-propeller introduced, 1837.

Up to this time the paddle-wheel was the only propelling agent employed; but in 1837 the rival system of propelling ships by means of the screw-propeller first came prominently into notice, through the successful experiments of Captain Ericsson and Mr F. P. Smith. Captain Ericsson's small vessel, of 45 feet in length, 8 feet beam, and but 2 feet 3 inches draught of water, towed the American ship Toronto, of 630 tons, on the Thames, on the 25th of May 1837, at the rate of $4\frac{1}{2}$ knots an hour, against the tide, as authenticated by the pilot; and also towed the admiralty barge, with their lordships on board, from Somerset House to Blackwall and back, at the rate of about 10 miles an hour. Later in the same year Mr Smith made some very successful trips with his small boat and screw-propeller between Margate and Ramsgate. The next screw-vessel was the Robert Stockton, built in 1839 by Messrs Laird for an American gentleman, who had witnessed Captain Ericsson's experiments. This boat was also perfectly successful; but the Board of Admiralty still failed to recognise the peculiar applicability of this means of propulsion for vessels of war. The next year, however, in 1840, Mr F. P. Smith, having obtained the support of some influential mercantile men, brought out the Archimedes, a screw-vessel of 232 tons burthen and 80 horse-power. The success of this vessel was so complete, that the Admiralty were at length induced

The Archimedes, 1840.

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to make a trial of the screw in the royal navy, and the Rattler was ordered to be built on the same lines as the Alecto paddle-wheel steamer, and to be fitted with engines of the same nominal power. The next screw-steamer worthy of notice was the Dove, an iron boat, constructed under Mr Smith's direction. Her speed, however, proved so unsatisfactory to her owners, that they ordered her to be changed into a paddle-wheel boat; and as it happened that she had been built with very fine after-lines, her constructor unfortunately charged her deficiency of speed to this circumstance, and adopted the theory that full stern-lines were the most advantageous for the action of the screw. The Rattler was now tried; and her trials having fully satisfied the Board of Admiralty, they ordered the construction of several screw-vessels, which were all built with full sterns. This idea having at length been proved, by further experiment, to be erroneous, and that, on the contrary, fine after-lines were absolutely required for the proper efficiency of the screw-propeller, so as to allow of a ready access and escape of the water, the whole of these vessels were deficient in speed, and some of them were altered at great cost.

The Rattler, 1842.

The screw had meanwhile advanced rapidly into favour as an auxiliary power for fast sailing vessels in the merchant service; and more recently it has been extensively employed for full powered steamers of the very largest class (in preference to the paddle-wheel) by several of our great mail-packet companies, the Peninsular and Oriental Company taking the lead in this respect.

The requirements of the great navigable rivers of America have naturally led to the supremacy of that nation in the art of *river* navigation. The description of the large American river-steamer, The New World, given in another part of this article, as a type of her class, will be found both novel and interesting.

This rapid sketch of the rise and progress of steam navigation would not be complete without referring specially to the wonderful development it has lately received in the construction of the Great Eastern, whose giant bulk is even now struggling into life under peculiarly depressing circumstances. In addition to the interest naturally excited by the immense size of this vessel (whose proportions will be given hereafter), she is destined to solve another problem in marine engineering, namely, the desirability of combining screw-propeller and paddle-wheels in the same steamship.

A statistical table is subjoined, showing the progress of steam navigation in the British Empire, from its first introduction in 1814, down to the most recent times for which returns have been received.

Table showing the progress of Steam Navigation in the British Empire, by the Registrar-General of the Board of Trade.

British Merchant-Steamers built and registered each year.			Total number of Merchant-Steamers belonging to the British Empire in each year.		British Merchant-Steamers built and registered each year.			Total number of Merchant-Steamers belonging to the British Empire in each year.	
Year.	Steamers.	Reg. Tons.	Steamers.	Reg. Tons.	Year.	Steamers.	Reg. Tons.	Steamers.	Reg. Tons.
1814	6	672	2	456	1836	69	9,700	600	67,9 9
1815	10	1,394	10	1,633	1837	82	12,147	668	78,288
1816	9	1,238	15	2,612	1838	87	9,857	722	82,716
1817	10	2,054	19	3,950	1839	65	6,522	770	86,731
1818	9	2,538	27	6,441	1840	77	10,639	824	95,807
1819	4	342	32	6,657	1841	54	12,391	856	104,845
1820	9	771	43	7,243	1842	67	14,931	906	118,930
1821	23	3,266	69	10,534	1843	53	6,739	942	121,455
1822	28	2,634	96	13,125	1844	73	6,930	988	125,675
1823	20	2,521	111	14,153	1845	73	11,950	1012	131,202
1824	17	2,234	126	15,739	1846	88	17,172	1070	144,784
1825	29	4,192	168	20,287	1847	115	17,333	1154	146,557
1826	76	9,042	248	28,958	1848	128	16,476	1253	158,078
1827	30	3,784	275	32,490	1849	80	13,480	1296	167,310
1828	31	2,285	293	32,032	1850	81	15,527	1350	187,631
1829	16	1,751	304	32,283	1851	88	23,527	1386	204,654
1830	19	2,226	315	33,444	1852	112	31,792	1414	223,616
1831	36	4,436	447	37,445	1853	162	49,008	1534	264,336
1832	38	4,090	380	41,669	1854	189	66,446	1708	326,452
1833	36	3,9 5	415	45,017	1855	263	84,862	1910	408,290
1834	39	5,756	462	50,735	1856	245	58,621	1950	417,717
1835	88	11,281	538	60,520					

Explanation of statistical table.

It should be observed that the "register" tonnage here given is exclusive of the tonnage of the engine-room, which in a well-powered steamer generally amounts to one-half, or more, of the registered tonnage. An addition of one-third should therefore be added for the gross tonnage of this table. To take an example. The Shannon, West India mail packet, has

Register tonnage	2187·24	H.-P. 775
Engine-room do.	1284·57	
Gross do.	3471·81	

The horse-power (nominal) averages about one-third of the register tonnage; so it may be fairly assumed that this country now possesses a fleet of 2150 merchant-steamers, having an aggregate gross tonnage of 670,000 tons, and a nominal horse-power of 165,000 horses.

The steam navy of this country consists at present of about 468 vessels, having an aggregate tonnage of 470,000 tons, and a nominal horse-power of 110,000 horses.

	Afloat (1859).		Building or Converting.	Total.
	Screw.	Paddle.	Screw.	
Ships of the Line	33	—	16	49
Frigates	19	9	6	34
Block Ships	9	—	—	9
Mortar Ships	4	—	—	4
Corvettes and Sloops	38	35	9	82
Small Vessels	3	24	—	27
Gun Vessels	26	—	—	26
Gunboats	161	—	1	162
Floating Batteries	8	—	—	8
Tenders, &c.	4	38	—	42
Troops & Store Ships	13	2	—	15
Yachts	1	4	—	5
Total	319	112	32	463

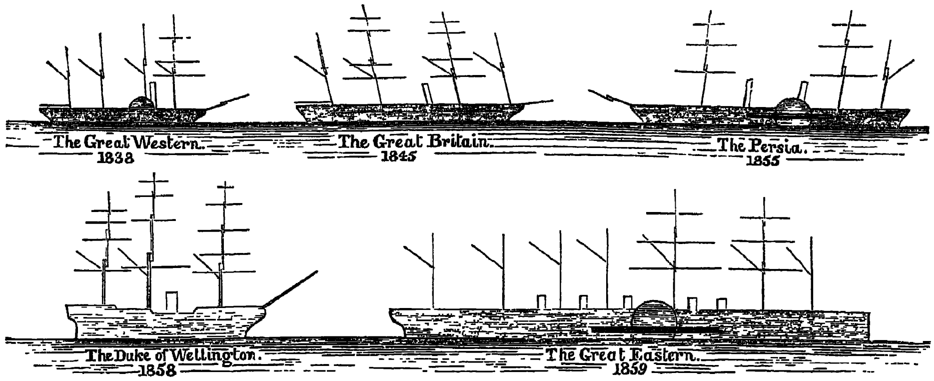

Fig. 1.—Comparative sizes of the above Steamers.

In constructing a steam-vessel three things require to be specially considered, each of which is a sufficiently complex study in itself; namely, the ship, the engines and boilers, and the propeller. To combine these in such a manner as to produce a perfect whole is one of the most difficult problems of modern engineering, demanding at once the theoretical attainments of the natural philosopher, and the laboriously acquired knowledge and shrewd sagacity of the practical mechanician. As the limits of this article must preclude the pursuit of theoretical investigation, it is proposed to confine it almost exclusively to the practical part of the subject, and to a record of the results of actual and approved performance.

The marine engine.

The marine steam-engine, although acting on the very same principles as the ordinary land condensing-engine, and provided with the same integral parts, differs from it essentially in the particulars of weight and form, being necessarily made as light, and as compact, as possible. These requirements throw many obstacles in the way of the marine engineer which are not encountered on shore, both as regards the engines and boilers; and his difficulties are increased by the stern necessity which exists on board ship for the utmost economy in the consumption of fuel, the value of which is there immensely enhanced.

Side-lever engines.

The oldest type of the marine-engine is the side-lever variety, which, till within the last ten or twelve years, was almost universally employed in steamers; and which is, indeed, still preferred for paddle-wheel steamers, by at least two large mail-packet companies—viz: Cunard's and the West India Mail Company (fig. 2). There are several

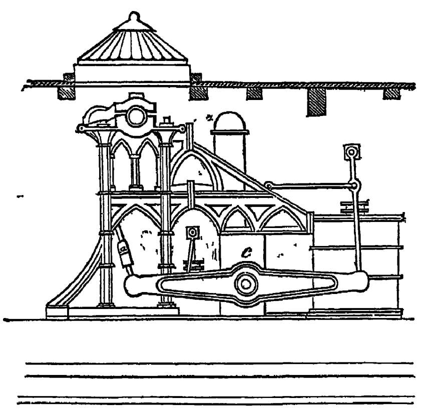

Fig. 2.
Side-lever Engine.

good reasons why this form of engine should be thus favoured. In the first place, the working parts are well balanced on either side of the main centre (*c*, fig. 2), so that the engine will stand in any position without the piston having a tendency to fall by its own weight, thus enabling the crank to be kept in the most advantageous position for giving prompt motion to the shaft immediately that the engine is started. Direct-acting engines are often very troublesome in this respect. Another advantage of the parts being nicely balanced is, that the engine works with little friction, and consequently less strain, and tear and wear of the brasses and moving parts of the machinery. Hence the side-lever engine is very economical in maintenance and repairs, as well as in the quantity of oil and tallow required for lubrication, no mean item in the expenditure of some engines. Again, this form of engine admits of a good long stroke and connecting-rod, by which means the steam may be used to best advantage in the cylinder, while, at the same time, the thrust of the piston is transmitted to the crank in the most equable and effective manner. Many pairs of side-lever engines are still doing their work well, after more than twenty years' service, and have cost less for repairs than most direct-acting varieties in half that time.

Direct-acting engines.

But although it may be quite true that side-lever engines are thus economical in their working, it does not necessarily follow that they are the best form of engine for passenger-steamers. On the contrary, when we consider the

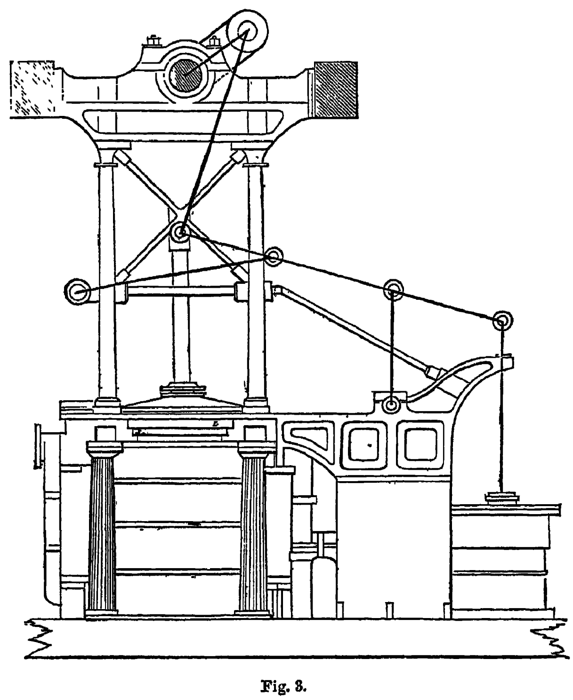

Fig. 3.
Direct-acting Engines in Gorgon, &c. (Seaward.)

value of space and weight in a first-class merchant-steamer, it appears probable that they are really more expensive

Steam Navigation.

than the lighter and more compact forms of direct acting-

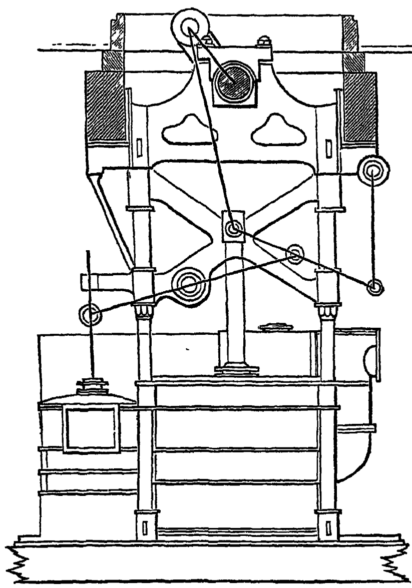

Fig. 4.
Direct-acting Engines in Vulture, &c. (Fairbairn.)

engines which have now so generally come into use, and by

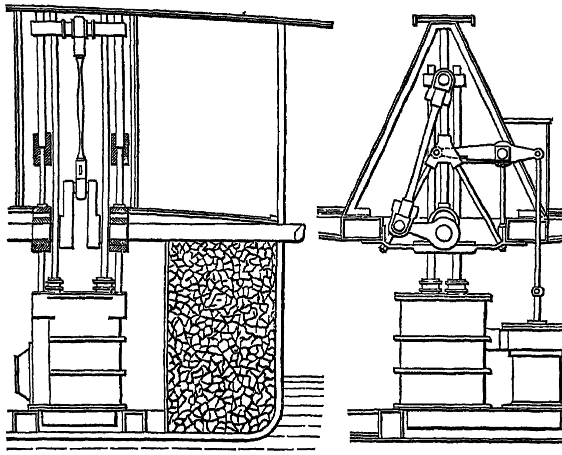

Fig. 5.
Direct-acting Engines for shallow draught. (Maudslay and Field.)

employing which we may save at least 20 feet in the length of the engine-room, and 100 tons of displacement, in engines of 500 nominal horse-power. Direct-acting engines, being susceptible of great variety of form, have assumed as many different shapes as there are manufacturing engineers ready to invent, adapt, or distort them, as the case may be; and the now very general use of the screw-propeller has, of course, varied and modified these forms still more). In the merchant service, the height of the machinery is not of much moment, provided only that it does not raise the centre of gravity of the vessel too high; but in the steam-navy it is considered essential that the whole of the engines and boilers should (if possible) be kept under the water-line of the ship, as a protection from shot; which, in the case of screw-vessels, is now generally accomplished (see fig. 15).

Varieties.

Direct-acting paddle-wheel engines may be classed under four heads; namely, those which preserve the parallelism of the piston-rod by means of the system of jointed rods called a parallel motion (figs. 3 and 4); those which use guides or sliding surfaces for this purpose (figs. 5 and 7); oscillating engines (fig. 6), in which the cylinders are hung upon pivots, and follow the oscillations of the crank; and

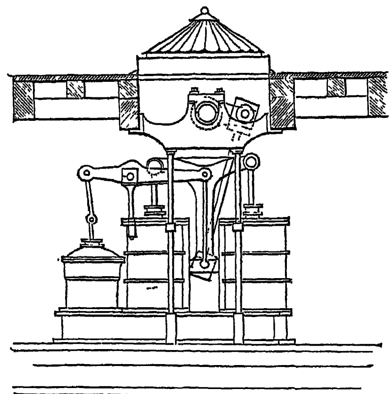

Fig. 7.
Direct Double-cylinder Engines, suitable for large power. (Maudslay.)

those denominated "trunk-engines" (fig. 8), in which a hollow cylindrical trunk is attached to the piston, and passes, steam-tight, through the cylinder cover. Several of these varieties have their distinctive appellations, being known as the "steeple-engine" (which is a favourite form on the Clyde); Maudslay's double-cylinder engine (fig. 7); the annular-piston engine (with two piston-rods); the atmospheric engine; the combined-cylinder engine (Plates XXXIV. and XXXV.); and several others. As verbal description is of little value in making these forms intelligible to the reader, sketches of the more characteristic of them are subjoined, as well as detailed plates of approved examples (see Plates). These engines are generally made with two cylinders, but in the case of screw-engines there are sometimes three, and sometimes four cylinders

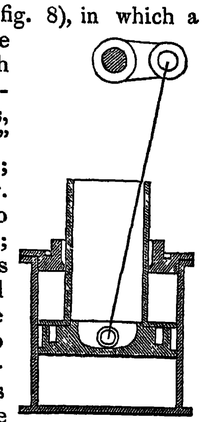

Fig. 8.

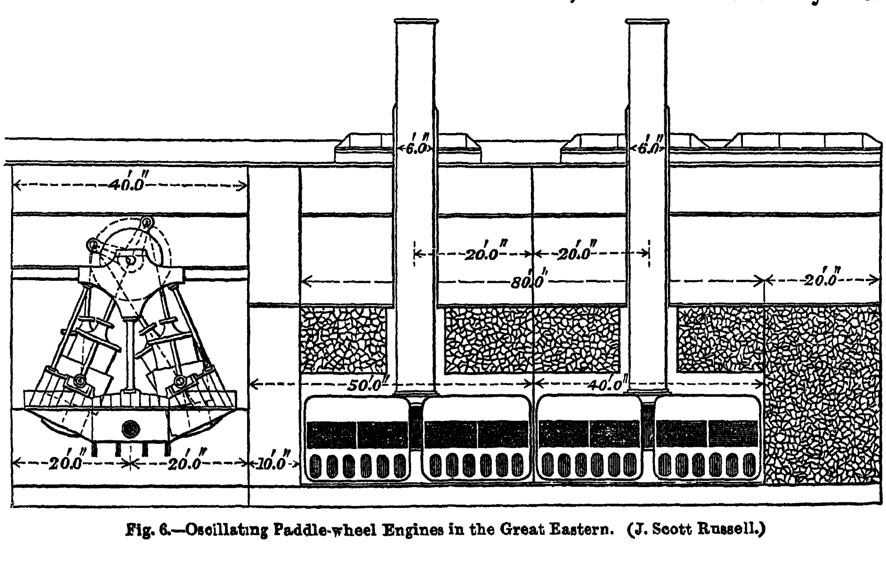

Fig. 6.—Oscillating Paddle-wheel Engines in the Great Eastern. (J. Scott Russell.)

placed in all possible positions; being found upright, inverted, horizontal, and inclined.

Screw-engines.

Screw-engines are made either with or without gearing. The use of geared wheels intervening between the engine and the propeller admits of a slow speed of piston with a high velocity of screw, and is so far beneficial, but in practice there are several disadvantages attending it.

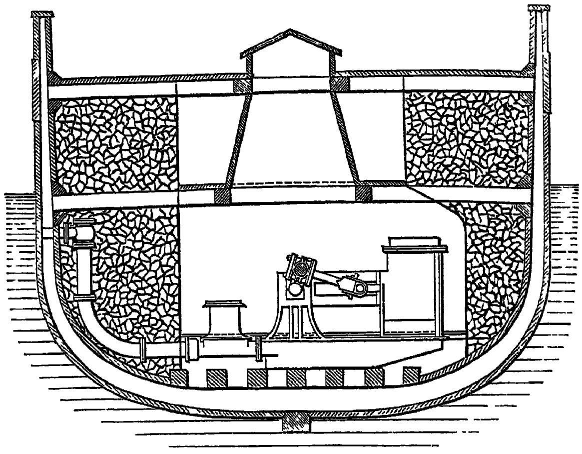

Fig. 9.
Horizontal Screw-engine (Direct), adapted for the Royal Navy, &c.

The driving-wheel is necessarily very large and cumbrous, while the wooden teeth with which it is fitted are subject to unequal wear, and are liable to be "stripped," or broken off, by a sudden stroke of the sea upon the screw. Their revolution is also attended with a loud rumbling noise, from which there is no escape on board-ship. In steam-vessels of war it is difficult to keep the top of the large wheel sufficiently low, while at the same time their draught of water admits of the use of a screw of great diameter and pitch, by which means the necessary speed may be obtained for the ship without unduly increasing the velocity of the piston. Hence there are comparatively few geared screw-engines in the Royal Navy. In the case of full-powered screw-engines in the merchant service, the use of gearing is generally found to be necessary (fig. 10),

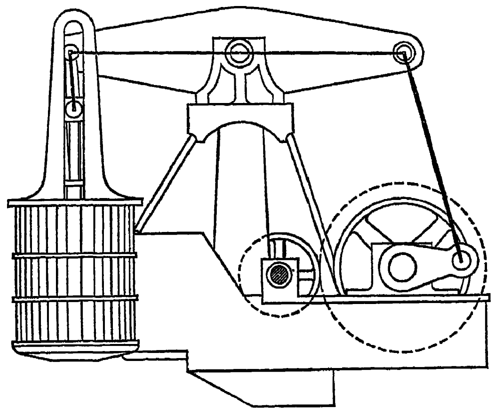

Fig. 10.
Vertical Screw-engine (Geared), adapted for the Merchant Service.

but it may be advantageously dispensed with wherever the power of the engines is not calculated to give a very high speed to the ship. The velocity of piston in actual use in different classes of steamers will be hereafter noted.

The following (Figs. 11 *to* 16) *are other examples of Screw-engines:—*

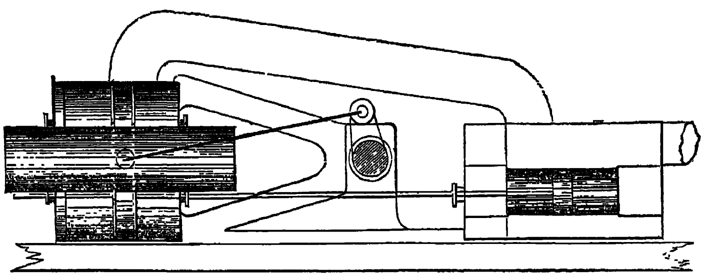

Fig. 11.—"Trunk" Screw-engine, Direct.

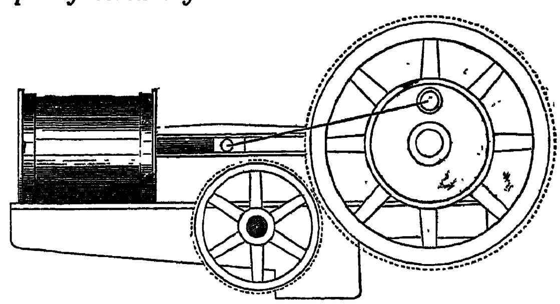

Fig. 14.—Horizontal Cylinder Screw-engine, Geared.

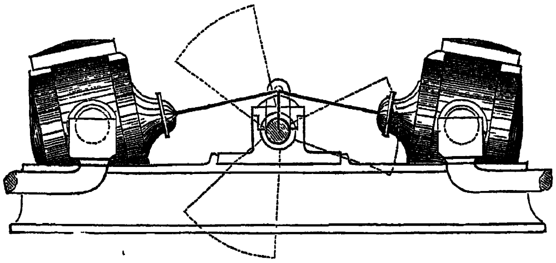

Fig. 12.—Oscillating-Cylinder Screw-engine, Direct.

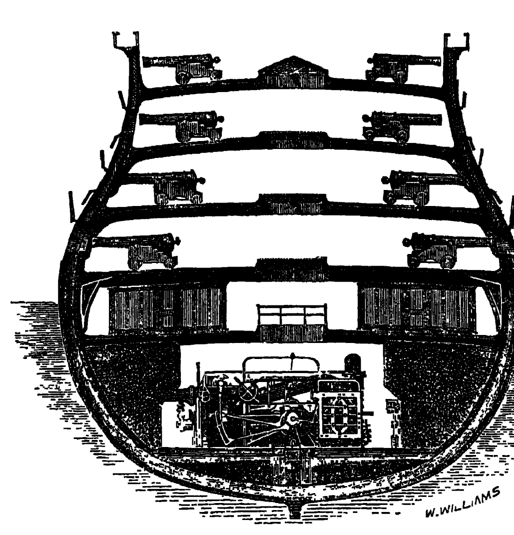

Fig. 15.—Screw-engines in the Royal Navy, Direct.

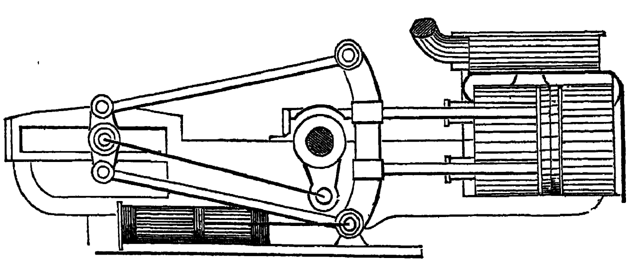

Fig. 13.—Double Piston-rod Screw-engine, Direct.

Steam Navigation.

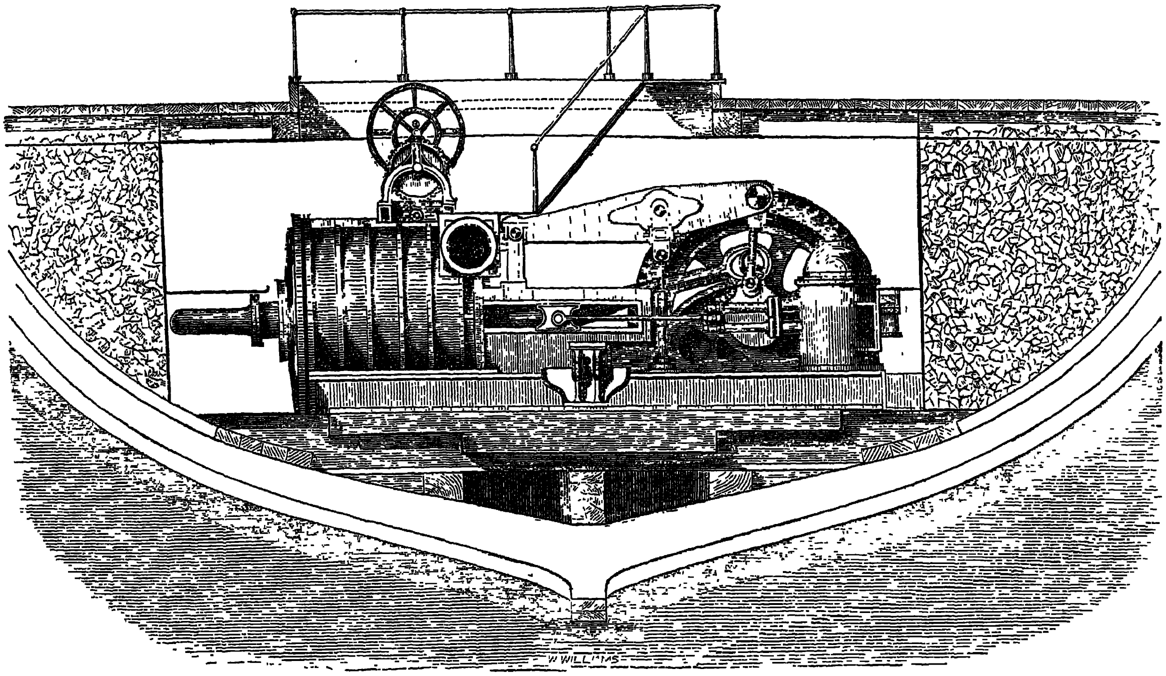

Fig. 16.—Screw-engines in the Royal Navy, Geared.

Nominal horse-power.

The cylinder of the steam-engine, being that portion of the machine in which the power is developed, must be considered as its principal member. Upon its dimensions depend, in some degree, the size of all the other parts of the engine, as well as its reputed powers, being called an engine of 100 or of 200 horse-power according to the diameter of the cylinder, modified to a small extent by the length of the stroke. This, called the nominal horse-power, is obtained by the formula—

$$\text{H.P.} = \frac{\text{Area of cylinder} \times \text{effective pressure} \times \text{speed of piston}}{33{,}000}.$$

In this formula the area of the cylinder is taken in square inches; the "effective pressure" is assumed at 7 lb. (by some makers at $7\frac{1}{2}$ lb.) to the square inch; and the speed of the piston (according to the arbitrary rule adopted by the admiralty), is presumed to vary with the length of stroke, as shown in the following table:—

Stroke.	Speed of piston.	Stroke.	Speed of piston.
Ft. In.	Ft. per min.	Ft. In.	Ft. per min.
3 0	180	6 0	221
3 6	188	6 6	226
4 0	196	7 0	231
4 6	204	7 6	236
5 0	210	8 0	240
5 6	216	9 0	248

It is at once apparent that the power thus calculated cannot be the real power of the engine, since it is wholly irrespective of the pressure of steam in the boiler, the perfection of the vacuum in the condenser, the actual number of reciprocations of the piston, and the varying loss by friction depending upon good or bad workmanship, and the general plan of the engine. For the sake of convenience, however, the nominal horse-power is still retained, since it defines, with tolerable accuracy, the actual *size* of the engine, and its commercial value, in so far as the latter is dependent upon the dimensions of the cylinder. To remedy, in some degree, the uncertainty attending the use of this term, it is now becoming usual for the purchaser of a steam-engine to insert a clause in his contract, binding the manufacturer to show a certain specified amount of indicated horse-power.

Indicated horse-power.

The indicated horse-power of an engine is obtained by the aid of a valuable little instrument called an indicator, consisting mainly of a small cylinder placed in connection with the cylinder of the engine, both above and below the piston. This little cylinder is open at the top, and is fitted with a piston which presses against a spiral spring. The cock which connects the indicator with the cylinder of the engine being opened, steam is admitted under the piston of the indicator during the one stroke, and vacuum during the other, precisely as in the large cylinders; thus causing the little piston to push and pull alternately against the spiral spring. If the pressure were uniform throughout the stroke, the indicator-piston would start at once from top to bottom, and *vice versâ*, remaining stationary until acted upon by the opposite pressure; but since the pressure within the cylinder of a steam-engine is constantly varying during every portion of the stroke, it follows that the pressure on the spiral spring of the indicator, and the corresponding movement of the indicator-piston, must be variable too. If a pencil be fixed to the piston-rod of the instrument, it will register the fluctuations of pressure upon a piece of paper held close to it; but unless some provision be made for allowing the pencil a clear space on the paper at each successive instant of time, it will only move up and down in the same vertical line, and the markings due to fluctuation of pressure will be undistinguishable. To obviate this, the paper receives a circular motion in one direction during the down-stroke of the piston, and a reversed circular motion during the return-stroke, the result being that, as the pencil moves vertically up and down, a continuous curved or sloping line is traced on the paper. By this line an oblong space is inclosed, called the indicator-figure, card, or diagram, the vertical ordinates of which will then represent the effective pressures at the corresponding portions of the stroke, and their mean length will therefore indicate the average pressure in the cylinder during the whole period of the stroke.

Description of the indicator.

Indicated and effective horse-power.

To find the indicated horse-power, therefore, we must take the area of the cylinder in square inches, multiply it by the average pressure as found from the indicator-figure, and again by the actual number of feet through which the piston is travelling per minute; when the product, divided by 33,000, is the indicator or gross horse-power of the

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engine. This must not be confounded, however, with the *effective* power of the engine, or that actually available for the purpose for which the engine is used. To obtain this, a considerable deduction (about 25 per cent., it is believed) must be made for the friction of the moving parts, and for the power required to work the valves, air-pump, feed and bilge pump, &c.; but as this would be nearly alike for all well-constructed engines of equal power, and no ready means exist for testing it, the gross or indicated horse-power is taken as the measure of the power in all ordinary cases.

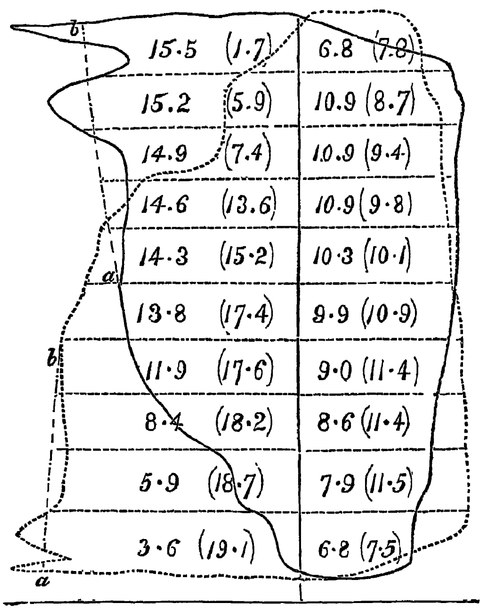
Proportion of indicated to nominal horse-power.

An example of a set of indicator-diagrams (fig. 17) is subjoined, to show the manner in which they are usually worked out; and it will be seen that, in this instance, a pair of engines of 500 *nominal* horse-power were actually exerting an *indicated* horse-power of more than 2000 horses, or four times the nominal. This may be taken as the usual proportion now existing between nominal and indicated horse-power in modern engines by the best makers, while using steam of from 15 to 20 lb. pressure; but the average performance of existing engines is still very much below this, not exceeding from 2 to 2·5 times the nominal horse-power.

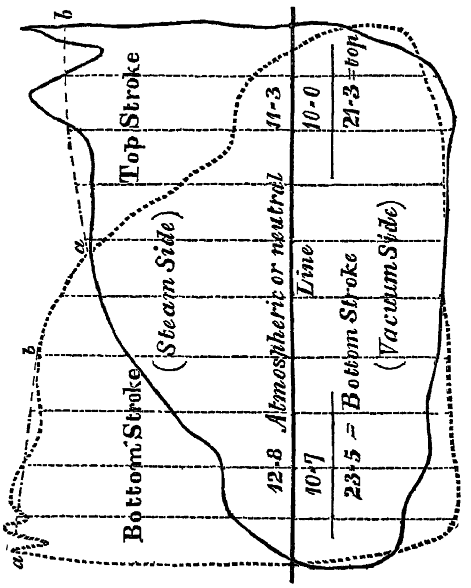
Indicator-Diagrams taken from Screw-engines of 500 *horse-power, by Ravenhill, Salkeld, and Company.*

(Steam in Boilers 20 lb.)

Forward Engine, vacuum 24½ in.



After Engine, vacuum 25 in.



Calculation for finding Ind. H.P.

Steam ....11·7	(13·5)	9·2 (9·8)	
Vacuum............ 9 2		(13·5)	
Top stroke..... 20·9		Bottom......(23·3)	

Diameter of cylinder ....71 inches.
Length of stroke...................................... 3 feet.
Indicated pressure (mean of 6 experiments)......21·904 lb.
Mean number of revolutions per minute.........63½.

$$\frac{3959\cdot2014 \times 381 \times 21\cdot904}{33{,}000} = 1001\cdot248 \text{ H.P.} \times 2 = 2002\cdot496. \quad \text{Ind. H.P. of both engines.}$$

Speed of the vessel at a mean draught of 24 ft. 9½ in....10·897 knots.

Mean of forward engine..................................22·1 lb.
„ after engine ....22·4 „

Mean of both engines.................. 22¼ lb.

[The dynamometer is an instrument used to measure the force actually expended in propelling the vessel; or, in other words, for showing the effective horse-power of the engines. It is fitted occasionally on board of a screw-steamer, the thrust of the propeller being transmitted through a series of levers to a Salter's spring-balance; but it is difficult to obtain true indications from this instrument, which is liable to many disturbing influences. There is a fixed dynamometer at some of H.M. dockyards, by means of which the pull of any steamer, whether paddle or screw, may be obtained in tons.]

Fig. 17.

Indicated horse-power depends mainly on the boiler.

The size of the boiler is obviously a very important element in determining the indicated horse-power of an engine, inasmuch as the speed of the piston (or the number of revolutions per minute) depends mainly upon the supply of steam from the boiler. The power of an engine may thus always be increased by adding to the size of the boiler, provided the steam-passages are large enough to admit of the increased flow of steam without its becoming throttled or "wire-drawn." A large boiler, however, implies a large consumption of coal as a necessary attendant upon any increase of power in the engines, or velocity in the ship; so that in practice it is generally found inconvenient for sea-going steamers to urge their engines to the utmost duty of which they are capable, as tending to limit the distance which it is possible to run with a definite weight of coals. Hence it follows, that while vessels making short runs (such as the Holyhead packets) will show an indicated horse-power of four, or even five times their nominal, a transatlantic steamer cannot afford to do so, although her engines may be equally efficient.

Velocity of piston.

It will be understood, from what has been already said, that the speed at which marine engines are driven is very various, and also that it is liable to vary (even in the same vessel) according to circumstances; such as the steaming capacity of the boilers, the necessity for economizing fuel, and the dimensions of the paddles or screw. Apart from the proper or "calculated" speed, there is of course the additional consideration of the variable trim of the vessel, and the undulations of the sea, which affect the speed of the engines by throwing more or less work upon them, in proportion as the propelling agent is deeply or lightly immersed. The subjoined tables will convey some idea of the velocity at which pistons are driven (under the most favourable circumstances of *trim*) by some of the principal marine engineers of the day:—

Steam Navigation.

Speed of Pistons in Merchant-Steamers (Paddle and Screw).

Name of Vessel.	Makers of the Machinery.	Diameter of cylinder.	Length of stroke.	Revolutions per minute.	Speed of piston in ft. per min.	How propelled.
		Inches.	ft. in.	Revols.	Feet.	
Great Eastern	Watt	84	4 0	50	400	Screw, direct.
Delta	Penn	72	7 0	25	350	Paddle, feathering floats.
Great Eastern	Scott Russell	74	14 0	12	336	Do. common.
Shannon	R. Napier	97	9 0	18	326	Do. „
Mersey	Maudslay and Field	60	5 0	30	300	Do. „
Ceylon	Humphrys	72	3 0	50	300	Screw, direct.
Colombo	R. Napier	72	5 6	26½	291·5	Do. geared.
Atrato	Caird	96	9 0	15	270	Paddle, feathering.
Pera	Rennie	75	4 0	32	256	Screw, geared.
Oneida	Inglis	82	4 6	26	234	Do. do.
Tamar	Penn	72	7 0	16½	231	Paddle, feathering.
Prince Consort	Scott Russell	30	2 6	45	225	Do. do.
	Speed of Pistons in Government Screw-Steamers.					
Agamemnon	Penn	70¾	3 6	60	420	Trunk, direct.
Mohawk	Humphrys	42¼	2 2	88	381	Horizontal, direct.
Esk	Scott Russell	50	2 9	68	374	Oscillating, direct.
Arrogant	Penn	55	3 0	61	366	Trunk, direct.
Princess-Royal	Maudslay and Field	64	3 0	58	348	Horizontal, direct.
Simoom	Watt	43¾	3 0	55	330	Oscillating, direct.
Conflict	Seaward	46¼	2 0	70	280	Horizontal, direct.
Duke of Wellington	R. Napier	94	4 6	30	270	Horizontal, geared.
Highflyer	Maudslay and Field	55¼	2 6	53	265	Horizontal, direct.
Dauntless	R. Napier	84	4 0	31	248	Horizontal, geared.
Fairy	Penn	42	3 0	40	240	Oscillating, geared.
Sharpshooter	Miller and Ravenhill	46	3 0	38	228	Horizontal, geared.
Rifleman	Ravenhill	34	2 9	36	198	Oscillating, geared.
Rattler	Maudslay and Field	40¼	4 0	25½	204	Double cylinder, geared.

All the merchant-steamers in this table have a speed of above 13 knots, and the government steamers of 10 knots.

Some of these speeds are nearly twice as great as would be sanctioned by the table previously quoted as embodying the practice of James Watt; and although, theoretically speaking, there may be no objection to such high velocities, they are inconvenient in practice, from the tendency of the working parts to heat by the friction, from the rapid wear of the parts, and their increased liability to accident or derangement.

Long and short stroke engines.

Although engineers are perfectly agreed as to the superior advantages of a long stroke for their engines, it will be seen by the preceding table how rarely in the case of screw-engines this desirable object can be accomplished. The cause of this is, that the *pitch* of the screw-propeller (by which term is implied the linear advance made by the screw during one complete revolution, supposing it to be working in a solid), cannot be effectively increased beyond a certain proportion, depending upon the diameter of the screw; and as this is necessarily limited by the draught of water, it follows that the only available means for augmenting the linear advance of the screw is by increasing the number of revolutions. For each revolution of the screw, two journeys of the piston (in a direct engine) are required, and to enable this to be done within the required time, the strokes must be short. The chief disadvantages attending a short stroke are the more frequent recurrence of the "dead points" of the crank (when the piston arrives at the top and bottom of the cylinder), at which times much of the momentum of the moving parts is destroyed; and the loss of a certain quantity of steam contained within the cylinder ports or passages at each stroke, which does not exert a direct pressure on the piston. It is natural to suppose, also, that short-stroke engines do not derive so much benefit from expanding in the cylinders as those having longer strokes.

Another desideratum for all kinds of steam-engines is a long connecting-rod, as tending to diminish the angular strain thrown upon the main crank, and thus avoid the loss of power arising from unnecessary friction. This action is

Long and short connecting-rods.

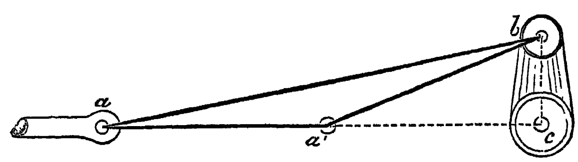


Fig. 18.

made apparent by the accompanying sketch (fig. 18), in which *a b* represents a long connecting-rod, and *a' b* a short one, their relative efficiency varying as the angles *a*, *b*, *c*, and *a'*, *b*, *c*. The defects of a short connecting-rod become sensible in practice by greater liability of the bearings to heat, by an increased wear of "brasses" and packings, and a larger consumption of oil for lubricating.

Cutting off the steam in the cylinder.

The cylinder of a steam-engine is never allowed a full measure of steam from the boiler, this being shut off at some part of the stroke according to the power it may be desirable to exert. A certain quantity of steam, varying generally from ⅙ to ⅛ of the contents of the cylinder, is always excluded by the slide-valve, which is made to close the steam-port before the end of the stroke. In most engines a further amount of steam is excluded by means of a separate valve, called the expansion-valve, which is so arranged that it may "cut off" the steam, or prevent a further supply, at any desired point, according as it may be wished to economize fuel, more or less, at the expense of velocity. Thus, some engines are worked with ¾ of a cylinder full of steam to each stroke, some with ½, and others with only ¼; or the same engine may be worked successively at the different "grades of expansion" corresponding to these quantities. This is called "working expansively," because the portion of steam thus shut in continues to expand in volume, and to give out elastic force, to the end of the stroke.

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Advantages of expanding steam in the cylinders.

Two advantages arise from cutting off the steam in this way. Firstly, it allows the stroke to be completed under a diminished pressure, so that the piston comes gently to rest at the top and bottom of the cylinder, without imparting a destructive jar to the machinery; and, secondly, it is economical of power (or, which is the same thing, of *fuel*), since it is found that the force actually exerted upon the piston by the isolated steam, during its expansion into the increased volume as the piston descends in the cylinder, is considerably greater than that due to the simple pressure of the same weight of steam acting at a uniform density.

It is found by calculation that when the steam is cut off at $\frac{1}{2}$ stroke, seven-tenths of the power already exerted in the cylinder is added by the subsequent expansion of the steam; when cut off at $\frac{1}{3}$, 2·1 times the power is added; and when cut off at $\frac{1}{4}$, 2·4 times nearly. According to the usually-received natural law regulating the pressure and elasticity of steam, it is assumed that the pressure is inversely proportional to the volume of the steam after it has expanded into the increased bulk, or, in other words, that when the steam has expanded to twice its original volume, its pressure will be reduced one-half; when it has expanded four times its volume, the pressure will be $\frac{1}{4}$th, and so on. The pumping-engines in Cornwall, which do their work so very economically, use steam of about 40 lb. pressure, cutting it off in the cylinder after $\frac{1}{6}$th or even $\frac{1}{8}$th part of the stroke has been made, the remaining $\frac{7}{8}$ths being performed wholly by expansion.

Fxpansion can be rarely pushed to its extreme limits.

It is very seldom, however, and that only when special means are provided for this purpose, that the principle of expansion can be beneficially carried out in marine engines to an extent nearly approaching that just mentioned. It is a well known property of all gaseous fluids, steam of course included, that any expansion of volume is necessarily accompanied with the loss of sensible heat, which is taken up in the latent form by the expanded gas or vapour. Hence, when the steam expands under ordinary circumstances within the cylinder of a steam-engine, a portion of it is compelled to part with its latent heat, to enable the rest to retain the gaseous form. This portion of steam, therefore, condenses into water of the same temperature, which forms a thin film over the interior surface of the cylinder. When the return stroke begins, and the watery lining of the cylinder is brought into connection with the condenser, it rapidly evaporates into steam of low tension. This steam, besides vitiating the vacuum, acts still more injuriously by robbing the cylinder of the heat which it required for evaporation; when the metal of the cylinder, being thus lowered in temperature, condenses the steam, upon its re-admission, to a serious extent. Thus it happens that the principle of expansion, when carried out to any great extent in cylinders which are only "clothed" in the usual way, has so frequently failed to realize the expected economy of fuel; and this has been most unjustly charged to a defect in the principle of expansion.

Advantage of a steam-jacket.

In the case of the Cornish engines already mentioned, where the steam is expanded to eight times its volume with known advantage, the cylinder is invariably surrounded with a "jacket" kept well supplied with dense hot steam from the boiler; by which means it is retained at a high and nearly uniform temperature during the entire stroke; and to this steam-jacket it is mainly due that so remarkable an economy attends the use of expansion in Cornwall. The cylinders of a marine engine, on the other hand, are protected from radiation by a clothing of felt and wood only; but in the few instances where a steam-jacket has been applied, the most beneficial results have followed.

Advantage of super-heating the steam.

Another mode by which the expanded steam may be protected from condensation in the cylinder is by previously imparting to it an extra dose of heat beyond that due to its pressure, or, in other words, by "superheating" it. It is apparent that this extra heat becomes available for the supply of the latent heat demanded by the expanding steam, which is thus saved from premature condensation.

Conditions under which the full benefit of expansion may be obtained.

In order to derive the utmost benefit of which the principle of expansion is capable, it is necessary that the initial pressure of steam should be considerable, that it should have plenty of space to expand into, and that the cylinder should be maintained at a high temperature. These conditions would seem to imply the use of a large jacketed cylinder of sufficient strength to bear the high initial pressure. As such a cylinder, however, would be very heavy and cumbrous, the plan has been occasionally adopted of using *two* cylinders, in which to utilize the steam, namely, a large and a small one. In this case the high-pressed steam from the boiler is admitted into the small cylinder only, and after expanding in that to twice or three times its volume (by which its pressure is reduced to one-half, or one-third), it is then admitted from the small cylinder into the large one, where the expansive process is finally completed under the most favourable circumstances.

Combined-cylinder engines.

This combination, called the combined-cylinder engine, has of late been brought prominently forward by the engineering firm of Randolph Elder and Co., of Glasgow. Plates XXXV. and XXXVI. represent the engines of the steamers Callao, Lima, and Bogotâ, made on this principle, and which have attracted much notice by their remarkable economy of fuel. Their principal dimensions will be afterwards given with the description of the plates. They were thus described by Mr Elder at the late meetings of the British Association—"These engines are constructed with the view of getting the greatest amount of power from a given quantity of steam at a given pressure, with less total weight of engines, boilers, and water, and occupying less total space than is found in the ordinary class of steam-engines on board of steamships. To accomplish these objects the following construction of engine has been adopted:—The cylinder capacity is so great as to admit of the steam being expanded to within 2 lb. of the pressure in the condenser at the end of the stroke, while the engines are working full power. In order to reduce the violent shock of steam at 42 lb. pressure on such a large piston, a cylinder with a piston one-third of the size is placed beside it. This small cylinder receives the steam direct from the boiler during one-third of its stroke, after which it is cut off. This steam is consequently reduced to one-third of its original pressure, or to 14 lb., at the end of the stroke, and it then enters the second or larger cylinder. Here it is expanded three times more, or down to $4\frac{2}{3}$ lb. Thus, the steam at 42 lb. is expanded to 14 lb. in the first cylinder, at which pressure it enters the second cylinder, and is further expanded down to $4\frac{2}{3}$ lb.; but as the second piston has three times the area of the first, the load will be the same on both pistons, and the piston-rods, cross-heads, and connecting-rods may be the duplicates of each other." The steam is super-heated in the boilers to about 400°, and the cylinders are steam-jacketed and clothed with felt and wood. The feed-water is heated before entering the boilers. It is stated that, although the engines worked with superheated steam, this was found inadequate to prevent condensation in the cylinders without the use of the steam-jackets in addition, the indicator diagrams taken from these engines showing a marked increase of power resulting from a free use of the steam-jackets, the supply of steam to which may be modified at pleasure.

Economy of fuel in Lima, Bogota, &c.

These vessels have all shown a minimum consumption of from 2 to $2\frac{1}{2}$ lb. of best Welsh coal per indicated horse-power per hour, their speed being at the same time $12\frac{1}{2}$ to 13 knots, which must be considered a very satisfactory result. Their consumption of coal at their usual working trim is about 3 lb. per indicated horse-power, the vessel making 11 knots; whereas the more usual consumption of modern marine engines varies from 4 to 5 lb. per indicated horse-power per hour, and the average consumption of all classes cannot be less than 6 lb.

Two cylinders not considered requisite.

It is not contended, however, that the system of expanding in two cylinders is essentially requisite towards the attainment of a great economy in the consumption of fuel, and there are many instances of single-cylinder engines in which the same beneficial results have followed a like judicious combination of means and appliances for this purpose. A case in point is supplied by the recent performances of the steamship Thunder, a vessel fitted with machinery of much the usual kind, by Messrs Dudgeon of London. Although supplied with steam of only 14 lb. pressure, her engines do not consume more than $2\frac{1}{4}$ lb. of coal per indicated horse-power per hour, the vessel making 13 knots. Her machinery

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is represented by Plates XXXIII. and XXXIV., and will be found fully described at page 668. An indicator-diagram from her engines is here subjoined (fig. 19).

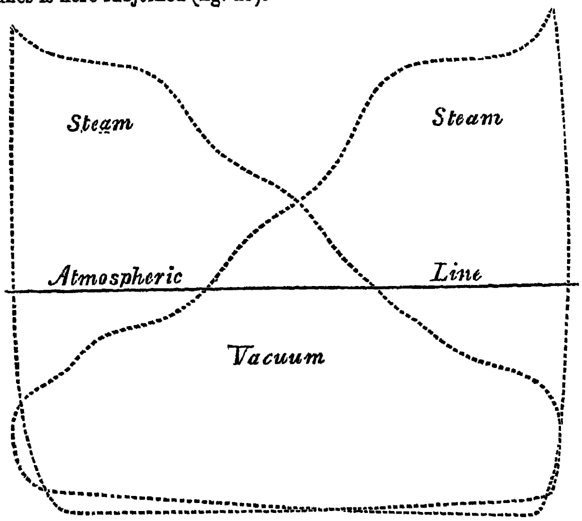

Fig. 19.

Screw-steamer Thunder.—3d Nov. 1859.

Forward Engine.—With super-heated steam and expansion.

Steam in boiler	13 lb.
Pyrometer on super-heater	350 deg.
Number of revolutions	50
Diameter of cylinder	55 inches.
Stroke	36 „
Indicated horse-power, each cylinder, with expansion	= 348

Economy of fuel in steamer Thunder.

It may be stated that a consumption of $2\frac{1}{4}$ lb. of coal per indicated horse-power per hour would represent in Cornwall a "duty" of about 90,000,000 of pounds raised 1 foot high in an hour by a bushel (or 94 lb.) of coal, which is considered economical working even for a Cornish engine. The success achieved in the case of the Thunder appears to be due to the conjunction of the following good qualities in the machinery—viz., a perfect command of steam in the boilers, the super-heating and expanding the steam in "belted" or jacketed cylinders, and the allowance of an unusually large inlet and outlet for the steam by the main valves.

Economy of fuel in Omeo.

Another example of unusual economy in the consumption of fuel has been recently shown in the auxiliary screw-steamer Omeo, fitted with engines of 100 nominal horse-power, by Messrs Morrison of Newcastle. These engines use steam at 60 lb. pressure, which is expanded to a large extent in single cylinders, and afterwards condensed in the usual way, the cylinders being surrounded with steam-jackets. The engines work up to 426 indicated horse-power, while driving the ship at 9 knots, and burning only 2·4 lb. of coal per indicated horse-power per hour. As the use of high pressure steam necessarily implies a boiler of corresponding strength, the Omeo's boilers are cylindrical, with "coned" furnaces and upright "coned flues," fitted with a superheating chamber on the top. The employment of steam of this high tension, however, is not to be recommended for passenger-steamers.

Importance of the question of economy of fuel.

The question of economy of fuel is of vital importance even in a national point of view, as affecting the maintenance and extension of some of our great postal lines of ocean steamers, and it is now receiving a large share of attention both from steamship owners and engineers. The subject naturally divides itself into two heads—the production of steam in the boiler, and its subsequent employment in the engine.

The boiler.

1st, *The Boiler.*—It is a material point towards economical working that the boiler should be large enough to ensure a constant command of steam without the necessity for "forcing" the fires, or continually stirring them up. This acts prejudicially in more ways than one. In the first place, each time that the fire-door is opened the cold air rushes in through it, and mixing with the hot gases in the furnace, checks their perfect combustion, at the same time that it robs the interior of the boiler of much valuable heat. Again, if the boiler be deficient in heating surface, the fires must be kept *thin*, to promote rapid combustion; and as these fires are specially liable to "burn into holes," a quantity of cold air enters the furnace through them, and the same cooling effect is produced in the flues and passages. It may be also remarked that, however desirable it may be to "burn smoke" by admitting air into the furnace above the bars, it is seldom an *economical* process, and if not managed with great caution, is apt to become very much the reverse. The natural consequence of stirring the fire too much is, that a large quantity of small coal and cinder falls through the bars into the ash-pit, and as the boilers cannot supply the constant demand for steam unless the fires are kept bright and active, these cinders cannot be re-burned, probably, for fear of checking the formation of steam. They are thrown overboard, therefore, with the ashes, and a heavy expense is incurred.

Forcing the fires is expensive of fuel.

Smoke-burning not economical.

Stoking is not a mere mechanical operation.

It may be thought by some persons that stoking is a mere mechanical operation, easily acquired by the commonest labourer; but this is a great and vital error, which generally costs steamship owners many thousand pounds before they find it out. The stokers, in fact, may be wasting coals by the ton at the furnaces of the boilers for want of proper supervision, while the engineer is straining every nerve to save a few pounds weight by economizing steam in the engines, and possibly congratulating himself, at the same time, upon his able management. It is no unusual case for a difference of 20 per cent. in the consumption of fuel to arise simply from good or bad stoking, by which is meant the whole management of the fires and the draught. The *quality* of the coals is another important item in estimating the consumption per horse-power, and some remarks on this subject will be made hereafter. In large ships the mere labour of passing the coals along to the front of the fires is very severe, and some contrivance of slides or rails to enable the buckets to be easily run down the firing stage is recommended. The stoker's duty is, at the best, a most irksome one, and it is found in practice that any contrivance which adds to their comfort and convenience, whether it be by reducing the heat of the stoke-place, supplying them with a tap of cold distilled water, &c., is amply repaid by the increased attention bestowed on the fires. A marked reduction in the heat of the stoke-place in many of her Majesty's ships has attended the use of the double smoke-box doors, shown in the subjoined sketch (fig. 20),

The comfort of the stokers should be consulted.

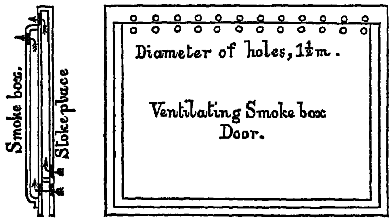

Fig. 20.

which are kept cool by a current of air passing between the double linings. It is very important, both as regards the coolness of the stoke-place and the steaming power of the boilers, that the draught of air to the fires should be encouraged as much as possible by means of large hatches, wind-sails, and air-tubes. It is found preferable, where rapid combustion is required, to allow two or more funnels to the boilers, if by this means the draught may be made more direct; for the question is not merely how to generate steam with the least possible consumption of fuel, but how to do this in the least possible time, and with a boiler of the least possible weight and capacity. It is comparatively an easy matter to evaporate water economically in a Cornish boiler, for instance, but a very difficult and complex one under the conditions imposed upon the marine engineer. The ordinary rate of combustion in the furnaces of marine boilers is about 15 lb. of coal burned on each square foot of grate-bar surface per hour; and the ratio existing between the absorbent or "heating surface" of the boiler and the grate-bar surface varies from 15 to 25 of the former to 1 of the latter. The furnace-bars are frequently made so thick as unnecessarily to impede the admission of air to the fires. They should not exceed $\frac{3}{4}$ of an inch for wrought-iron, or 1 inch for cast-iron, on the upper edge, and should have an air-space of from $\frac{7}{16}$ths to $\frac{1}{2}$ inch between them, while burning Welsh coal.

Draught to the fires.

Rapidity of combustion.

Heating surface.

The nature and arrangement of the heating surface in a boiler is very material, the chief points to be considered being, that the steam may have a ready escape from every part of the heated surface, that every portion of the interior of the boiler should be accessible for "scaling," or removing the crust of insoluble matter, which forms upon the plates and tubes, and that soot and ashes should not collect in any of the flues or passages. A large and high furnace is very desirable for facilitating the proper admixture of the combustible gases with the oxygen of the air. Brass tubes are much preferable to iron for rapidity of evaporation, as might be expected from their relative powers of conducting heat. Some recent experiments have shown, that the evaporative power of clean brass tubes is, to that of iron, as 125 : 100; and copper tubes as 150 : 100, nearly.

Use of salt-water in marine boilers.

Salt-water being necessarily used in the boilers of sea-going steamers, this is liable to become more and more saturated with

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salt and earthy impurities in proportion as the steam passes off to the engines. A twofold evil thus arises. The super-salted water, as it increases in density, demands more heat before it will part with its steam; and the insoluble imgredients it contains (chiefly the carbonates of lime and magnesia, and the sulphate of lime), gaining strength with the abstraction of the steam, are deposited inside the boiler, thus forming a non-conducting skin, which greatly impairs its efficacy, and subjects the plates to risk of injury from the fire. To remedy this, a certain portion of the water in the boiler is "blown off" into the sea, its place being supplied by the feed-pumps with a corresponding portion of the hot-water, which results from the condensation of the steam by a jet of sea-water. As the temperature of the "feed," however, does not exceed 100°, while that of the brine it replaces is probably about 230°, it is evident that much heat is thus lost, more especially as a good deal of steam is believed to escape with the water that is blown off.

Constituents of sea-water.

According to Dr Ure's experiments, the largest proportion of salt held in solution in the open sea is 38 parts in 1000 by weight, and the smallest 32. In a specimen brought from the Red Sea, 43 parts were found, the specific gravity of the water being 1·035. The Mediterranean contains about 38 parts in 1000, the British Channel 35·5, the Arctic Ocean 28·5, the Black Sea about 21, and the Baltic only 6·6.

The same authority states, that deep sea-water from the ocean (from whatever locality) holds nearly the same ingredients in solution, containing, on an average, in 1000 parts—

25·0	Chloride of sodium or common salt.
5·3	Sulphate of magnesia.
3·5	Chloride of magnesium.
0·2	Carbonates of lime and magnesia.
0·1	Sulphate of lime.
34·1	

Also a little sulphate and muriate of potash, iodide of sodium, and bromide of magnesium.

"Blowing-off."

It is now the usual practice to "blow-off" the requisite quantity of brine continuously, in the proper proportion to the amount of feed admitted, so as to keep the water in the boiler at a certain regular degree of saturation, at which it is found by experience that little or no deposition of "scale" will take place. Till within the last few years, boilers were always blown-off from the *bottom* only, it being not unnaturally supposed that the heaviest and most saturated water would be found there; but experience has now proved that the greater portion of the impurities from which the scale is formed are to be found on the *surface* of the water of the boiler (being carried upwards by the steam), and should be abstracted from thence. Mr Lamb, the superintending engineer of the Peninsular and Oriental Steam Navigation Company, was the first to introduce "surface blow-off," which is now very generally used in addition to blowing-off from the bottom, and is attended with a considerable improvement in the condition of the boiler-surfaces.

Surface blow-off.

Proper degree of saturation of water in boiler.

The rule adopted by this company is, that the feed and blow-off shall be so regulated, the one to the other, that the water in the boiler may be always at the degree of saturation marked 17 on the scale of their hydrometer, which represents a saturation of between $\frac{3}{32}$ and $\frac{4}{32}$ parts of salt.

The following table shows the boiling point and specific gravity of sea-water (at 60° Fahr.) of different degrees of saturation, expressed in parts of salt contained therein, the barometer indicating 30 inches of mercury:—

	Saltness.	Boils.	Sp. gr.	
Pure water.............	0	212°	1·	
Common sea-water......	$\frac{1}{32}$	213·2°	1·029	
Up to this point but	$\frac{2}{32}$	214·4°	1·058	
little deposit will be	$\frac{3}{32}$	215·5°	1·087	
formed............→	$\frac{4}{32}$	216·7°	1·116	
	$\frac{5}{32}$	217·9°	1·145	
	$\frac{6}{32}$	219·1°	1·174	
	$\frac{7}{32}$	220·3°	1·203	
	$\frac{8}{32}$	221·5°	1·232	
	$\frac{9}{32}$	222·7°	1·261	
	$\frac{10}{32}$	223·8°	1·290	
	$\frac{11}{32}$	225·0°	1·319	
	$\frac{12}{32}$	226·1°	1·348	saturated solution.

As a general rule, the atmospheric boiling point of the water should never be allowed to exceed 216°, when the barometer stands at 30 inches. The temperature must be ascertained by drawing off a small quantity of the brine, and boiling it in a deep copper vessel in the engine-room, a correction being made, as nearly as possible, for the state of the barometer.

The following table shows the height of the boiling point of pure water at different heights of the barometer:—

Barometer. Inches.	Boiling Point.	Barometer. Inches.	Boiling Point.
27	206·96°	29½	211·20°
27½	207·84°	30	212°
28	208·69°	30½	212·79°
28½	209·55°	31	213·57°
29	210·38°		

In testing brine by the hydrometer, care must be taken that it has the particular temperature for which the hydrometer scale was calculated. This is usually 200° Fahr. About 3° of temperature make a difference of ·0001 of the specific gravity, or ·036 of the usual hydrometer degree, or ·0036 of the density of sea-water. The steam raised from salt-water and fresh is precisely the same in every respect; but it has been found by experiment that water of the density which it usually acquires in marine boilers, demands about one-tenth more of heat to convert it into steam than if it were fresh-water, its "capacity for heat" being greater to this extent. It is needless to say, that salt itself will not be deposited until the brine arrives at its point of greatest saturation, or three times the density which the water should ever be allowed to acquire; but what the engineer has to guard against is, the deposition of a solid stone-like incrustation, composed of the sulphate and carbonate of lime, and the carbonate of magnesia. These are at first held in solution by the water, but are subsequently rendered insoluble, and become deposited on the plates and tubes of the boiler, partly from the free carbonic acid being expelled by the boiling of the water, and partly by its continued saturation.

Surface condensation.

Many, though hitherto unsuccessful, attempts have been made to obviate the necessity for this expensive process of blowing off. The only effectual remedy is the employment of fresh water in place of salt in the boilers; but this can only be accomplished by the adoption of "surface condensation." By this term is understood the condensation of the steam by contact with a large extent of cold metallic surface, instead of the usual method of condensing by a jet of sea-water. This principle, though repeatedly tried, has hitherto proved more or less inefficient, and the invention of an effective method of surface condensation is still a problem in marine engineering. It is believed that an economy of about 15 per cent. in consumption of fuel would result from the use of fresh-water in the boilers of marine engines, with a longer duration of the boiler, and the saving of much valuable time consumed in cleaning. The average duration of boilers using salt-water does not exceed six years, while those using fresh-water last eight or nine; but the life of a boiler is very uncertain, depending so much on the care and attention bestowed upon it.

Process of "scaling."

The process of "scaling" a boiler, or removing the deposit from the internal surfaces, is a very tedious and troublesome one, the scale being detached by hammers and chisels, after being loosened as much as possible by lighting fires in the furnaces of the empty boiler. In some recent experiments on this subject made at Portsmouth by Mr Lindsay, the boiler was filled with hot air at a temperature of 400°, which acted most successfully in detaching the scale by the rapid expansion induced. The boiler was afterwards filled for service, and so soon as a pressure of steam was obtained, the bottom blow-off cocks were opened, and most of the scale previously detached was "blown off" into the sea.

Donkey-engine.

Almost all boilers are now fitted with an auxiliary or "donkey" engine, for the purpose of keeping up the requisite supply of feed, while the regular feed-pumps attached to the large engines are not working. The "donkey" is also made useful for pumping water either from the sea or the bilge, and is an invaluable aid in case of fire.

Feed-water heaters.

In many steamers the feed-water is heated to a point considerably above the temperature of the condenser, by means of the waste heat of the boiler itself; being brought into contact either with the brine which is blown off, or with the hot air at the foot of the chimney. By this means its temperature may be raised from about 100° to 180° or 200°; and as modern practice shows the advantage of freshening the boiler by a plentiful admission of feed, it is very desirable that its temperature should be thus previously raised. Various modes of effecting this will be found mentioned in the descriptions to the plates accompanying this article. The feed-water heater of the Great Eastern has acquired an unfortunate notoriety from the sad consequences attending its explosion, though there is no inherent danger in the arrangement there adopted, which has been safely and successfully applied in many other vessels.

"Priming."

When the ebullition inside a boiler is so rapid and violent that the water rises with the steam in considerable quantity, and is carried over with it to the engines, or is blown up the waste steam-pipe, the boiler is then said to "prime." This is one of the most

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dangerous and troublesome propensities to which a boiler can be subject, as it may occasion a break-down in the engines by the shock of the piston upon the incompressible fluid (if escape-valves of sufficient capacity are not fitted), and in all cases it entails a great loss of heat carried off by the hot-water which boils over.

Causes of priming.

Priming may arise from a variety of causes, but the prevalent one, more especially in the government service, is a too contracted steam space over the water of the boiler. For where the reservoir of steam from which the engines are supplied is very small, there must be constant pulsations of pressure in the boiler; and each time that the surface of the boiling water is relieved of a certain amount of pressure by the rapid withdrawal of a cylinder full of steam, it boils up with great violence, and possibly overflows into the steam-pipe. The only remedy for this is an addition to the size of the steam-chest, and an increased height above the surface of the water to the steam-pipe orifice. Priming, however, is frequently the result of accidental causes, apart from the construction of the boiler. Water charged with mud or mucilage, which forms a viscid scum on the surface, is sure to induce it; also while the ship is passing from fresh-water into salt, and *vice versâ*. A new boiler with clean "raw" surfaces, is more liable to prime than after it has contracted a coating of scale, in consequence of the brisker ebullition going on, as well as from the dirt and grease left in a new boiler by the workmen. It is a usual practice to put tallow in a boiler as a preventive of priming, but this is not always attended with the desired effect. When the boiler primes very much, it is necessary to slow the fires, so as to prevent the too rapid formation of steam.

"Wet" steam.

All boilers are subject to the loss of a certain quantity of water, which rises with the steam in the shape of fine spray, and passes over with it into the cylinders of the engines. When much of this is present, the steam is said to be "wet;" but it is believed that all steam raised in the ordinary way is more or less charged with water in a state of fine subdivision. To evaporate and utilize this water is one of the principal incentives to the use of surcharged or "superheated" steam. The other advantage arising from its use, namely, the prevention of condensation in the cylinders, has been already referred to while treating of expansive working.

Superheating apparatus.

The steam in the boiler may be superheated in a variety of ways, but those methods seem preferable which use for this purpose the spare heat at the bottom of the chimney, which would otherwise be almost entirely lost. The accompanying sketch (fig. 21) explains the method

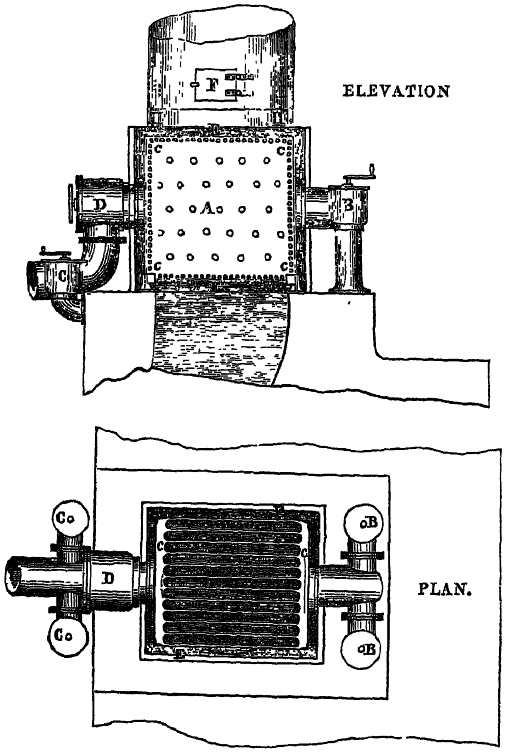

Fig. 21.
Lamb and Summers' Superheating Apparatus.

which has been already largely employed in the steamships of the Peninsular and Oriental Steam Navigation Company, those of the Union Steam Packet Company (carrying the Cape mails), and many others at Southampton, and which has been attended with the most undoubted success. It will be observed, that the steam in its way from the boilers to the engines passes through the superheating chest A, at the foot of the chimney, the steam occupying the narrow spaces between the sheet-flues through which the smoke and hot air pass.

BB are stop-valves for admitting the steam to the apparatus, or excluding it if necessary.

CCC are stop-valves for passing the steam direct from the boilers to the engines without going through the apparatus.

DD are stop-valves for admitting the superheated steam to the engines, or shutting it off when common steam only is used.

EE is a square casing enclosing the apparatus, and forming the foot of the chimney, the smoke and hot air of which entirely surround the superheating chest. Other casings of thin iron are fitted outside this to prevent the radiation of heat.

F is a door for getting into the chimney, and examining the flues of the apparatus.

The chimney is not rigidly fastened to the square casing, but ships over the projecting part HH, the space between being filled with clay. This mode of carrying the chimney is adopted, so that, in the event of collision, the loss of the chimney should not entail the destruction of the apparatus and its connexions.

It is found, from experience, that a heating surface of about 4 square feet per nominal horse-power of boiler is required to superheat the steam under ordinary circumstances. The temperature of the steam, when issuing from this apparatus, is generally found to be about 320° to 360°; and in the slide-jacket, from 20° to 30° less, according to the length of the steam-pipe.

A high temperature not required.

The saving of fuel in the steamships of the Peninsular and Oriental Company, by the use of this apparatus, is stated to vary from 20 to 33 per cent., without any injurious effects resulting to the piston-packings, &c. By this simple and inexpensive process the whole steam given off by the boiler is "superheated" from the temperature due to its pressure (which for steam of 15 pounds pressure would be 250°) to a temperature of from 350° to 380°, which has been proved to be amply sufficient for obtaining all the benefit derivable from the process. That much of the heat of superheated steam is really employed in evaporating the particles of water held in suspension seems to be proved by this fact, that its temperature will fall as much as 40 or 50 degrees, in some cases, during its passage from the boiler to the engine, though there is no perceptible escape of heat by radiation from the surface of the well-protected steam-pipe. The heat thus apparently lost is undoubtedly taken up (in the latent form) by the steam resulting from the vaporization of these watery particles, by which means the heat already contained in the water is turned to good account, and the evaporative power of the boiler is virtually increased.

Economy of the process.

A great many experiments have been made to test the actual economy of the process by comparison with the existing consumption of coal before the superheating apparatus was fitted, and in every instance there has been a perceptible improvement. This sometimes takes the shape of increased speed in the engines and vessel, sometimes a saving of fuel alone is effected, and in other instances both of these are combined in the same vessel in variable proportions. Where the speed of the vessel has been kept a constant quantity, there would appear to be an actual saving of from 15 to 25 per cent. of fuel, according to the nature and qualities of the boiler to which the process has been applied, and the amount of expansion in the cylinders. The high rates of economy are naturally shown by those boilers which were previously the worst to keep steam with, and which required very hard firing to do so. Those addicted to priming and wet steam rank next in apparent economy, while those boilers which show the least were originally the best specimens of their class. There is no question, however, but that the process is beneficial *in all cases*, though not equally so, and enables the steam to be raised in the boilers without "hard firing" being resorted to, being in this respect a great boon to the stokers.

Wethered's *mixed* superheated steam.

It is believed that not the slightest advantage over the ordinary methods of superheating the steam is due to Mr Wethered's system of mixing superheated and ordinary steam together at the point where they enter the valve-jacket. To this gentleman's patent, however, we owe, in a great measure, the general awakening of marine engineers to the undoubted advantages of the process, which have been till now so unaccountably overlooked.

Conservatism in marine engines.

The plan adopted by the government of contracting for their steam machinery with only a few favoured and old-established houses, has undoubtedly tended to promote conservatism in marine engines, and to repress innovations and improvements, the wholesome though often unpalatable principle of competition being, in their case, scarcely roused into action. These lordly manufacturers have nothing to gain, in fact, by breaking new ground, being well assured of their accustomed orders from the Admiralty, and not caring to raise the ques-

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tion whether their beautifully constructed machinery might not possibly be made to content itself with 60 tons of coal per diem in place of 80. In the case of those manufacturers, however, who have not the *entrée* at Whitehall, but who are dependent upon the custom of the great steam shipping companies, and other private owners of steam-vessels, who are fully alive to their own interests, there exists an active competition, and consequently a strong inducement to improve upon the economical performance of their machinery. We find, accordingly, that it is this class who have taken the lead in the recent steam reformation which has now fairly set in.

Marine boilers.

There are three principal kinds of marine boilers in use in this country, namely, the rectangular-flue boiler (which is now very generally discarded); the multitubular boiler, or, as it is more usually called, the *tubular* boiler; and the sheet-flue boiler.

The tubular boiler.

The tubular boiler (as shown in Plates XXXIII. and XXXIV.) is that in most general use. This construction enables a very large quantity of heating surface to be crowded into comparatively small space; while the form of the tubes, which vary from $2\frac{1}{2}$ to 4 in. in diameter, affords great strength, at the same time that the thinness of the metal composing them offers little impediment to the conduction of heat. They are attended with this inconvenience, however, that the flame arising from the combustion of the inflammable gases in the furnace is prematurely extinguished by the minute subdivision and rapid reduction of temperature to which it is exposed in passing through these small tubes.

It is well known that flame requires a very high temperature for its maintenance, and is easily extinguished by contact with a comparatively cool surface; as for instance, in passing through the wire-gauze of the miner's safety-lamp. A precisely similar effect is produced by the boiler-tubes, whose temperature, from their being surrounded with water, must be considered low when compared with that of the flame and hot gases passing through them.

Vertical-tube boiler.

The Americans have adopted a different form of tubular boiler (as shown in the accompanying wood-cut, fig. 22),

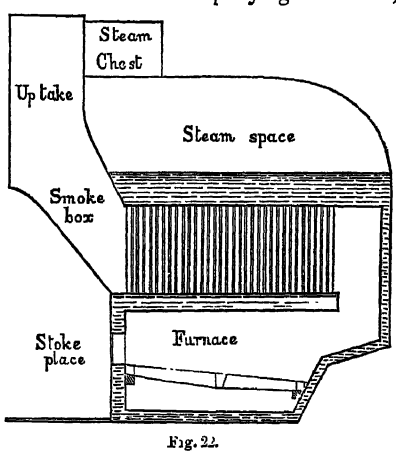

Fig. 22.
American upright-tube Boiler.

in which the tubes are disposed vertically, the smoke and flame passing round the *outside* of the tubes, and the water being contained *inside*. These vertical-tube boilers are very effective in generating steam, and partly for this reason, that the flame reaches further amongst their tubes than in the case of a horizontal boiler, in consequence of the greater space outside the tubes in which the flame may develop itself. The importance of this, while using the bituminous *flaming* coal of the northern coal-fields, is very great. The absorbent surface of the vertical-tube boilers is, of course, greater than that of the horizontal in proportion as the external diameter of the tubes exceeds their internal diameter, and the weight of water it is necessary to carry is much less.

Sheet-flue boiler.

Sheet-flue boilers are constructed with numerous flat, narrow water-spaces, alternating with flues of the same form in place of tubes. The width of the water-spaces in "Lamb and Summers' patent sheet-flue boilers" varies from $1\frac{1}{2}$ to 2 inches, and the flues from $2\frac{1}{2}$ to 3 inches. They are extensively used in the steamers of the Peninsular and Oriental Company, where they give much satisfaction from their durability, and economy in repairs.

Explosions of boilers. Causes.

When a marine boiler explodes, the presumption is, either that the safety-valve has not acted properly, or has been over-weighted, and the boiler has burst simply from excess of pressure; or that the water has been allowed to fall too low, and thus expose the tops of the flues or furnaces, or the boiler-tubes, which, getting red-hot by the action of the flame, have suddenly generated such a rush of steam, upon the re-admission of the feed, as to cause a rupture of the weakened plates. Explosions most frequently happen at the moment of opening or shutting a safety-valve or communication-valve, which shows that so long as the steam remains undisturbed within the boiler, it will sustain a very high pressure without bursting; but should a wave or pulsation be carried through it, the equilibrium is instantly destroyed, and a rupture takes place. The very act of suddenly opening a safety-valve, or a communication-valve to the engines, would cause the water to boil up with great violence, and an immense volume of steam to be instantly liberated, in consequence of the water being relieved from a certain amount of pressure.

Precautions, &c.

In the event, therefore, of the discovery being made that any portion of the boiler has become overheated from want of water, the engineer should neither open the safety-valve nor admit the feed, but throw open the fire-doors, close the dampers, and draw the fires, after which the safety-valves may be cautiously relieved, and the feed gradually admitted, until the overheated surfaces are covered with water.

In those parts of the boiler where the heat is most intense (as at the backs of the furnaces) the plates will gradually become oxidated and weakened by the fire, even although kept constantly in contact with water. This is probably owing to the rapid disengagement of steam from the surface, which interposes a non-conducting film of steam between the iron and the water, and thus permits the former to get overheated. Thick plates, or overlapped joints, in such a position, "burn out" quicker than thin ones, from the imperfect conduction of the heat through the métal, and this is of course much aggravated when the plates are coated with scale. Plenty of steam room is a safeguard to a boiler, as tending to diffuse and neutralize any dangerous oscillation or sudden accession of steam. The immense rush of steam which always follows an explosion is satisfactorily explained, when we consider that the instant the water contained in the boiler is relieved of pressure it throws off steam with great rapidity, and continues to do so until the whole mass of the water is reduced to the atmospheric condition of 212°Fahr. To make matters worse, the steam-chests of all the boilers are usually in communication.

Rarity of explosions in steamers.

It is gratifying to find that while explosions in America are so frequent, they rarely occur on board of steam vessels in this country—a result which is doubtless to be attributed, in a great measure, to the supervision of the Board of Trade. It is worthy of remark, also, that the majority of such accidents havè happened to tug-boats, which, from not carrying passengers, are exempt from government interference; and it will be remembered that the Great Eastern, when her feed-water heater exploded with such fatal consequences, had not yet received a certificate of sea-worthiness.

Requirements of the Merchant Shipping Act.

By the Merchant Shipping Act of 1854 the Board of Trade are empowered to enforce certain provisions of equipment of the vessel and her machinery, supposed to conduce to the safety of the passengers and ship. The principal points to which attention is directed by this act are, that the masters and mates of steamers shall

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have proper certificates of competency; that the hull and machinery generally shall be of sufficient strength; that the number of passengers carried shall be limited by the accommodation; that a sufficient number of boats be carried; that proper water-tight bulkheads be fitted, as well as pumps, fire-pumps and hose, life-buoys, lights, compasses, &c., &c. Each boiler is required to have one safety-valve, and recommended for further security to have two, the weights upon which have been sanctioned by the Board through their surveyor. One of these valves (called the government safety-valve) is left locked beyond the control of the engineer of the boat, the key being placed under the master's charge. Every passenger-steamer is required by this act to renew her certificate of efficiency or sea-worthiness twice a-year, after periodical surveys have been held upon her hull and machinery; and if such certificate is not granted, she is debarred from carrying passengers until the required provisions are complied with.

Qualities of coal.

It will now be desirable to convey some practical information regarding the coals used in steam-vessels. The qualities it is most desirable for steam-coals to possess may be summed up as follows:—1. They should have a high evaporative power, or, in other words, they should be capable of converting much water into steam with a small consumption of fuel. 2. They should not be highly bituminous, as such coals produce a dense black smoke which it is difficult to consume in the furnace, and the soot and tarry matter evolved are found to clog the tubes and flues, and detract from the evaporative power of the boiler. 3. The coal should light quickly, and be capable of a rapid combustion. 4. It should be sufficiently cohesive in its nature to bear the constant attrition it is subjected to without becoming broken into small fragments. 5. It should combine a considerable density with such a mechanical structure as may admit of its being stowed in the smallest possible space, this involving a difference of 20 per cent. 6. It should be as free as possible from sulphur, which induces progressive decay and spontaneous combustion.

Admiralty experiments on coals for the Royal Navy.

Table, showing an Abstract of the Principal Results obtained from the Best Coals of the United Kingdom, collated from the Admiralty Reports on Coals suited to the Steam Navy.

Name of Fuel.	Evaporative power or No. of lbs. of Water converted into Steam by 1 lb. of Coal.	Weight of cubic foot in lbs.	Space occupied by 1 ton in cubic feet.	Cohesive Power percentage of large Coals.	Evaporative Power after deducting for Combustible Matter in residua.	Evaporative Power per Hour per Square Foot of Grate surface.	Lbs. of Clinker per ton.
Graigola	9·35	60·17	37·23	49·3	9·66	...	30·6
Anthracite (James and Awbrey)	9·46	58·25	38·45	68·5	9·7	...	0
Pentrefelin	6·36	66·17	33·85	52·7	7·4	40·6	22·7
Duffryn	10·14	53·22	42·09	56·2	11·8	69·8	0
Oldcastle Fiery Vein	8·94	50·92	43·99	57·7	...	71·0	0
Ward's Fiery Vein	9·40	57·43	39·0	46·5	10·6	87·8	54·5
Binea	9·94	57·08	39·24	51·2	10·3	...	0
Llangennech	8·86	56·93	39·34	53·5	9·2	...	68·6
Pentrepoth	8·72	57·72	38·80	46·5	8·98	61·5	80·2
Mynydd Newydd	9·52	56·33	39·76	53·7	10·59	79·6	59·1
Three-quarter Rock Vein	8·84	56·39	39·72	52·7	...	88·3	42·8
Cwm Frood Rock Vein	8·70	55·28	40·52	72·5	9·35	...	40·8
Cwm Nanty-gros	8·42	56·00	40·00	55·7	8·82	71·3	23·7
Resolven	9·53	58·66	38·19	35·0	10·44	71·4	0
Pontypool	7·47	55·70	40·22	57·50	8·04	55·0	20·9
Bedwas	9·79	50·50	44·32	54·00	9·99	90·5	25·2
Ebbw Vale	10·21	53·30	42·26	45·00	10·64	90·5	9·3
Porth-Mawr	7·53	53·30	42·02	62·00	7·75	77·3	27·0
Coleshill	8·00	53 00	42·26	62·00	8·34	75·7	39·5
Neath Abbey	9·38	59·30	37·77	50·00	9·65	116·0	19·2
Llynvi	9·19	53 30	42·02	...	9·58	89·0	36·0
Rock Vawr	7·68	55·00	40·72	65·5	7·88	91·0	38·0
Aberdare Company's Merthyr	9·73	49·30	45·43	74·5	10·27	92·4	9·8
Thomas's Merthyr	10·16	53·00	42·26	57·5	10·72	111·8	3·9
Nixon's Merthyr	9·96	51·70	43·32	64·5	10·70	102·6	5·7
Hill's Plymouth Works	9·75	51·20	43·74	64·0	10·18	119·8	7·5
Slievardagh (Irish Anthracite)	9·85	62 80	35·66	74·0	10·49	84·5	18·0
Dalkeith Jewel Seam	7·08	49·8	44·98	85·7	7·10	63·0	62·2
Wallsend Elgin	8·46	54·6	41·02	64·0	8·67	91·0	14·6
Grangemouth	7·40	54·25	40·13	69·7	7·91	71·4	16·4
Eglinton	7·37	52·0	43·07	79·5	7·48	90·0	8·2
Newcastle Hartley	8·23	50·5	44·35	78·5	8·65	62·0	17·0
Carr's Hartley	7·71	47·8	46·86	77·5	8·13	84·6	5·0
North Percy Hartley	7·57	49·1	45·62	60·0	7·72	94·0	7·8
Hasting's Hartley	7·77	48·5	46·18	75·5	7·96	104·0	1·7
Hedley's Hartley	8·16	52·0	43·07	85·5	8·71	74·8	14·4
Original Hartley	6·82	49·1	45·62	80·0	6·98	106·5	10·1
Derwentwater's Hartley	7·42	50·4	44·44	63·5	7·66	95·0	28·3
Gadley Four-feet Seam	9·29	51·6	43·41	68·5	10·73	96·5	11·6
Haswell's Coal Company's Steamboat	7·48	49·5	45·25	79·5	7·85	61·0	9·8
Davison's West Hartley	7·61	47·7	46·96	76·5	7·83	96·5	2·1
Cowpen and Sydney Hartley	6·79	47·9	46·76	74·0	7·02	84·0	3·7
Balcarres Lindsay Mine	7·44	51·1	43·83	70·0	7·58	93·5	22·3
„ Haigh Yard	7·90	50·8	44·13	80·0	8·23	79·0	26·4
Johnson and Wirthington's Sir John	6·32	51·6	43·41	82·0	6·62	80·5	34·4
Wylam's Patent Fuel	8·92	65·08	34·41	...	9·74	72·4	61·6
Bell's „ „	8·53	65·3	34·30	...	8·65	91·5	76·1
Warlich's „ „	10·36	69·05	32·44	...	10·60	96·5	29·7
Lyon's „ „	9·58	61·10	36·66	...	9·77	93·0	38·7
Watney's Anthracite	11·08	67·0	33·43	87·5	11·40	127·4	24·6

Steam Navigation.

Average properties of coal.

Properties.	Average of Seventeen Samples of Welsh.	Average of Six Samples of Newcastle.
	lb.	lb.
Theoretical evaporative power	15·785	14·208
Specific gravity	1·325	1·259
Coke	86·87	66·1
Moisture	0·88	5·07
Frangibility, large	79·2	85·0
„ small	20·8	15·0

Average Chemical Analysis of 100 *parts of Dried Coal.*

Ash	2·24	4·32
Carbon	89·13	78·45
Hydrogen	4·23	5·11
Nitrogen	1·27	1·79
Sulphur	1·01	1·36
Oxygen	2·12	8·97

In the foregoing tables the "theoretical evaporative power" is deduced from the composition of each coal as determined by chemical analysis. It gives the maximum amount of heat which each coal could produce, calculated in terms of the number of pounds of water at 212°, which would be converted into steam at 212° by the complete combustion of 1 lb. of each variety of coal.

Evaporative power of coal.

1 pound of pure carbon (according to the most accurate experiments) emits, by its combustion, an amount of heat sufficient to evaporate 14·88 lb. of water at 212° into steam at 212°; and 1 lb. of hydrogen, when burned, emits heat enough to convert 63·56 lb. water at 212° into steam of the same temperature. It is found experimentally, that the quantity of water capable of being evaporated by any coal is (as nearly as possible) directly as the quantity of coke which can be produced from that coal; the fact being, that in the case of bituminous coals, as burned in an ordinary furnace, as much heat is required for liberating the volatile products of the coal as is afterwards produced by the combustion of these volatile products, taking into account the cooling effect of the air admitted to maintain their combustion. Hence the very high evaporative power of anthracite coal, which, unfortunately, has certain countervailing disadvantages, that preclude its use in the boilers of a steam-vessel under ordinary circumstances. It is not only very difficult to light, but when lighted can be maintained in active combustion only by the aid of artificial draught, when the heat evolved is so intense as rapidly to destroy the fire-bars, as well as the material of the boiler itself.

Anthracite.

Welsh coal.

Welsh coal, which holds an intermediate rank as to its evaporative power between anthracite and the bituminous coals of the northern district, is considered the most suitable for steamers in general, and is much more easily stoked than bituminous coal.

Treatment of bituminous coals.

As Newcastle and other bituminous coals demand careful and peculiar treatment in the furnace, it may not be out of place here to give some directions for stoking it. The fires should be kept at a uniform thickness of from 12 to 14 inches. When the furnaces of one boiler are being charged, the fresh coal should be thrown upon the right-hand half of each fire in succession for one charge, and then upon the left-hand half of each fire during the next charge, and so on alternately, so that the whole fire may never be covered with "green" coals at once. The green coal is to be thrown upon the front half of the fire only, and never at the back of the fire, but when necessary the red burning fuel must be pushed back by the shovel, to keep up the proper thickness of the fires at the bridge. Where no means are provided for admitting air through the fire-doors, these must be left slightly open, after charging with fresh coal. By a due observance of the three last directions, the formation of black smoke with north country coal may be prevented. The cinders, as they fall through the spaces between the fire-bars, are to be raked forward in the ash-pits, and at every fresh charge a portion of them is to be thrown upon the fires after the green coal, so that nothing is removed from the stoke-hole but clinkers and ashes. The spaces between the fire-bars are at all times to be kept clear of clinkers and ashes, so that the air may have free access to the burning fuel. When the coals cake on the bars, the poker must be gently used to raise and open them for the admission of air to the mass of the burning fuel.

Patent fuels.

Some of the "patent fuels" have a very high evaporative power, but they are all, more or less, difficult to manage in the furnace, and should never be used where the stokers are unaccustomed to their peculiarities. They are very valuable in special cases, from the compactness with which they may be stowed.

Marine engines.

We shall now advert to a few particulars having reference to the general construction and management of the Marine Engines of steam-vessels. The first valve through which the steam passes after leaving the boiler is the *throttle-valve*, by means of which the flow of steam to the engines is regulated or shut off entirely by hand. In the event of a ship pitching very much in a heavy sea, it is often necessary to station a man at the throttle-valve to shut off the steam from the engine whenever it begins to "race," or fly off at a high velocity, according as the resistance is removed by the propeller becoming raised out of the water. Both paddle and screw engines are subject to this dangerous action, but particularly the latter, on account of the screw being, from its position in the ship, more exposed to sudden variations of "dip" or immersion. To mitigate this (in some measure), the contrivance called a "governor" has been successfully applied in many cases of screw-steamers, whose consumption of fuel in bad weather has been thereby much diminished, as well as the working of the machinery rendered more regular. Indeed, the commander of a screw-steamer has often found it practicable, after this little instrument had been fitted to his machinery, to keep his vessel head to wind in such weather as would have formerly necessitated his laying to.

Marine governor.

Description of Silver's governor.

The annexed figure (23) represents the best, and indeed almost the only, species of marine governor that has yet been applied. It is called "Silver's momentum-wheel governor," constructed by Messrs J. Hamilton and Company of Glasgow, who have purchased the patent. "It consists of a momentum-wheel A, fixed on the boss of a pinion B, which works loosely on the spindle C, and gears into the two-toothed sectors DD. These two sectors, being supported on a crosshead E, made fast to and carried with the spindle C, work in opposite directions on the pinion B; and as they are linked by the rods FF to the sliding collar G, which receives and works the forked lever H, communi-

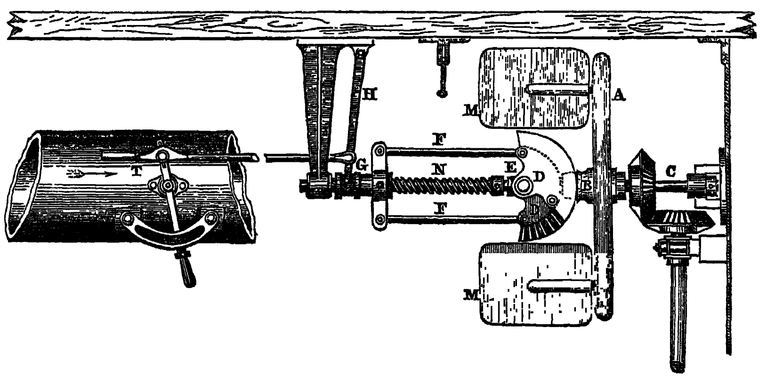

Fig. 23.
Silver's Marine Engine Governor.

cate motion to the throttle-valve T. MM are vanes, and N is a spiral spring, both of which are adjustable."

"The action of the above instrument is as follows:—When the spindle of the governor is turned by the engine to which it is attached, the two toothed sectors, which are carried on the fixed crosshead, being geared into the pinion on the momentum-wheel, have the tendency to turn round on this pinion; but as they are linked to the sliding collar, they necessarily pull inwards this collar, and so compress the spiral spring, and this spring reacting on the collar, and consequently on the toothed sectors, serves to turn round the momentum-wheel, while the vanes on the momentum-wheel balance the action of this spring by the resistance the atmosphere offers to their progress through it. As the leverage action of the toothed sectors upon the momentum-

wheel pinion increases (as the spring becomes distended, and *vice versâ*), it will be seen that the reaction of the spring in propelling the momentum-wheel will at all times be uniform, and as much only is required as will carry round the momentum-wheel with its vanes at its proper speed, and overcome the friction of working the throttle-valve and throttle-valve connections. When the momentum-wheel is in motion, it will rotate with the engine to which it is attached at a velocity proportioned to that at which it is fixed by the connecting gear; and while the engine, from the usual causes, may attempt to vary this velocity, it cannot affect the momentum-wheel, but leaves it free to act upon the sliding collar, and consequently upon the throttle-valve—at one time closing the throttle-valve by its action in resisting any increase of velocity, and at another time opening the throttle-valve by its action in resisting any decrease of velocity on the part of the engine. A momentum-wheel of 2 feet 8 inches in diameter, and 2 inches breadth of periphery, running at a speed of 180 revolutions per minute, is found to be sufficient to work with promptness and ease the largest throttle-valve."

The same engineers have also introduced, for this purpose, an ingenious modification of the ordinary Watt's centrifugal governor, called "Silver's four-ball governor," in which the action of a spiral-spring is substituted for that of gravity, and the whole apparatus (like the preceding one) is balanced, so as to remain undisturbed in its action by the pitching or rolling of the vessel.

Jensen's marine governor.

It is evident that the action of all such governors is so far imperfect, that they do not shut off the steam before the speed of the engine has begun to be sensibly affected by the very evil it is desired to remedy, and it has been therefore attempted (by Mr Jensen of Copenhagen) to construct a marine governor, which may make use of the *cause* of the evil as the remedy against it; or, in other words, to employ the irregular immersion of the vessel as the means of regulating the engines, in preference to letting the engines regulate themselves. This he effects in a very simple and ingenious manner, by employing two small cylinders, which communicate with the sea below their pistons, whose motion is then transmitted, by rods and bell-cranks, to the throttle-valves of the engines. These cylinders are placed inside the vessel (one on each side), and as near as possible to the position occupied by the propeller. As the sea has free admission under the pistons, the latter are subjected to a varying pressure of water, nearly corresponding with that to which the propeller itself is exposed. This varying pressure (modified by the action of a spiral spring) is therefore communicated immediately to the throttle-valves through the cranked rods, and thus shuts off or admits the steam before the engines have felt the variation in the load about to be transmitted to them from the propeller.

Expansion-valve.

The steam, after passing the throttle-valve, next enters the *expansion-valve*, where it is cut off at any desired portion of the stroke, by the action of an eccentric, or cam, on the main shaft. Such an arrangement is shown in Plate XXIX. The valve usually employed for this purpose is the "equilibrium" or "double-beat" valve, as shown in the annexed engraving. This kind of valve has the advantage of being opened and shut with great facility, since, from its construction, the pressure of the steam has no tendency to jam it against its seat, the objection to which all single flat valves are subject. It is also apparent that a slight rise of this valve gives a large opening for the steam to pass. In the engraving, the valves *a a* are made of *brass*, and the valve-box, and the spindles connecting the valves, are of *iron*. In this instance the valves are purposely connected by iron spindles, in order that the linear expansion of the sides of the box containing the valves, and of the spindle connecting them, may be equal in amount, and therefore have no tendency to raise the upper valve off its seat, which would certainly ensue were the valves connected by a brass spindle, in consequence of the greater expansion of that metal by heat. This arrangement of the metals will be seen to be of special importance when superheated steam is used, and the temperature thereby increased.

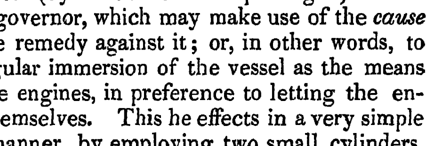

Fig 24.

Slide-valves.

Having passed the expansion-valves, the steam now enters the jacket of the cylinder *slide-valves*. These are usually so constructed and arranged as to fulfil the following conditions for the admission and exclusion of the steam, independently of the action of the expansion-valves:—1*st*, The steam is shut off a little before the end of the stroke, by the valve prematurely closing the steam-port aperture. The use of this is to check the velocity of the piston, by causing it to finish the stroke by the expansion of the enclosed steam only. This is effected by giving "lap" to the valve. 2*d*, The eduction-port, or the passage to the condenser, is closed a little before the end of the stroke, which is called *cushioning* the piston, because it then completes the stroke against an elastic *cushion* of vapour shut up between it and the top or bottom of the cylinder. 3*d*, The port is opened for the admission of steam to the cylinder a very little before the piston begins the return-stroke, in order that the steam may have filled the passages and the "clearance" of the piston, and have acquired its full pressure, by the time that the crank shall have turned the centre. This is effected by giving what is called "lead" to the valve. 4*th*, The communication with the condenser is opened a little before the end of the stroke, so as to have a vacuum ready made in the cylinder so soon as the return stroke begins. In this way each operation which takes place in the cylinder is slightly *anticipated* by the mode of setting the valves. In the case of screw-engines especially (which run at a high velocity), it is of the greatest importance that the steam-passages and valves should be of ample size, and those valves only should be used which give a large opening for the steam, with a short "travel" of the valve.

Condenser.

As the nature and limits of this article preclude a minute description of the details of the marine engine (which indeed are very similar to those of the stationary condensing engine, already given in the article STEAM-ENGINE), we will not attempt this, but at once follow the steam from the cylinder into the *condenser*. In this magical little chamber the whole of those perplexing processes we have been considering are at once reversed, and all the labour and expense incurred in generating the steam in the boilers (themselves about twenty times larger than the condenser), are, as it were, instantly annihilated. The condensation of the steam is usually effected by the dispersion of a jet of cold sea-water amongst it, which is the most effectual means yet known for producing that instantaneous condensation, upon which the efficacy of the process is entirely dependent.

Surface-condensers.

Many attempts have been made, as we have before stated, to condense the steam by contact with cold metallic surfaces without the use of the water-jet, but they have all, more or less, failed, from the condensation not being sufficiently sudden. The plan known as "Hall's Condensers" is, indeed, partially successful; but, owing probably to their weight, bulk, complexity, and expense, they are very little used, although it is now twenty years since their first introduction. In most surface-condensers the steam is passed through a great many small copper pipes, contained in a cistern of cold water, through which a current from the sea is made to flow by means of a force-pump. In such an arrangement, the loss of water arising from

Steam Navigation.

leakage, or from blowing-off at the valves, is compensated to the boiler by employing a small apparatus to distil sea-water, by the aid of which the boilers are kept constantly supplied with fresh water. A close connection exists between the temperature of the condenser and the vacuum, the latter being of course more complete as the temperature is reduced. There is a limit, however, beyond which any further reduction of temperature, by injecting more sea-water, is attended by a loss of power. It is found in practice, that a temperature of from 95° to 105° (depending upon the pressure of the steam), is the most economical, with which a vacuum of from $27\frac{1}{2}$ to 26 inches of mercury is obtained when the weather barometer stands at $29\frac{1}{2}$ inches, the standard of this country. It is a curious fact, and contrary to what might at first sight have been anticipated, that a better vacuum, and a lower temperature of the condenser, is obtained with superheated steam, than with common steam, being probably owing to the more perfect condensation of the steam, when not mixed with particles of hot water held in mechanical suspension. This fact appears also to indicate, that the extra doze of heat contained in the superheated steam has been all previously and usefully expended in the cylinder (by supplying the expanding steam with latent heat), and that no portion of it survives to enter the condenser. Whatever the cause may be, the result is, that considerably less injection-water is required when superheated steam is used, much to the surprise of the engineer in charge.

Best vacuum for the condenser.

Superheated steam condenses freely.

Contents of the condenser.

According to Dr Ure's experiments, uncondensed watery vapour at a temperature of 100° balances 1·86 inch of mercury; at 110°, 2·45 inches; at 120°, 3·3 inches; at 130°, 4·366 inches; at 140°, 5·77 inches; and at 150°, 7·53 inches of mercury, or exerts a pressure of $3\frac{1}{4}$ pounds per square inch. In addition to the uncondensed vapour, a considerable quantity of atmospheric air is always present in the condenser, having entered it in combination with the condensing water. The contents of the condenser, therefore, are sea-water used for condensation, condensed steam, uncondensed watery vapour, and atmospheric air. To remove these is the duty of the *air-pump.* It has a capacity of about $\frac{1}{8}$ths of that of the cylinder, and is furnished with a "bucket" and valves, which are now usually formed of a stout circular disc of vulcanized India-rubber. The air-pump draws its contents from the condenser through the *foot-valve,* and then passes them on through the *delivery-valve* and the *discharge-pipe* into the sea, a small portion of the hot water being abstracted by the feed-pumps to supply the boilers.

The air-pump.

Marine engines should be simple.

The machinery of a sea-going steamer should be as simple in design and possess as few moving parts as possible. In vessels designed for long voyages more especially, as well as in those which are intended for foreign stations, it is far preferable to dispense with those clever and ingenious contrivances for saving infinitesimal quantities of fuel which are in vogue with some manufacturing engineers of the present day, and more especially in Scotland. During a long run, as from Aden to Australia, for instance, the chances of derangement of the machinery are much increased by the mere inability to make the usual adjustments demanded by ordinary wear and tear; and it is surely wise to avoid the additional risk attending a great multiplicity of parts, the failure of any of which may cause the stoppage of the engines. When we consider that a large pair of engines may very possibly have five hundred different parts all in motion at once, and that each of these parts is making a thousand rotations, or double-oscillations, each half-hour, for twenty days consecutively, it can scarcely be wondered at that accidents should occasionally happen. But allowing that everything goes well with this complicated machinery, it is not by the use of such finical refinements of mechanism that any great saving of fuel can be effected (for this is the main point aimed at), but rather by the careful and judicious management of the boilers and engines. The fortunate selection of a good chief-engineer for the vessel will generally effect more saving in fuel than the most ingenious and expensive "modern improvements." These remarks are not intended to apply to the obvious advantages obtained by superheating the steam, large expansion, careful clothing (or jacketing) of the cylinders and steam-pipes, &c., which do not add much to the complexity of the engines.

Large bearings necessary.

The tendency of modern practice is to run the pistons of steam-engines at a much higher speed than formerly. This is more especially the case with screw-engines, whose pistons frequently run at the rate of 400 feet per minute, in place of Watt's old rule of 220 as a maximum. Although theory does not impose larger dimensions on the moving parts of a machine on this account, it is found in practice that the shafts of screw-engines running at a high velocity must be considerably increased in size to avoid accident. This arises partly from the increased momentum of the parts in motion; partly from the greater tendency of the bearings to heat from friction; and partly from the more rapid wear and tear of the brasses and sockets, by which the accurate fitting of the parts is destroyed, and these are consequently subjected to unequal jerks and strains. The simple remedy for such disorders is to enlarge the main-shafts and bearings, the latter being also made unusually long, so as to diminish the effects of friction and wear and tear.

Linings of bearings.

The iron shafts of marine engines revolve in sockets or bearings lined with brass or gun-metal. These give rise to little friction, but, as their wear is rapid, they require frequent attention to keep the lining screwed up to the neck of the shaft, and they must be renewed when much worn. In the case of screw-ships, where the bearings of the screw-shaft are not readily accessible, this used to give much trouble, until it was found out (partly by accident) that bearings lined with *lignum vitæ* instead of brass are subject to exceedingly little wear or friction. A plan has been therefore adopted of fitting these bearings with rings of *lignum vitæ* alternating with rings of gun-metal, which answers very satisfactorily.

Deterioration of shafts.

Before leaving the subject of shafts, it may be remarked that these, whether paddle or screw, appear liable to deteriorate by continued use, and finally to give way, sometimes suddenly, but oftener gradually. It is contended by some that the iron of which they are formed has a tendency to lose its toughness, and assume a crystalline texture, from long exposure to the shocks and vibrations to which all such shafts are subject. Having had very many opportunities of observing broken shafts, the author does not hold with this theory, but thinks the following explanation to be more probable. It is allowed to be a difficult operation to make large shafts perfectly sound in the centre, where the bars of iron of which they are built up are not always thoroughly welded into one homogeneous mass. These imperfections, when they exist, are of course not visible on the outside, nor do they seriously affect the strength of the shaft at first; but as the continued jarring and twisting goes on from year to year, they become more and more developed, and the shaft becomes loose in the centre, acquiring a "reedy" structure which gradually extends to the surface. A fracture then takes place, if the crack be not observed and the shaft renewed.

Lubrication of the machinery.

The efficient lubrication of the bearings and other working parts of the engine with oil or melted tallow is a material point to be attended to, both as regards the smooth working of the machinery and its preservation from injury. From want of this simple precaution the bearings get strongly heated by the friction, and may either be damaged by the consequent expansion which takes place, or else

cracked by the cold water which is usually poured on them from a hose, to cool them down again. Self-lubricating apparatus is preferable for this purpose, wherever it can be applied, as it is both more economical of oil and more certain in its operation. Although compactness in an engine is desirable within certain limits, this should never be carried to such an excess that the engineer is unable to get conveniently about his engine while it is at work, in order to lubricate the parts, and tighten brasses and packings.

Engineer's log.

Every chief engineer of a steamship should be furnished with a printed form of Engineers' Log to be filled up by the engineer in charge during each watch of four hours. It should be arranged in a manner somewhat similar to the annexed form:—

Steamer .... ENGINE-ROOM REGISTER.

Proceeding from .... *To* ....

Date.	Watch ending.	Pressure on Steam-gauge.	Revolutions per minute.	Consumption of Coals.	Barometer, Starboard-Engine.	Barometer, Port-Engine.	Barometer, Atmospheric.	Density of Water of Boilers.	Temperature of the Sea.	Temperature of the Hot Well.	Total Expenditure per 24 hours.							Remarks on the state of the Sea and Wind, &c.
											Coals.				Stores.			
											For Engines.		For Ship.		Oil.	Tallow.	Waste or Oakum.	
	Hour.	Lb.	No.	Lb.	In.	In.	In.	Deg.	Deg.	Deg.	Tons.	Cwt.	Tons.	Cwt.	Galls.	Lb.	Lb.	

Note.—Indicator-diagrams to be taken occasionally.

Steam-vessels are propelled either by paddle-wheels or screws.

Paddle-wheel;

1. Paddle-Wheels.—There are two kinds of paddle-wheels in general use in this country, namely, the common wheel, and that with feathering floats. The common paddle-wheel, notwithstanding many attempts to supersede it, still maintains a high place as a simple and efficient propelling agent; the faults which have been attributed to it being, it is believed, more apparent than real. When a steam-vessel is moored in a harbour and prevented from moving, or when first commencing motion after having been at rest, the defects of the common paddle-wheel appear to be very great. The paddle-boards, on entering the water, press obliquely down into it, tending to raise or lift the vessel up out of the water with a force which produces no useful effect. Again, when the paddle-board is leaving the water, it seems to do little more than raise or drive the water upwards in the form of back-water. It is only, therefore, in the middle of its path that the propulsion of the paddle seems to be exerted in forwarding the boat, and that only for a short time. A large part of the force of the steam-engine seems thus to be expended in raising the vessel, and in elevating the back-water, and only a small portion in carrying the ship forward.

its defects are more apparent than real.

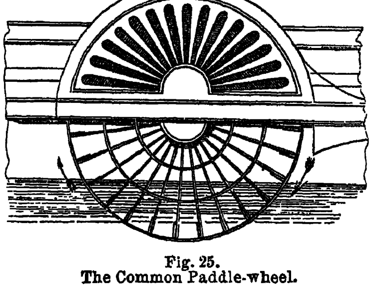

Fig. 25.
The Common Paddle-wheel.

This is the case of a vessel at rest, or not in rapid motion; but the phenomena of a paddle-wheel revolving when the vessel is in motion differ essentially from the phenomena of a wheel revolving on a vessel at rest. When it is just starting, or as yet moving very slowly, the evils here mentioned do in some degree take place; but by the motion of the vessel forwards (which is the result of the revolution of the paddles), the faults complained of are at once remedied, and the paddle-float of a common wheel in a quick vessel is virtually "feathered" as perfectly as the most practised rower could feather his oar. A little study of the geometrical conditions of a paddle moving forwards and in a circle at the same time renders this plain. The paths described by the boards are trachoidal curves, being of the family of the cycloid; and from the study of the motion actually performed by the paddle-board of the common wheel, it is seen, first, that the board is inserted into the water in an angular position resembling closely the entrance of an oar into the water; secondly, that it is then made to act horizontally on the water during a short interval; and thirdly, that it is withdrawn from the water edgeways, with an easy and graceful movement.

Its actual motion.

Feathering paddle-wheel.

When the paddle-wheel is either badly proportioned, immersed too deep in the water, or attached to a very slow boat, its action becomes much impaired or impeded. Hence much attention has been devoted to the construction of a paddle that should be more effective in these unfavourable circumstances than the common wheel. Some of the contrivances invented for this purpose have failed for want of perception of the precise motion it was necessary to give to the paddle-board; others from the complexity of the mechanism employed. In the year 1829 a patent was granted to Elijah Galloway for a paddle-wheel with movable boards, which patent was purchased by Mr William Morgan, who made some unimportant alterations in the

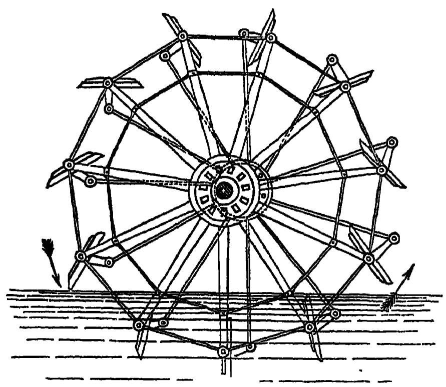

Fig. 26.
Feathering Paddle-wheel.

mechanism. This, called the feathering paddle-wheel, is represented by the above wood-engraving (fig. 26), by

Steam Navigation.

inspecting which it will be seen that a distinct feathering movement is imparted to the boards on entering and leaving the water. This movement, it will be observed, is derived from the excentric motion of the periphery of the second paddle-centre, to which are hinged the long rods that communicate the desired movement to the boards turning on pivots. Wheels made on this principle, though considerably heavier and more expensive than the common paddle-wheels, are frequently preferred for sea-going steamers subject to much variation of draught. They have been known to improve the average speed of a steamer by more than a knot an hour, and they are always accompanied with less vibration than the common paddles.

Slip of the paddle.

The "slip" of the paddle-wheel, by which is meant the excess of its velocity above that of the vessel, is usually reckoned at $\frac{1}{5}$th (or 20 per cent.) of the vessel's speed when the wheel is well proportioned, and the vessel tolerably fast. Feathering wheels have less slip.

Want of power in a steamer to start a load.

The captains of steamers are frequently both surprised and disappointed to find how powerless their vessel is to drag a stranded ship off the shore, even when the whole power of their engines is exerted for this purpose. A slight consideration of the subject will show that the requirements of such a case are very unfavourable to the proper development of the power of a steamer. We will suppose a vessel fitted with a pair of paddle-wheel engines of 500 horse-power collectively. The diameter of each cylinder will then be, say, 80 inches, and the stroke 6 feet. The length of the crank will therefore be 3 feet, driving a paddle-wheel of, we will suppose, 28 feet effective diameter, reckoned at one-third of the depth of the boards from their extreme edge. When the piston of each engine alternately arrives at the top or bottom of its stroke, that engine is then powerless, and the whole of the work devolves upon the other engine, which is then at half-stroke, with the crank nearly at right angles to the thrust, and therefore in the most advantageous position for transferring the power. By bringing the pistons of both engines to $\frac{3}{4}$ stroke, we obviously improve upon this, for now both engines are assisting to turn the shaft, though acting at a reduced leverage in the proportion of 3 feet to 2·15 feet nearly. By calculating the pressure upon the two pistons, we find the statical power exerted by the engines (the one *pushing* and the other *pulling*); but as the thrust thus found is transmitted by a lever of the second order, the short arm of which is the crank, and the long arm the radius of the paddle-wheel, it is necessarily reduced in the inverse ratio which these bear to each other, or as 14 : 2·15. The calculation would then be as follows:—

Explanation.

$$\overset{\text{Sq. in.}}{5026\cdot5}\ (\text{area of cyl.}) \times \overset{\text{lb.}}{22} \left\{ \begin{array}{l} \text{supposed effective press.} \\ \text{per sq. inch of piston..} \end{array} \right\} \times 2\ (\text{for both cylinders}) = 221\cdot166\ \text{lb.} = 98\cdot75\ \text{tons total pressure on pistons.}$$

Then as 14 : 2·15 : : 98·75 : 15·16 tons.

This being further reduced by 20 or 25 per cent. for the friction of the machinery, working the air-pumps, &c., leaves scarcely eleven tons of thrust available for starting a weight, or dragging a stranded vessel off the shore, by a steamer of 500 nominal horse-power.

A similar calculation made for screw-engines shows a like result.

Definition of a screw.

2. *Screw-Propeller.*—A screw as used for propelling vessels may be defined as a metal plate wound, edgeways, round a cylinder or spindle, as shown in the accompanying sketch (fig. 27 *a*), which represents one full turn of the common screw.

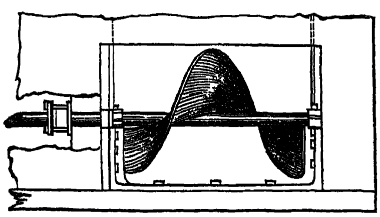

Fig. 27 *a*.

This would be a single-threaded screw, but it is evident that two, three, or more threads, if kept uniformly parallel to each other, may in the same way be wound round the spindle without interfering with each other. We should thus have a two-threaded or a three-threaded screw, the former being chiefly used for propelling in the navy, and the latter in the merchant service. The whole length of one complete turn of the screw, measured in a straight line along the spindle, is called the PITCH of the screw. In the preceding engraving, therefore, the pitch is measured by the length of the spindle (fig. 27 *a*), since the thread makes one complete turn upon it. It is also apparent, that if this screw were turned once round in a piece of soft wood (in the same manner as a carpenter's screw), it would advance through the wood the exact distance between the cut ends of the thread, which (we have seen) is the pitch. Hence, by the pitch of a screw, we understand always its linear progression for one revolution, and the speed of the screw is measured by multiplying the pitch into the number of revolutions. If the screw were working in a solid, the speed thus found would give its actual linear advance; but as it revolves in water, which is a yielding medium, the water gives way to some extent, and the screw does not advance the full amount of its pitch, this deficiency in its progress being called the SLIP of the screw.

Pitch of the screw.

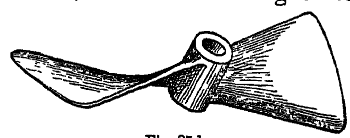

Fig. 27 *b*.

Slip of the screw.

Form of the screw-propeller.

Now, if the screw represented by fig. 27 *a* be cut into several portions by planes passing across it at right angles to the axis, each of these sections would have the appearance of the vane of a windmill. If the screw were two-threaded, the vanes or "blades," as they are called, would be exactly opposite each other, as shown in fig. 27 *b*, or as in the annexed sketch, fig 28 *b*, which represents a two-bladed screw as used in propelling. The

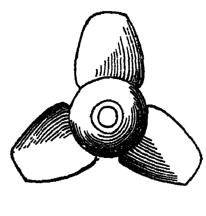

Fig. 28 *a*.

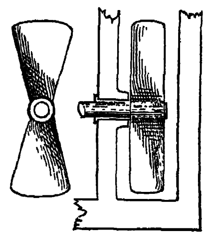

Fig. 28 *b*.

screw here represented is about one-sixth part only of the whole length, or *pitch*, of the full turn of the screw shown by fig. 27 *a*, this small fraction of the pitch being found sufficient to absorb the whole power of the engines, so that any greater length of screw would only be hurtful by causing unnecessary friction, as well as by increasing the size of the aperture in which it works. By the LENGTH of the screw, therefore, is meant the fraction of the pitch employed, measured along the axis of the screw. By the DIAMETER of the screw is meant the diameter of the circle described by the extremities of the blades during their revolution.

Action of the screw in propelling.

The effect produced in propelling the ship will be best understood by supposing the screw represented by fig. 27 *a*, to be revolving rapidly in a trough full of water. It would then send the water away from it with great force; but as action and reaction are equal, it would be itself, at the same time, urged in the opposite direction with exactly the same degree of force. If we suppose it, then, to be fixed in a ship, the ship will be pushed *forward* with the same force that is exerted by the screw in pushing *back* against the water. If the screw is made to revolve in the opposite direction, the converse of this takes place, and the ship is then pushed backwards by the reaction of the screw.

Different forms of screws.

The screw-propeller has been subjected by would-be inventors to an endless variety of form; but these have generally shown themselves more or less inefficient according as they may have departed from the principle of the true screw. The first patent of any interest connected with this subject is that of Mr B. Woodcroft, taken out in 1832, for an "increasing pitch" screw-propeller. His specification describes "A spiral worm-blade or screw coiled round a shaft or cylinder of any convenient length and diameter, in such form that the angle of inclination which the worm makes with the axis of the cylinder continually increases, and the pitch or distance between the coils or revolutions of the spiral continually increases throughout the whole length of the shaft or cylinder upon which the spiral is formed." Mr Woodcroft's idea, that the after-part of the screw would thus be made to act with increased efficiency upon the water which had been previously acted upon by the foremost part, is undoubtedly correct in principle, and had a full turn of the thread been found necessary for propelling (as was at first thought), this plan would probably have been found practically advantageous; but when the length of the screw was cut down by Lowe to one-sixth part of the pitch, very little scope was afforded for Mr Woodcroft's refinement, and it has proved to be really of little or no value.

Woodcroft's propeller.

Smith's screw.

Mr F. P. Smith's patent was secured in 1836 for "a sort of screw or worm made to revolve rapidly under water in a recess or open space formed in that part of the after-part of the vessel commonly called the dead rising or deadwood of the run." Mr Smith's original drawings showed a screw with two whole turns of the thread, which was afterwards altered in 1839 to one whole turn.

Lowe's screw-blades.

Mr James Lowe obtained a patent in 1838 for a screw-propeller formed of "curved blades, each a portion of a curve, which, if continued, would form a screw." The drawings attached to his specification show a shaft with one blade, a shaft with two blades, and a shaft with four blades. The screw-propeller now generally used (see fig. 27 *b*, and fig. 28 *b*), may be considered as a combination of Smith's screw and Lowe's blades, its present form having been in a great measure determined by the series of experiments with the Rattler in 1844. (See page 660.)

Griffith's propeller.

Griffith's screw-propeller, first patented in 1849, is probably the best modification of the common screw which has yet been produced. Its principal feature consists in the employment of a large sphere occupying the central portion of the screw. The second peculiarity of Griffith's screw consists in the peculiar form of the blades, which, unlike those of the common screw, are larger towards the centre, and tapering towards the extremities. The extremities of the blades are curved from the front or propelling side towards the vessel, which causes the screw to take a greater hold of the water, and drive it towards the inner or central portion, which, in Griffith's screw, is the most effective part.

Description.

This propeller is represented in its simplest form by the wood-engraving (fig. 28 *a*), and as recently improved by the annexed engraving (fig. 29.) It will be seen that this propeller consists of three main parts, viz., the boss which is keyed on to the screw-shaft in the usual manner; and the two blades, which have turned shanks fitting into bored recesses in the boss. Each blade is retained in its position by a key, which is adjusted into its place after the blade has been inserted and turned in its socket about ninety degrees, or until the arrow marked on the flange points to the pitch which it is desired the screw shall have, of which several have been previously measured, and marked upon the screw.

When Griffith's screw was first introduced, it was expected that great advantages would result from an arrangement in its construction (which it shared with Maudslay's feathering screw), by which the pitch or angle of the blades could with facility either be increased, diminished, or "feathered" during the voyage, to suit the varying exigencies of a steam-vessel at sea. Experience, however, has proved that the risk of derangement incident to the machinery requisite for this purpose is too great to admit of practical success, and also that the advantages to be obtained by such an arrangement are far less than was supposed. The use of screws to feather at sea has, therefore, been very generally abandoned.

Feathering-screws not successful.

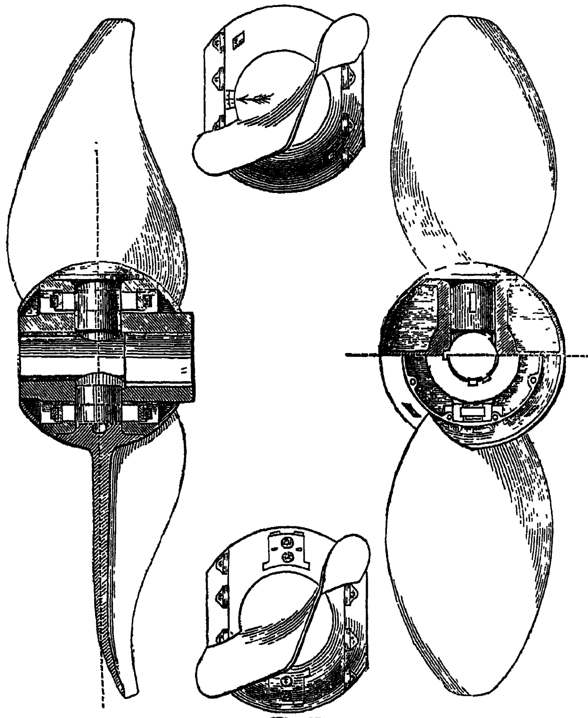

Fig. 29.
Griffith's Improved Patent Screw-propeller.

Advantages of Griffith's screw.

It will be observed, by looking at the engraving, that the blades of Griffith's screw are quite distinct from the boss, into which they are inserted and keyed in such a manner that their angle or pitch may be altered and fixed before the voyage, though not at sea. The use of this arrangement is, that the engineer may find out *experimentally* the particular pitch of his screw which is most suitable to the engines and ship, experience having shown how very difficult a thing it is to hit upon the right pitch by previous calculation alone. Another advantage resulting from this arrangement is, that when a blade is accidentally broken, it can be replaced without having to remove the centre part, which in Griffith's form of screw is tolerably safe from injury. It is unnecessary, therefore, to carry a spare screw, but only a couple of blades. When the ship is placed under canvass alone, the screw is brought into a position with the blades vertical, in a line with the stern-post, when little resistance is offered to the water. Although Griffith's screw cannot be said to have shown any very decided superiority in speed over a common screw of the best form, it is certainly not inferior in this respect, while it is attended with less vibration, is less affected by a rough sea, and is more manageable under canvass from offering less resistance to the water, and less obstruction to the free action of the rudder.

Common screw.

When the common screw is employed in merchant-steamers, a three-bladed screw is usually preferred, since this causes less vibration, and gives a steadier motion in a rough sea than the two-bladed screw.

Resistance to sailing.

The resistance which such a screw occasions to the vessel, when sailing under canvass alone, is very serious, in addition to the difficulty experienced in steering; and it is found in practice, that but little advantage is gained by disconnecting the screw from the engines, and letting it revolve in its bear-

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ings, in preference to *dragging* it through the water. Hence, in the case of steamships which depend much upon their canvass, one of three remedies must be adopted: namely, the screw must either be hoisted bodily out of the water; it must be feathered; or, thirdly, such a form must be employed (as Griffith's two-bladed screw, for instance), which will not interfere much with the sailing and steering of the ship, when the blades are placed vertical, and the screw left down in its place.

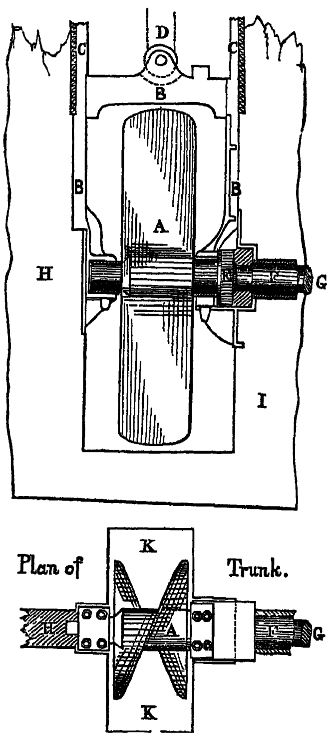

Fig. 30.

Hoisting screw.

The *hoisting* screw has been adopted generally for war-steamers, which are supposed to make great use of their sails, and which have a larger number of men available for quickly hoisting and lowering it. The annexed engraving shows the manner in which this is effected in the royal navy.

Description.

A is the screw (of gun-metal); B is the hoisting-frame (also of gun-metal) which lifts the screw, with its bearings, bodily out of the stern-frame of the ship; C is a gun-metal rack, to hold the hoisting-frame at any portion of its ascent; D is the chain and pulley used in hoisting; E is a clutch upon the screw-shaft, to enable the screw to be disconnected, and rise when brought into a vertical position; F is the gun-metal lining of the screw-shaft, which passes water-tight through the inner stern-post I; G is the iron screw-shaft; H is the outer stern-post; K is the "trunk" through which the screw is raised to the main-deck, when the blades are brought vertical.

Having now seen what are the principal forms of screw-propellers in general use in this country, let us briefly examine some of the qualities inherent in the screw itself.

Functions of the pitch of a screw.

1. *Pitch.* The question between the relative valves of fine and coarsely pitched screws still remains, in a great measure, undecided. In fact, our experience hitherto has only tended to show, that nothing but actual trial of different pitches can satisfactorily establish the best pitch of screw for any particular vessel. The points to be considered in reference to this inquiry are so numerous and complicated in their bearings upon each other, that they utterly defy previous calculation of their effects; some vessels giving the best results with coarsely-pitched screws running at a low speed, while other vessels, not very dissimilar, attain their highest velocity with a finely-pitched screw running fast. It is generally acknowledged, however, that a coarsely-pitched screw is the best for a vessel with fine after-lines, and a finely-pitched screw for vessels with full sterns. The form of the after-lines has undoubtedly a very great influence on the most advantageous pitch of screw for that particular ship, depending on the amount of "back-water" in which the screw works, and the velocity with which it follows the ship. It is by no means an uncommon thing for one vessel to gain a knot an hour by an alteration of the pitch; while in the case of another vessel, perhaps, no improvement is effected by a similar alteration.

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Diameter.

2. *Diameter.* This is made simply as great as the draught of water will admit. In sea-going steamers the top of the screw should be submerged about 18 inches or 2 feet at the average trim, to allow for the undulations of the sea.

Area and length.

3. *Area and Length.* By the area of the screw is generally understood the plane projection of the resisting surface of the blades. In the experiments made with the Dwarf, it was found that the speed of the vessel remained almost a constant quantity, although the length of her screw was successively diminished from 2 feet 6 inches to 1 foot, the *area* corresponding to each of these lengths being respectively 22·2 and 8·96 square feet. The slight improvement which did take place in the speed of the boat attended the diminished area. It seems at first sight extraordinary that so great a variation in the resisting surface should cause so little disturbance either in the speed of the engines or of the vessel, thus showing plainly how small a segment of the whole pitch is required to absorb all the power which the reaction of the water is capable of imparting, any extra length of screw beyond this point only retarding by friction. The Rattler's experiments were in the same way commenced with a screw 5 feet 9 inches long, which was gradually shortened until it reached its point of maximum effect at 15 inches only. It is now a common practice to make the length of the screw $\frac{1}{6}$th of the pitch.

Slip.

4. *Slip.* The apparent slip of the screw depends upon a great variety of circumstances. It is modified by the diameter and by the speed, being generally found to diminish as these increase. Thus, the diameter of the Rattler's screw, during her experiments, was 10 feet, and her average slip 15 per cent.; while the Dwarf and Fairy, with screws of 5 or 6 feet diameter, show an average slip of about 35 per cent. The form of the after-lines of the vessel has a very notable effect on the apparent slip of the screw, which must not be regarded as a measure of the efficiency with which the propeller is acting. On the contrary, many vessels whose lines are most unfavourable for speed show an exceedingly small slip of the propeller; and in some instances of this kind there is not only *no slip* apparent, but the screw has actually what is called *negative slip*, which implies that the vessel is going faster than the rate at which the screw which propels it would advance if working in a solid.

Negative slip.

This curious and paradoxical result is due to the current which all ships, more or less, but especially those with full sterns, carry in their wake; and since the screw acts in this current, the *apparent* slip will be positive or negative in proportion as the *real* slip, or the velocity of the current, may preponderate; but in every case the screw must have some slip relatively to the water in which it acts. Suppose, for instance, that a badly formed ship has a current of water following in its wake, and closing in upon the screw at a velocity of 4 miles an hour, while the *real* slip of the screw is but 3 miles an hour, the result will be that the screw will show an apparent negative slip of 1 mile an hour. It must not be supposed that in such a case the power of the engines is economically applied, for, in fact, much power is uselessly consumed in dragging this current of water after the ship. The same apparent diminution of slip is always found when the vessel is advancing with a tide or current. Anomalies of this kind most frequently occur in auxiliary screw-steamers, where the vessel, after attaining a high velocity by sails alone, still continues to receive a propelling thrust from the screw, even after the speed of the latter *appears* to be less than that of the vessel.

Trials of screws in the Rattler.

In order to give the reader some perception of what really are the conditions of the screw most conducive to speed in the vessel, I have selected the trials of twelve different screws made in the same vessel, the Rattler, arranging them in the order of their relative efficiency, beginning with the lowest.

1. With a four-threaded Woodcroft's increasing pitch screw, 9 feet diameter, 1 foot 7 inches long, and the pitch varying from 11 feet to 11 feet 6 inches (mean 11·275), the speed of the vessel was 8·159 knots; the engines making 24·15 revolutions per minute, and the screw 96—slip, 23·5 per cent.

2. With a three-threaded common screw, 9 feet diameter, 3 feet long and 11 feet pitch, the speed of the vessel was 8·23 knots; the engines making 24·2 revolutions, and the screw 94·3—slip 19·66 per cent.

3. With Sunderland's propeller, 8 feet in diameter, the speed of the ship was 8·38 knots; the engines making 17·49 revolutions, and the screw-shaft 69 97.

4. With the same screw as No. 2, reduced in length to 1 foot $7\frac{1}{2}$ inches, the speed of the vessel was 8·57 knots; the engines making 24·8 revolutions, and the screw 98·4—slip, 19·7 per cent.

5. With the same screw as No. 1, but with two of the blades cut off, the vessel's speed advanced to 8·63 knots; the engines making 27·07 revolutions, and the screw 107·5—slip, 25·97 per cent.

6. With a two-threaded common screw, 10 feet diameter, 3 feet long, and 11 feet pitch, the speed of the vessel was 8·958 knots; the engines making 24 revolutions, and the screw 95—slip, 13·8 per cent.

7. With a four-threaded common screw, 9 feet diameter, 1 foot 7 inches long, and 11 feet pitch, the speed of the vessel was 9·18 knots; the engines making 26·3 revolutions, and the screw 104·4—slip, 27·7 per cent.

8. With a two-threaded common screw, 9 feet diameter, 3 feet long, and 11 feet pitch, the speed of the vessel was 9·25 knots; the engines making 26·8 revolutions, and the screw 106—slip, 19·5 per cent.

9. With the same screw as No. 6, shortened to 2 feet, the vessel's speed increased to 9·448 knots; the engines making 25·5 revolutions, and the screw 107—slip, 13·5 per cent.

10. With the same screw as No. 6 further reduced in length to 1 foot 6 inches, the speed of the vessel was 9·811 knots; the engines making 27·92 revolutions, and the screw 110·7—slip, 18·3 per cent.

11. With the same screw as No. 2 further reduced in length to 1 foot 2 inches, the speed of the vessel was 9·88 knots; the engines making 27·39 revolutions, and the screw 108·4—slip, 15·97 per cent.

12. With the same screw as No. 6 further reduced in length to 1 foot 3 inches, the speed of the vessel increased to 10·74 knots; the engines making 26·19 revolutions, and the screw 103·97—slip, 10·42 per cent.

Trials made with her Majesty's Steamer Flying Fish.

Screw.								Indicated horse-power of Engines.	Speed of Ship.
Description of Screw.	Diameter.		Pitch.		Revolutions of.	Speed of.	Slip p ct.		
	Ft.	in.	Ft.	in.	No.	Knots.		H.P.	Knots.
Common Screw,	11	0	21	4	82	17·263	$32\frac{7}{8}$	1302·26	11·585
	11	0	21	4	$79\frac{1}{2}$	16·737	$32\frac{1}{2}$	1154·86	11·298
	13	2	20	0	75	14·802	$20\frac{3}{4}$	1166·76	11·736
	13	2	20	0	$74\frac{1}{2}$	14·704	21	1160·60	11·603
Griffith's Screw with feathering blades,	13	$1\frac{1}{2}$	19	0	$71\frac{1}{2}$	13·406	$15\frac{7}{8}$	1198·56	11·284
	13	$1\frac{1}{2}$	17	0	$77\frac{1}{2}$	13·00	$10\frac{1}{2}$	1287·00	11·640
	13	$1\frac{1}{2}$	16	0	$77\frac{1}{4}$	12·197	$4\frac{3}{8}$	1265·00	11.568
	13	$1\frac{1}{2}$	15	0	83	12·286	$3\frac{3}{4}$	1358·80	11·832
	13	$1\frac{1}{2}$	18	0	$75\frac{1}{2}$	13·411	$14\frac{1}{2}$	1226·20	11·461
	13	$1\frac{1}{2}$	17	0	$77\frac{1}{2}$	13·00	$11\frac{1}{8}$	1265·80	11·552

Trials of screws in the Doris.

A very interesting series of experiments has been recently made with the screw-frigate Doris, to determine the most suitable form of screw-propeller for our steam-vessels of war. The following is a resumé of the principal results arrived at, the first five trials having been made with the common or admiralty screw, and the last three with Griffith's propeller. The engines of the Doris (by Messrs J. Penn and Son) are of 800 nominal horse-power. The draught of water while under trial was kept constant at about 19 ft. 6 in. forward and 21 ft. 9 in. aft—exact mean, 20 ft. 6 in.; giving an immersed midship-section of 7421 square feet. Pressure of steam in boilers, 20 lbs.; indicated horse-power, about 3000. The first trial with the admiralty screw was with a diameter of 18 feet, the vessel's speed being 11·823 knots. On the second trial, with the diameter increased to 20 feet, the speed realized was 11·826 knots, with a great increase of vibration; steering imperfect. On the third trial, the "leading" corner of each blade was cut off, and in this form the common screw attained its greatest speed, giving a result of 12·032 knots, with 50 revolutions of engines per minute, and 2384 indicated horse-power; vibration reduced, and steering good. On the fourth trial, both the corners of each blade were cut off, so as to assimilate the blades to Griffith's form, when, with a greater number of revolutions, the speed fell off to 12·012 knots. In the fifth trial, with the "following" corner of each blade cut off, but the screw restored to its perfect form in every other respect, a result of 11·815 knots was obtained. The common screw was then removed, and the next trial was made with Griffith's propeller, 20 feet diameter and 32 feet pitch; this gave a result of 11·981 knots, there being scarcely any vibration, and the ship steering well. The second trial, with the same Griffith's propeller, having the blades set at 26 ft. 6 in. pitch, gave a speed of 12·269 knots, being the highest of the series; steering perfect, and no vibration perceptible; indicated horse-power, 3091. The third trial of Griffith's 20-feet screw, with the blades set at a medium pitch of 30 feet, gave 12·158 knots.

Results of Doris's trials.

Several important points connected with the screw-propeller seem to have been proved by these trials—1*st*, That the leading edge of the screw is the part that mostly affects the steering of the ship, and also causes the greater part of the vibration; 2*d*, That increased diameter of the screw is better than increased pitch for reducing the speed of the engines, but it considerably increases the vibration with the common screw; whereas with Griffith's it did not produce that effect, in consequence of its chief propelling surface being towards the centre. The common screw, when its blades are cut to the form of Griffith's, is not so effective as when the centre sphere is applied to them. The power required to obtain the same speed was very much the same for both screws.

The annexed sketch is interesting from the peculiar markings shown upon the surface of the screw, which is that of the steamer Crœsus. This vessel had on one occasion got under way while the paint on her screw was still wet, and on being docked soon afterwards the paint was found streaked by the water, as here shown.

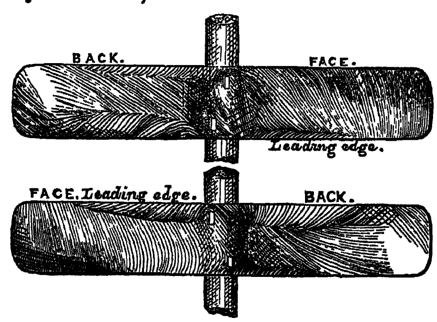

Fig. 31.

Official explanation of the Table of "Results of Trials made in her Majesty's Screw-ships."

"The numbers in the last two figure-columns of the table show approximately the relative excellence, in respect of speed, of the forms of the various vessels, conjointly with the relative efficiency of the propeller, as adapted to each of them.

"The formulæ by which the calculations are made are founded on the assumption that the resistance of a vessel varies as the square of her velocity, and, therefore, that the power required to produce that velocity varies as the cube, and that the usual effect of the engine—that is, the effect which remains after deducting the power absorbed in overcoming friction, working air-pumps, &c.—bears a constant ratio to the power developed in the cylinder, known by the term 'Indicated horse-power.' The resistance is, in the first of these columns, assumed to vary, *cæteris paribus*, as the area of the midship-section, and in the last column as the square of the cube-root of the displacement.

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"None of these assumptions, however, more especially the last two, are absolutely correct, but probably they are not so far from the truth as to render useless and uninteresting a comparison, of which they are the basis, made between the performances of any two screw-vessels; while between two vessels which do not materially differ in engines and displacement, or in the area of their midship-sections, such a comparison is not only highly interesting, but it may prove of great value in pointing out the forms of vessels and proportion of propellers which ought to be adopted. In some striking cases it is scarcely necessary to make any other comparison than that of speed. For example, as may be seen in the table printed in 1850, the Teazer, after her form had been improved, went above a knot an hour faster with 40-horse engines than she had previously gone with engines of 100 horse-power. Again, these engines of 100 horse, when transferred to the Rifleman—a vessel approaching to double the tonnage—drove her, after her form had been altered, as fast as she was previously driven by engines of double the power, and nearly two knots faster than the same engines drove the smaller vessel before the alteration of her after-body.—Admiralty, August 1856."

Ruthven's water-jet propeller.

The only other mode of steam-propulsion which has been attended with any considerable success is that known as Ruthven's water-jet system, in which the propelling power is derived from the reaction, or recoil, of two jets of water projected, at a high velocity, from nozzles at the ship's side. The first experimental vessel on this principle was built by Messrs. Ruthven, of Edinburgh, in 1843, and was tried on the Firth of Forth, when it attained a speed of from 6½ to 7 miles an hour. This was an iron-boat, 40 feet long.

The Enterprise.

More recently, in 1853, the Enterprise was constructed on Ruthven's principle, for deep-sea fishing, a preference being given to the jet propeller in this case, from its being less likely to interfere with the fishing-nets than the screw or the paddles. The dimensions of the Enterprise are as follow:—length of deck, 95 feet; length on the water-line, 87 feet; breadth of beam, 16 feet; depth, 8 feet; draught at load-line, 4 feet; burthen, 100 tons. The propelling power is derived from two pairs of horizontal oscillating cylinders, each 12 inches in diameter, and 24 inches stroke (condensing), working a vertical shaft. There is one cylindrical boiler, 6 feet in diameter, and 5 feet long, with two fire-tubes running through it, each 22 inches diameter, and 105 return flue-tubes, each 5 feet long, and 2 inches internal diameter. The propeller consists of a fan-wheel, or centrifugal pump, 7 feet in diameter, with curved blades, keyed on the lower end of the vertical crank-shaft; this revolves horizontally in a water-tight casing into which the water from the sea flows (along a covered passage), through crescent-shaped openings in the bottom of the hull. The water is expelled laterally, from the fan-wheel, in two continuous streams, through curved pipes with nozzles, 10 inches in diameter, protruding from the sides of the hull. The nozzles turn in collars fixed to the ship's side, so that they can be pointed a-stern or a-head, as required, for forward or backward motion, or downwards, when the vessel is to remain at rest. These changes can be made rapidly and easily from the deck, since the nozzles alone require to be operated upon, while the engine continues to work at full speed. Again, by setting the nozzles in opposite directions, one pointing a-head and the other a-stern, the vessel can be turned on the spot, swinging on her beam without the aid of the rudder; and she could thus be steered by the nozzles in case of the rudder being lost or disabled, the manœuvring of the vessel being entirely in the hands of the officers on deck. The vessel progressed very smoothly, without tremulous motion.

In a trial trip with the Enterprise on the 16th of January 1854, from Granton to Kirkcaldy, in the Firth of Forth, and back, a distance of 10½ miles each way, the speeds obtained were 9·69 statute miles per hour going, and 9 miles per hour returning, giving an average of 9·35 miles per hour—the engine making 50 revolutions per minute. On another occasion, she is stated to have made a considerably higher speed, the engine making 65 revolutions per minute. The draught of the vessel, during the trial, was 3 feet 2 inches; and the immersed midship-section, 40·5 square feet. The indicated horse-power of the engine was not known, no indicator-diagrams having been taken. In such an arrangement, much power is necessarily lost in communicating to the water which enters the propeller a velocity equal to that of the ship, besides a considerable loss from friction, eddies, &c.; but upon the whole, the power of the engine seems to be applied to considerable advantage.

Advantages of the water-jet propeller.

Even allowing that the speed attained does not equal that from paddles or screw, the jet-propeller possesses other undoubted advantages which recommend it for special cases, as for instance, in the Government floating-batteries and steam-rams, where the screw and the rudder are particularly liable to be fouled by wreck and cordage. It would also be preferable to the screw in cases of river-steamers of very light draught, where the paddle might not be applicable. Several of the large floating fire-engines on the Thames have been fitted with this propeller, the water being ejected by the powerful steam-pumps with which these vessels are fitted. The speed, however, has in these cases not proved satisfactory. A steamer, called the Albert, propelled on this principle, was placed on the Rhine, as a passenger-boat, a few years since, but did not attain a speed proportional to her power or consumption of fuel.

Paddle and screw compared.

It is frequently asked, Whether is the paddle-wheel or the screw the most efficient propeller? This question may now be safely answered, by asserting, that when both are in their best trim, and both are equally well proportioned to the engines and vessel, they are, as nearly as possible, equally efficient. It follows, therefore, that the preference for one or the other, in any particular case, depends entirely upon the class of vessel and the nature of her service. The objections to the paddle, as compared with the screw, may be thus briefly stated, namely, the unequal immersion of the wheels, according as the vessel swims light or deep; the obstruction to the *sailing* of the ship caused by the resistance of the paddle-boxes to the wind; and the dragging of the paddle-boards through the water when the engine power is not used, and the wheels are not disconnected; and, in the case of steam-vessels of war, the exposure of the wheels and machinery to an enemy's shot. The *advantages* of the paddles, on the other hand, are, that they are not so much affected by the pitching motion of the ship, when steaming head to wind, as the screw is; that they do not require such a speed of engine (or else gearing); and that, from the disposition of the weights in respect to the centre of gravity of displacement, the movements of the vessel are easier than those of a screw-steamer, a matter of considerable interest to the *passengers* at least. With regard to the screw, its efficiency is but little impaired by variations of trim in the ship, but it is most injuriously affected by the pitching motion. Its advantages in facilitating the sailing of the ship are self-evident, and have been already alluded to. In fine, the superiority of the screw for sea-going steamers appears to amount to this, that it retains its efficacy as a propelling agent under a greater variety of conditions of sea, weather, and trim, than the paddles, and that it admits of more use being made of the sails and a greater display of seamanship in the navigation of the vessel. Under proper management, therefore, it appears to be more economical of steam-power than the paddle-wheels; and this, it may be remarked, is the actual experience of the Peninsular and Oriental Company, whose steam fleet is composed of vessels on both principles.

Having thus briefly considered, firstly, the engine-power of the steamship, and secondly, the immediate propelling agents employed to produce locomotion, it will now be necessary to view her as a completed whole, and to ex-

amine some of the general properties and qualifications inherent in, or demanded by, this complicated structure, as well as the relations they severally bear to each other. The construction of the steamer's hull will be found amply detailed in the article Ship-Building, so this need not be here adverted to.

Resistances offered to a steamer.

When a steamer is once set in motion, the motion is, of course, continued by her momentum, and she would then evidently continue to advance at a uniform speed, without any more force being applied to her, were it not for the opposition of external causes. These external forces which she encounters, and which are constantly at work to destroy her momentum, and bring her to a state of rest, are the resistance of the water to her hull, and the resistance of the air to her upper works and rigging; the *impetus* of the waves and the winds being exerted sometimes in her favour, and at other times against her. The power of the steam-machinery is, therefore, applied to counteract these retarding forces, and to maintain a certain amount of progressive motion in the ship, depending upon the resistance on the one hand, and the power of the engines on the other.

The resistance offered by the water to the passage of the hull must be divided into two parts; firstly, that due to the dividing and displacing of the water, to make room for the hull of the ship to pass through (which is analogous to scooping out a long trough or canal, of the full breadth of the ship); and, secondly, the resistance arising from the friction of the water upon the sides and bottom of the vessel. Of these resistances, the first is by much the more serious, although the second must not be overlooked. The resistance offered to the passage of the hull depends mainly upon the area of the immersed midship-section of the ship, (or its greatest cross-section), but also very materially upon the form of the vessel's lines under the water. There is considerable discrepancy of opinion as to the relative value of these two functions of the ship; one naval constructor relying for speed upon a small immersed midship-section, while another holds that fine lines for dividing and closing the water are still more essential. The lines of a ship undoubtedly exert a great influence upon her speed, as has been shown experimentally in numerous instances. In the case of the Government dispatch-boat, Flying Fish, (already referred to at page 660), this vessel, of 1050 tons displacement, attained a speed of only 11·73 knots, with 1166 indicated horse-power. That performance did not equal the expectations of the Admiralty authorities; and without making any variation in the other parts of the vessel, they added, not a *new* bow, but an elongated bow, 18 feet in length, in advance of the original one, to divide the water more freely. The result was, that with the same draught of water, the velocity of the vessel increased from 11·73 knots to 12·55 knots an hour.

Direct resistance.

Influence of form.

Mr J. Scott Russell, in the course of a discussion on this subject at the Institution of Civil Engineers,[1] has given some very interesting results of experiments, all tending to show that the shape of the vessel has a very decided influence upon her speed, irrespective of her engine-power. He relates that he had, on one occasion, the control of four timber ships of the same dimensions, the same displacement, and the same horse-power; but each had different lines, being constructed by different ship-builders. The engines were all alike, being made by the same firm. The result was that, upon a run of 16 miles, their several speeds were $12\frac{1}{2}$, 12, under 11, and between 10 and 11 miles an hour. In another instance, a steamer, constructed to go both ways, but built with one end finer than the other as an experiment, went fully a knot faster one way than the other, although the midship-section and the horse-power were necessarily identical at all times. A third case was the following:—Two vessels were built of the respective lengths of 190 feet and 186 feet, their breadths being equal. The engines were the same in each, the cylinders being 48 inches diameter and 4 feet 6 inches in stroke, making 39 revolutions per minute. The speed attained by the first vessel, however, was 15·03 knots, while that of the second was but 11·32 knots. The difference in the two vessels consisted mainly in the shape, the other and minor elements being much in favour of the slower vessel. For instance, the faster vessel had 124 feet of midship-section, whilst the slower vessel had but 71 feet of midship-section to drag through the water. The faster vessel drew 6 feet 8 inches of water, whilst the slower vessel drew only 2 feet 10 inches. The difference in length was only 4 feet, yet a radical difference in shape thus reduced the velocity, with equal power, from 15 knots to 11 knots per hour.

Colonel Beaufoy's experiments determined the resistance of the water to a ship with a square head only, and it has since been found that a semicircular or round head offers two-thirds of the resistance derived from his formula $\left(R = aw\frac{v^2}{2g}\right)$, and an elliptical head considerably less.[2] By making the bow still finer, the resistance had been gradually reduced to one-sixth, and one-eighth, of that given by the formula; and Mr Scott Russell believes that the engine-power required to drive a large vessel through the water has now, in some cases, been reduced as low as one-twelfth. We learn from the same authority (the highest, indeed, which it is possible to adduce on this subject), that with a vessel of proper form, measuring about 1500 tons, the resistance of a ship can be reduced to 50 lb. per square foot of immersed midship-section, while steaming at the rate of 10 knots an hour. This is the direct resistance of the water upon the hull, and Mr Scott Russell asserts that he has thus been enabled to calculate confidently, to within a quarter of a knot, the amount of steam-power necessary to propel a given ship at a given speed, basing the calculation upon his own peculiar form of "wave-line," there being necessarily a shape for every speed. For instance, when a speed of 10 knots an hour was desired, he provided engine-power for 50 lb. per square foot of immersed midship-section (exclusive of the resistance of the machinery, which brought it up to 65 lb. per square foot), for a vessel of about 1500 tons, built on the "wave-line" construction. These figures, 50 lb. and 65 lb., are *gross* resistances, and include friction of skin.

Frictional resistance.

With regard to the absorption of power by the friction of the skin, it is seen by every day's experience how much a vessel will fall off in speed by the fouling of her bottom. This often amounts to a loss of one-fifth of her original speed, the engine-power exerted remaining the same, so that, under these circumstances, double the power would be required to attain the same speed as before. The total immersed surface of the Rattler's hull has been calculated at 7000 square feet, and according to Beaufoy's experiments on the friction of immersed surfaces, the resistance thus arising would be eight-tenths of a pound per square foot for a speed of 10 knots an hour, and nearly 1 lb. per square foot at 11 knots. At the speed and friction first named, the power absorbed would be equivalent to nearly 170 I.H.P., the total I.H.P. of the engines amounting to 428 H.P. only. In the case of the Himalaya, an immersed surface of about 18,000 square feet is exposed, the friction from which, at a velocity of 13 knots an hour,

[1] See *Transactions of Institute of Civil Engineers*, Session 1856–57.

[2] In the formula in the above sentence a represents the midship-section in square feet, v the velocity of the vessel in linear feet per second, g the accelerating force of gravity $= 32\frac{1}{6}$ and w the weight of a cubic foot of sea water at $64\frac{1}{3}$ lb. avoirdupois.

would absorb about 650 I.H.P., supposing the bottom to be perfectly clean.

Effect of increased length.

The consideration of frictional resistance, of course, places a limit to increase of length in a steamer, although many instances have occurred in which the vessel has gone as fast, or very nearly as fast, with the same engines, and on the same draught of water, after some 30 or 40 feet have been added in midships. The Candia is a remarkable instance of this, as will be seen by the following comparison of her speed when originally built, and after she was lengthened in midships by $33\frac{1}{2}$ feet, her load displacement being thereby increased about 470 tons:—

Date of trial.	Draught of water.	Length.	Displacement.	Weight on board.	Revls. of engines.	Pressure of steam.	Indicated H.P.	Pitch of screw.	Number of blades.	Speed of vessel.
	Ft.	Ft.	Tons	Tons	No.	lb.	H.P.	Ft.		Knots.
May 31, 1854...	18·6	281	2·520	650	$36\frac{1}{2}$	22	1672	20	2	12·651
Aug. 12, 1857..	19·0	314·6	3 090	1000	33	20	1462	21	3	12·443

Although in this instance, from some unexplained cause (owing possibly to improved trim, or circumstances of wind and sea), it would appear from the trial trips that a considerable increase of length has been obtained without any corresponding absorption of power, there must necessarily be a limit where further extension of length is more than neutralized by increased frictional resistance.

Law of resistance.

It is universally admitted that the gross resistances (direct and frictional) to which a vessel is subject increase as the square of the velocity, and therefore, as a necessary consequence, the power expended in producing this velocity varies as the cube of the velocity. For instance, if the resistance to one square foot of midship-section propelled through the water at 5 miles an hour be 5 lb., then the resistance at 10 miles an hour would be four times 5, or 20 lb. But the latter resistance has acted over double the space, so that the result must be again doubled for the measure of the power expended; and hence the power developed in one hour must necessarily and unavoidably be as the cube of the velocity. This rule cannot be expected to hold strictly good in all steamers alike, looking to the great diversity of form and displacement which exists, but in the great majority of cases it is fully borne out in practice. Thus, in H.M. screw-steamer Desperate, the following relation between power and speed was found to obtain:—

Relation of power to velocity.

	Indicated Horse-Power.	Knots.	Coal per I.H.P. p. hour.
			lbs.
With 4 boilers and 4 cylinders	805·89	9·15	4·61
With 3 boilers and 4 cylinders, working expansively	579·32	8·25	5·13
With 2 boilers and 4 cylinders, do. ...	363·87	7·35	5·58
With 1 boiler and 2 cylinders, do. ...	169·32	5·98	5·89

The Retribution, paddle-wheel steamer, had a speed of 10·4 knots with 1092 I.H.P., and a speed of ·6·22 knots with 226 I.H.P. The Onyx, with 2 boilers and 533 I.H.P., realized a speed of 13·16 knots, whilst with one boiler and 158 I.H.P. the speed was 8·6 knots. The Minx, with 234 I.H.P., made 9·14 knots, and with 31·6 I.H.P. 4·51 knots. These, and many other instances, are all in accordance with the rule, that the power and consumption of fuel vary as the cube of the velocity.

Practical examples.

The practical value of this rule will be made apparent by the following examples:—

1. If it be wished to find the speed corresponding to a diminished consumption of fuel for any particular steam-vessel, the calculation will be effected thus:—The vessel, we will suppose, has engines which propel her at the rate of 12 knots, with a consumption of 35 tons of coal per diem, and we wish to find the speed corresponding to a consumption of 25 tons per diem; then—

$$35 : 25 :: 12^3 : V^3 \text{ (cube of required velocity).}$$

When reduced, $7 : 5 :: 1728 : V^3$

As an equation, $5 \times 1728 = 7\,V^3$;

or, $\dfrac{8640}{7} = V^3$.

And $\sqrt[3]{1234} = V^3$ 10·726 knots $= V$, the required velocity.

It is thus seen, that by reducing the consumption of fuel by 10 tons per diem, we lose in this instance about $1\frac{1}{4}$ knot per hour.

2. If it be wished to increase the speed of the vessel, on the other hand, from 9 to 11 knots, and we desire to know the increased consumption attending the increase of speed, this will be in the proportion of 9^3 to 11^3, or as the numbers 729 : 1331, or as 1 : 1·825. All we have to do, therefore, is to multiply the present consumption by this latter number.

3. If a certain steamer consumes, say 220 tons of coal, during a run of 1600 miles, performed at the average speed of 11 knots per hour, and we wish to find her probable consumption of coal for a longer voyage of 2400 miles, at a reduced speed of 9 miles, the calculation will then be as follows:—

$$220 \text{ tons coal} : C \text{ (required consumption)} :: 11^2 \text{ knots} \times 1600 : 9^2 \text{ knots} \times 2400 \text{ miles,}$$

Then $C \times 121 \times 1600 = 220 \times 81 \times 2400$;

or, $C \times 193{,}600 = 42{,}768{,}000$.

Reduced to $C = \dfrac{427{,}680}{1936} = 220{\cdot}9$ tons, required consumption.

It is thus seen that the consumption of fuel is almost exactly equal in these two cases, showing that the same vessel would steam 1600 miles at 11 knots, or 2400 miles at 9 knots, with the same quantity of coals.

4. Supposing that we have a steamer with stowage-room for only 460 tons of coal, which she has nearly expended during a trip of 1800 miles, while steaming at the speed of 11·5 knots an hour, and we wish to place her upon another station, where she must run 2500 miles without coaling, it is required to find at what reduced speed she must steam so as not to run short of coals?

$$\underset{\text{tons.}}{460} \times \underset{\text{knots.}}{11{\cdot}5^2} \times \underset{\text{knots.}}{1800} = \underset{\text{tons.}}{460} \times \underset{\text{knots.}}{2500} \times V^2 \text{ required velocity;}$$

or, $460 \times 132{\cdot}25 \times 1800 = 460 \times 2500 \times V^2$;

reduced to $109{\cdot}503 = 1150\,V^2$;

or, $V^2 = \dfrac{109503}{1150} = 95{\cdot}04$.

Therefore, $V = \sqrt{95{\cdot}04} = 9{\cdot}75$ knots, required velocity.

We thus find that the same vessel which ran 1800 miles at a speed of 11·5 knots, and with a consumption of 460 tons of coal, must reduce her speed to $9\frac{3}{4}$ knots, to enable her to run 2500 miles with the same consumption.

Efficiency of a steamer.

The preceding examples all show that an increase of speed is obtained only by the expenditure of a very great increase of power. Hence, to draw even the most superficial comparison between the efficiency of different steam-vessels, their speeds must first be reduced to a common standard, and the relation must then be found between the consumption of fuel at the standard speed, and the size or tonnage of the vessel, the *maximum* speed of each being treated as a separate question. The value of the term *efficiency* also varies so much for different classes of vessels, that steamers of the same class only can be justly compared together. The number of tons displacement that 100 gross or indicated horse-power will propel, at the rate of 10 knots an hour, has been proposed as a standard of comparison between different steamers.

Modes of comparison.

A vessel, for instance, is known to have a speed of 12 knots an hour, the engines exerting 1620 indicated horse-power, at a displacement of 2240 tons.

Then, as 12 knots : 10 knots :: $\sqrt[3]{1620 \text{ H.P.}}$: $\sqrt[3]{\text{Ind. H.P. required}}$;

or, 1728 : 1000 :: 1620 : 937·5;

and 937·5 : 2240 :: 100 : 238·9 = tons displacement propelled by 100 I.H.P., at 10 knots an hour.

By making similar calculations for other vessels, their relative efficiency may be, to a certain extent, compared one with the other. It is found, in practice, however, that the form of the vessel influences the ratio existing, theoretically, between the power exerted and the resulting speed.

Thus, in the Flying Fish, before she was altered, an increase of only 1·68 knots in the speed of the ship was obtained by doubling the indicated horse-power; but after a fine bow was fitted, she gained 2·452 knots by doubling the power, the latter increase of speed being just proportional to the cube of the extra power exerted.

Formulæ for determining steamship performances.

A formula frequently employed in comparing the relative merits of vessels is $\frac{V^3 D^{\frac{2}{3}}}{I.H.P.}$, which is thus expressed in words:—The cube of the speed in knots, multiplied by the square of the cube-root of the displacement, and divided by the indicated horse-power. The resultant number is called the co-efficient of dynamic duty for that particular steamer, and forms a criterion of the cost at which she performs her work, the higher the co-efficient the greater being the economy. In a steamer of good average performance, the co-efficient, as calculated by this rule, should lie between 250 and 320, or thereabouts.

As the preceding formula does not take note of the area of immersed midship-section, the following is also useful as a means of comparison: $\frac{V^3 \times \left\{\text{midship-section.}\right.}{I.H.P.}$

The two formulæ next to be given are used indiscriminately for estimating the probable speed of a steamer, viz.—

No. 1.—$V^3 = \frac{\sqrt{H.P. \times C,}}{D^{\frac{2}{3}}}$; or, when expressed in words, the cube of the velocity equals the square-root of the nominal horse-power, multiplied by the diameter of the cylinder in inches, divided by the square of the cube-root of the displacement.

$$\text{No. 2.—}V^2 = \frac{\frac{2}{3}\,I.H.P. \times 100}{\text{mid. sect.}}$$

The speed of the Candia, when measured by the first of these rules, is 11·38 knots, and by the second, 11·28 knots; while her actual speed, under the same conditions of displacement, &c., is 11·93 knots. In the same way the speed of the Pera, by the first rule, is 11·22; by the second, 11·28; and actual, 12·55 knots. The actual speed, in both of these cases, is therefore in excess of that calculated by the formulæ.

Proportion of horse-power to tonnage.

In proportioning the horse-power of a steamer, the fact must be borne in mind that the effective power of the engines increases in a higher ratio than simply as the tonnage, since the resistance varies as the square of the cube root of the tonnage. Thus, if a vessel of 1200 tons and 400 horse-power have a speed of 12 knots, a similarly constructed vessel of 1650 tons and 550 horse-power (with the same proportion of power to tonnage), ought to have a considerably higher speed, since the square of the cube root of 1200 being 112·78, and the square of the cube root of 1650 being 139·47, the proportion will then be 112·78 : 400 : : 139·47 : 494·6 horse-power, instead of 550 horse-power.

The proportion of horse-power to tonnage recommended for different classes of ocean steamships may be stated as follows:—For full-powered passenger paddle-steamers of from 500 to 1200 tons (builders' O.M.), 1 horse-power to 3 tons; for ditto, of from 1200 to 3000 tons, 1 horse-power to 4 tons; for full-powered passenger screw-steamers of from 500 to 1200 tons, 1 horse-power to 4 tons; for ditto, of from 1200 to 3000 tons, 1 horse-power to 5 tons; for auxiliary screw-steamers, 1 horse-power to 6, 7, or 8 tons, according to size.

It must not be supposed that a steamer can, or ever will be constructed by the sole aid of "formulæ," which are themselves, for the most part, empirical. They serve, however, to assist in estimating the value and tendency of the several proportions and attributes of the structure, a wide margin being left for the exercise of practical sagacity and experience on the part of the constructor.

Main elements of steamship economy.

To sum up, in a few words, the main elements upon which economy in steam navigation seems to depend, these are—a fine form, a moderate speed, considerable magnitude, a clean bottom, and a high ratio of length to breadth; to which may be added, effective engines, and a properly proportioned propeller. Again, after the naval constructor and engineer have each done their best, much still remains for the skill of the commander and officers of the ship.

Proportions of length, breadth, and depth.

With regard to the relative proportions of the hull, our fastest and most successful ocean merchant-steamers of the present day have their length and breadth as 7, 7·5, or even 8 to 1 for iron screw-steamers, wooden hulls being generally confined to 6·5 and 7 times the beam. The proportion of depth varies very much, but this should never exceed eight-tenths of the breadth, and is better limited to six-tenths. A very deep steamer is always unweatherly and unmanageable, and often dangerous. The proportions in actual use will be seen by inspecting the tables of steamers in the royal navy, and the table of merchant-steamers, at pages 669, 670, 671.

Management of a steamer at sea.

With reference to the management of steamers at sea, a full-powered passenger-steamer is generally so tied to time that she cannot afford to disuse any portion of her steam-power, contenting herself with expanding more or less in the cylinders, according as the wind and sea are propitious or otherwise. Every opportunity of a fair wind, however, should be eagerly seized for hoisting sail, which, in the case of a screw-steamer especially, affords a great addition to the power of the engines. Steam-vessels of war, on the other hand, are expressly designed to sail well, in addition to their steaming powers; and in estimating the performance of a Government steamer, we should rather look to the direct distance run by the combined action of steam and sails, at a moderate but uninterrupted speed, and with a small consumption of fuel, than to the attainment of a high velocity, which is seldom wanted in war-steamers. In steaming against a strong head wind, with a paddle-wheel steamer of moderate steam-power, it is found preferable to keep the vessel in a direct course as long as possible; but, so soon as her head begins to fall off for want of good steerage way, the fore and aft sails should be set, and the vessel tacked, the engines being kept working. In the screw-steamer, on the other hand, there is no economy in keeping a direct course against a head wind and sea, after her speed is reduced to three or four knots an hour, since the engines keep up their usual number of revolutions, and the steam is mostly wasted in slip, or during the "racing" of the machinery. In such a case, therefore, the ship's course should be altered, and the sails set to assist the screw, so soon as the speed falls to this amount. In paddle-wheel engines, the waste of steam is not so great while going head to wind, since the revolutions decrease with the speed of the vessel. When a vessel is steaming against an opposing stream or tide, it is found that her engine-power is most economically applied when she goes half as fast again as the velocity of the stream. Notwithstanding the many undoubted improvements which have been recently introduced in the application of the screw propeller, and the extended experience we have now had of its operation in different classes of ships, and under every variety of trial, the position which it holds in the merchant service, either as an antagonist to the paddle-wheel in full-powered steamers, or as an auxiliary to the sails in sailing ships, is still far from being well defined.

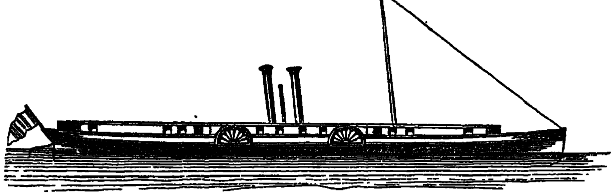


Fig. 32.
Paddle-steamer for the rivers of India.

Steam Navigation.

Before bringing this article to a close, it is proposed to give a few examples of steam-vessels which have either proved unusually successful, and may, therefore, stand as *types* of their class, or have some peculiarity of structure which seems to point them out for special notice.

1. DUKE OF WELLINGTON, 131 guns, steamship of the line, is 240 feet 6 inches long between perpendiculars, and 60 feet broad. Tonnage, 3826, builders' O.M. Has two horizontal, geared, screw-engines. Diameter of cylinders, 94½ inches, and 4 feet 6 inches stroke. Nominal H.P., 780; indicated do., 2500. Machinery by Robert Napier & Sons, of Glasgow. Has 4 tubular boilers, each containing 5 furnaces of the following dimensions, viz.—7 feet 4 inches long + 2 feet 9½ inches wide; the total space occupied by the machinery being 70 feet in length. The diameter of the screw shaft next the engines is 12½ inches. The screw itself is double threaded, 18 feet diameter, 16 feet 3 inches pitch, and 3 feet 4 inches long. The driving-wheel of screw-gearing is 10 feet 6 inches diameter, working into a pinion (with wooden cogs), 4 feet 6 inches diameter, and 4 feet 5 inches broad. The speed of the vessel at her trial trip was 10·2 knots.

2. MERSEY, 40 guns, screw steam-frigate, is 300 feet long between perpendiculars, and 52 feet beam. Tonnage, 3726; nominal H.P., 1000; indicated H.P., 4000. Makers of the machinery, J. Penn and Son. Pressure of steam, 20 lb.; mean number of revolutions of engines (direct), 55¼. Screw, diameter, 20 feet; pitch, 29 feet; immersion at trial, 6 inches; revolutions of screw, 55¼. Draught of water of ship, forward, 20 feet 8 inches; aft, 22 feet 7 inches. Coals on board, 850 tons; consumption of fuel at full speed, about 140 tons per day of 24 hours. Number of furnaces, 32; length of stoke-hole, 68 feet 10 inches; breadth of ditto, 10 feet; temperature of ditto, 100° Fahr. The tops of the boilers are 4 feet under the water-line; fitted with three auxiliary engines, two of which supply the boilers, and the third acts as a steam fire-engine. Weight of shot fired by one broadside, 1652 lb. Speed at trial, 13 29 knots.

3. RATTLER, screw-sloop, 179 feet 6 inches long between perpendiculars; 32 feet 8½ inches beam; 888 tons builders' O.M.; 13 feet 6 inches mean draught of water at trial; area of immersed midship-section, 330 square feet; displacement at trial, 1078 tons; nominal H.P., 200; ditto, indicated, 436; diameter of cylinders, four of 40⅛ inches each; length of stroke, 4 feet. Revolutions during trial, 27. Diameter of screw, 10 feet; pitch, 11 feet; length, 1 foot 3 inches; multiple of gearing, 4 : 1; revolutions of screw per minute, 107·9; slip per cent., 17·67. Description of engines, vertical geared. Makers of the machinery, Maudslay, Sons, and Field. Maximum speed of the vessel at trial, 10 knots.

4. GROWLER, screw gun-boat. Length between perpendiculars, 100 feet; breadth, 22 feet; draught of water, mean, 6 feet 10½ inches; immersed midship-section at this draught, 130 square feet; horse-power—nominal, 60; indicated, 200; high pressure engines working direct, with 2 cylinders, each 15½ inches in diameter, and 18 inches stroke. Makers of the machinery, Maudslay, Sons, and Field. Pressure of steam, 50 to 60 lb.; weight of engines, 8 tons 14 cwt. Boilers, 3 in number, are cylindrical, with internal tubes. Length of boilers, 15 feet 4 inches × 4 feet diameter, with one furnace in each, 2 feet 2 inches broad × 4 feet 6 inches long. Each boiler contains 82 iron tubes, 2 inches in diameter and 8 feet long. Total grate-bar surface in the three boilers, 29·25 square feet; weight of the three boilers complete, 13 tons 1 cwt.; weight of water in the three boilers, 9 tons. Screw, two-threaded, 6 feet diameter; 8 feet pitch; 16 inches long; weight, 840 lb. Total weight of the machinery with spare gear, 32½ tons. Coals carried in bunkers, 28 tons. Speed at above immersion, 8·38 knots; speed of engines and screw, 154 revolutions per minute; slip, 31 per cent.

5. WARRIOR, iron-cased steam-frigate, is built of iron; extreme length, 380 feet; breadth, 58 feet; depth, 41 feet 6 inches; tonnage, 6177. Weight of hull, about 5700 tons; fitted with engines of 1250 nominal horse-power, weighing 950 tons. Builders of the ship, the Thames Iron Co.; makers of the machinery, J. Penn & Son. She will carry 950 tons of coal, and the weight of armament, masts, stores, &c., will amount to about 1200 tons. The total weight at sea will thus be about 9000 tons. Sheathed with wrought-iron armour-plates 4½ inches thick from 5 feet below the water-line to the level of the upper deck for 220 feet of the broadside, each plate being 15 feet long by 4 feet broad. Behind the iron armour-plates there is a thickness of 24 inches of teak, protecting all the fighting portion of the vessel. The bow and stern are not thus sheathed, being merely plated with thick iron plates in the usual way, and crossed by several water-tight bulkheads. Armament will consist of Armstrong guns, each capable of throwing a 100 lb. shot a distance of 5 miles. The total cost of each frigate will be about L.320,000. Estimated speed, 14 knots an hour.

6. VICTORIA AND ALBERT, H.M. steam-yacht, is built of timber, and has the following dimensions:—Length between the perpendiculars, 200 feet 1 inch; breadth of beam, 33 feet; depth of hold, 23 feet 9 inches; burthen in tons, builders' O.M. 2343; horse-power, noninal, 600; horse-power, indicated, at trial 2980. Propelled by paddle-wheels. Has oscillating engines by J. Penn and Son, with two cylinders, each 88 inches in diameter and 7 feet stroke, the total weight of her machinery being 401⅓ tons. Her draught of water when complete for sea, with stores and coals on board, is 15 feet forward and 15 feet 9 inches aft. Revolutions of engines at this draught, 22; displacement at medium load-draught, 2120 tons. Has four tubular boilers, containing in all 3024 brass tubes, each 6 feet 5 inches long by 2½ inches external diameter. The boilers have altogether, 24 furnaces, each 7 feet long by 3 feet wide, fired from two stoke-holes. The pressure of steam on the safety-valves is 20 lb. The steam is superheated; has two funnels, each 5 feet 6 inches diameter, and 40 feet 3 inches high from top of boiler. The coal-boxes contain 410 tons of coal. The paddle-wheels are feathering, 29 feet extreme diameter, 14 boards to each wheel, each board 11 feet 6 inches by 4 feet 2 inches. The wheels can be disconnected by a friction-disc and break. Speed at trial trip, 17·022 knots.

7. FAIRY, H.M.'s screw steam-yacht, is built of iron, and has the following dimensions:—Length between the perpendiculars, 144 feet 8 inches; breadth extreme, 21 feet 1½ inches; mean draught of water at trial, 4 feet 10 inches; area of immersed midship-section, 71·5 square feet; mean displacement at trial, 168 tons. Tonnage, builder's O.M., 312; nominal horse-power, 128; indicated horse-power, 364. Builders, Mare & Co.; machinery by J. Penn & Son. Diameter of screw, 5 feet 4 inches; pitch, 8 feet; length, 1 foot. Revolutions of screw at trial, 258 per minute; slip of the screw, 34 per cent. Has two vertical, oscillating, geared engines, the cylinders 42 inches diameter, and 3 feet stroke, making 51½ revolutions per minute. Speed of the vessel at trial, 13·324 knots.

8. HIMALAYA, steam troop-ship, propelled by the screw, is built of iron, and has the following dimensions:—Length between the perpendiculars, 341 feet; breadth, extreme, 46 feet 4 inches; depth of hold, 35 feet; tonnage, 3560; horse-power, nominal, 700. Has horizontal direct engines, with cylinders 84⅜ inches diameter, and 3 feet 6 inches stroke, making 59 revolutions per minute. Boilers on Lamb and Summer's sheet-flue principle. Pressure of steam, 14 lb. She can stow 1000 tons of coal; her daily consumption, at full speed, being 70¾ tons. Fitted with the common 3-bladed screw, 18 feet diameter, by 28 feet pitch, making 59 revolutions per minute. Speed at trial, 13·9 knots. This steamer has proved eminently successful, having made the trip from England to Alexandria, on several occasions, at an average speed of 12 knots an hour; and with a favourable breeze, she has been known to run 16 knots within the hour.

9. TROOP RIVER-STEAMERS for India. These are now being built for Government of the following proportions:—Length on the water-line, 350 feet; length over all, 375 feet; breadth, 46 feet. Built of steel-plates, weighing about 5 lb. per superficial foot, with the exception of the keel-strakes, which are 7 lb., and the girder-strakes 15 lb. per square foot. They are flat-bottomed, to draw only 2 feet of water, with machinery, fuel, stores, and 800 troops on board. The hulls are estimated to weigh only 370 tons. They are to be propelled by paddle-wheel engines of 200 horse-power. They will be steered by two large patent steering-blades. The hull is stiffened by two iron girders, rising above the deck, and running for 300 feet of the length, from which vertical and diagonal trusses are carried. They will be sent to India in parts, after being put together and tried in this country. Estimated speed, 12 miles an hour.

10. GREAT EASTERN, of iron. Length between the perpendiculars, 680 feet; length on deck, 691 feet; breadth, extreme, 83 feet; depth of side, 58 feet; draught of water, from 20 to 30 feet. Gross tonnage, 22,500. Nominal horse-power, 2600. Builder, J. Scott Russell. Her screw-engines of 1600 horse-power, by James Watt and Company; and paddle-engines of 1000 horse-power, by J. Scott Russell. The screw-engines are horizontal direct, with 4 cylinders, each 84 inches diameter, by 4 feet stroke, making 45 strokes per minute; with tubular boilers, carrying 25 lb. pressure. The screw is of the common construction, with 4 blades, 24 feet diameter, with a pitch of 44 feet. The paddle-wheel engines are oscillating, with 4 cylinders, each 74 inches diameter, by 14 feet stroke. Boilers, tubular, 25 lb. pressure. Paddle-wheels are of the common construction, 50 feet diameter, 13 feet length of floats, and 3 feet depth. Total coals carried, 10,000 tons. Speed about 15 knots. Her ship-draught is shown in the plates illustrating article SHIP-BUILDING.

11. PERSIA, transatlantic mail-steamship, of iron, has the following dimensions:—Length between the perpendiculars, 360 feet; breadth of beam, 45 feet; depth of hold, 29 feet 8 inches. Medium load-draught of water, 21·5 feet. Displacement at this draught,

Steam Navigation.

5285 tons. Area of immersed midship-section, 818 square feet. Tonnage, builders' O.M., 3586. Builders of vessel and makers of the machinery, Robert Napier and Sons. The bottom plates of the hull are $\frac{15}{16}$ inch thick, tapering to $\frac{3}{4}$ inch at the load water-line, and above this $\frac{11}{16}$ inch, except round the gunwale, where they are $\frac{7}{8}$ inch. The hull is divided into 7 water-tight compartments, and has a double iron bottom for a considerable portion of her length. The launching weight of the iron hull was 2200 tons, her displacement with machinery, coals, and stores on board being about 5400 tons, on a draught of 23 feet. Accommodation is provided for 250 passengers (besides a crew of 150 persons), and stowage room is found for 1200 tons measurement goods. Coals carried are 1400 tons. The engines are on the side-lever construction, with 2 cylinders, each $100\frac{1}{2}$ inches diameter, and 10 feet stroke, 850 nominal horse-power, and about 3000 indicated horse-power. Diameter of paddle-shaft, $23\frac{1}{4}$ inches. There are 8 tubular boilers, containing, in all, 40 furnaces, each 7 feet long by 2 feet 9 inches wide. Total length occupied by the machinery is 107 feet 6 inches. The paddle-wheels are of the common construction, 38 feet 6 inches diameter to extremity of boards, which are 10 feet 8 inches long, 2 feet 1 inch broad, on 28 arms. On the occasion of the Persia's trial trip from Glasgow to Liverpool, she ran 175 knots in 10 hours 43 minutes; thus accomplishing an average speed of 16 knots, or nearly 19 British statute miles an hour.

12. PERA, Alexandria mail screw-steamship, is of iron, and has the following dimensions:—Length between the perpendiculars, 303 feet 7 inches; breadth extreme, 42 feet 3 inches; depth of hold, 27 feet 2 inches; gross tonnage, 2613; nominal horse-power, 450; indicated horse-power, 1500. Builders of the vessel, Mare and Company; makers of the machinery, Messrs Rennie. She has vertical trunk-engines, geared, with 2 cylinders each $70\frac{1}{2}$ inches diameter (trunk 30 inches diameter), and 4 feet length of stroke. Strokes of engine per minute, $29\frac{1}{2}$. There are four sheet-flue boilers; pressure of steam 16 lb., superheated. 700 tons of coal are carried in boxes; coals burned per day of 24 hours, 44 tons (in place of 56 before superheating apparatus was fitted). Screw propeller has 3 blades, is 15 feet 6 inches diameter, 21 feet pitch, making 60 revolutions per minute. Speed at trial trip, 12·5 knots. The Pera has made some very remarkable passages. Thus, in the month of July 1859, she ran from Southampton to Gibraltar, 1000 miles, in 3 days 21 hours (being at the rate $10\frac{3}{4}$ knots per hour); thence to Malta, another 1000 miles, in 3 days 12 hours (11·9 knots per hour); and from Malta to Alexandria, 1000 miles, in 2 days 19 hours (14·92 knots per hour). The Pera's lines are shown in the plates of article SHIP-BUILDING.

13. LEINSTER, ULSTER, MUNSTER, CONNAUGHT, new Holyhead mail-packets, are of iron, and propelled by paddle-wheels. They have the following dimensions:—Length extreme, 350 feet; breadth, 35 feet; depth, 20 feet; draught of water, 12 to 13 feet; tonnage, 2000; nominal horse-power, 700; indicated horse-power (estimated), 3500. Average speed contracted for, 20 miles an hour. The engines are oscillating, and the paddle-wheels have feathering floats. Three of the vessels are built by Messrs Laird, and one by Messrs Samuda; and the machinery is by Messrs Ravenhill, Salkeld, and Company, and Messrs James Watt and Company. They will be rigged very lightly, for fore and aft sails only, their great engine-power making them independent of the wind. They have 9 water-tight bulkheads, extending to the upper deck, one of which divides the engine and boiler rooms; this latter bulkhead constituting an important element of safety and strength, which might be advantageously introduced into iron steamers much more frequently than it is. The cabins are 9 feet 6 inches high; the principal saloon being 60 feet long.

14. BREMEN, screw-clipper steamship, is built of iron, and has the following dimensions:—Length between the perpendiculars, 318 feet; breadth of beam, 40 feet; depth of hold, 26 feet; mean draught of water at trial, 18 feet 6 inches. Displacement at this draught, 3440 tons. Area of immersed midship-section, 606 square feet. Rate of displacement at load draught, 25 tons per square inch. Builders of the ship and makers of the machinery, Messrs Caird and Company. The engines of the Bremen consist of two direct-acting inverted cylinders, each 90 inches diameter and 3 feet 6 inches stroke. Nominal horse-power, 500; indicated horse-power at trial, 1624. Speed at trial trip, 13·15 knots per hour. The average performance at sea, between Bremen and New York, with a mean displacement of 2950 tons, was found to be 11·05 knots, the engines showing a mean indicated horse-power of 1045. The superiority shown by the Bremen is believed to be principally due to her fine form of body, and judicious proportions. Her ship-draught will be found amongst the plates illustrating the article SHIP-BUILDING.

15. WINDSOR CASTLE, Clyde river-steamer, propelled by paddle-wheels, is built of steel-plates, and has the following dimensions:—Length, 190 feet; breadth, 20 feet; depth, 7 feet 6 inches; tonnage, gross, 190; register, 93. Mean draught at trial, 3 feet 1 inch. Immersed midship-section at this draught, 52 square feet. Average number of revolutions, 43. Nominal horse-power, 115. Indicated horse-power at trial, 620. Pressure of steam in the boilers, 40 lb. Builders of the vessel and makers of the machinery, Messrs Caird and Company. The cylinders are placed diagonally; they are 40 inches in diameter and 5 feet stroke, cutting off steam after 12 inches. The steam is supplied by an upright tubular boiler, and is superheated in the funnel to a temperature of 375° Fahr. before entering the cylinders. The boilers have 76 square feet of fire-grate surface, and 1526 square feet of total heating surface, consuming about 20 cwt. of coal per hour. The paddle-wheels are feathering, 15 feet diameter, each having 10 boards 8 feet long by 2 feet 3 inches broad. Speed at trial trip, 17·083 knots, or 19·679 British statute miles an hour. In this steamer *weight* is economized in every possible way, and only 10 tons of coal are carried.

16. TACHTALIA, river-steamer for shallow navigation, is built of iron, and has the following dimensions:—Length, 150 feet; breadth, 20 feet; draught of water, with machinery and passengers on board, $12\frac{1}{2}$ inches. Builders of the vessel and makers of the machinery, Messrs J. and A. Blyth. She is propelled by 4 condensing engines, of the collective power of 40 horses, acting through 4 paddle-wheels, each 6 feet in diameter and 6 feet wide; the forward engines making 87 revolutions and the after engines 96 revolutions per minute, and the speed through still water being about 11 miles per hour. The hull is formed of very thin plates, stiffened by frequent transverse bulkheads, and webs of plate surrounding the vessel internally. By employing 2 pairs of paddle-wheels, each pair driven by a distinct pair of steam-engines, not only are the weights of the machinery, water, and coals diffused over the vessel, but the propelling power is also widely distributed over the structure. The use of 4 paddle-wheels in place of 2 greatly improves the steering of the vessel, always a matter of much difficulty with boats of shallow draught running on swift rivers. Lightness of machinery in this vessel is promoted by the substitution of gun-metal for cast-iron in the condensers, &c., and of cast-steel and wrought-iron for the framing of the engines. The boilers are constructed of Lowmoor plates throughout, without angle-irons, to save weight. Vessels of this class are well adapted for the rivers of India. A representation of the Tachtalia is given at page 664.

17. SCREW-STEAMER for the rivers of INDIA, built of iron. Length, 70 feet; breadth, 7 feet 6 inches; depth, 3 feet 6 inches; draught of water, 2 feet. Boat and machinery constructed by Messrs G. Rennie and Sons. Propelled by two screws, one on each quarter (see annexed wood engraving, fig. 33); diameter of the

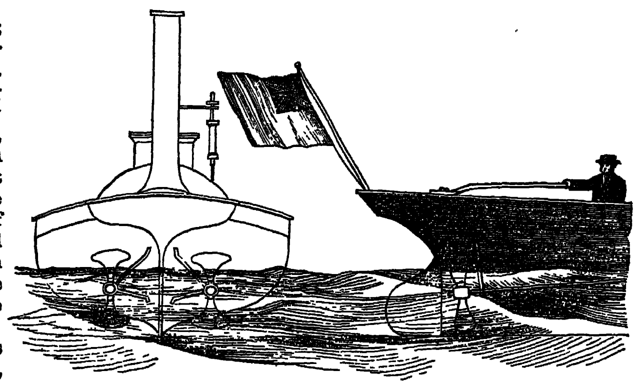


Fig. 33.

Screw-steamer for the rivers of India.

screws, 2 feet 2 inches; pitch, 4 feet. Driven by a pair of disc engines, acting direct. Speed of the engines and screws, 260 revolutions per minute. Speed of the boat, 10 knots per hour. Weight of the boat, 3 tons 8 cwt.; weight of the machinery, 3 tons. Consumption of coal, per hour, 100 lb. Power of traction, at slow speed, 250 tons. Cost of trackage, $\frac{1}{4}$ of 1d. per ton per mile.

18. AMERICAN STEAMBOATS (by a correspondent of *The Engineer*).—"Going aboard at a late hour in the evening, the scene which presented itself to our eyes was novel in the highest degree. Painted a pure white, as nearly all American river-steamboats are (for the anthracite coal burned under their boilers makes no smoke whatever), the enormous mass of the vessel rose like a giant iceberg above the water. Hurrying over the broad gangway, we found ourselves in a crowd of nearly 700 passengers, more than one-third of whom were ladies. We were upon the main-deck, although under a lofty ceiling, over which was a grand saloon of

palatial proportions and magnificence. Looking aft, a broad entrance, flanked with gilded columns and luxurious drapery, opened to the ladies' saloon—a *sanctum sanctorum* not to be profaned by the footsteps of a bachelor, although steamboat etiquette was not so strict, nor steamboat regulations so inflexible, as to forbid the momentary presence there of gentlemen accompanying their wives, or other fair charges, to be intrusted to the care of the stewardess. On either side of this entrance were broad staircases descending to an immense lower cabin, along the sides of which were more than 400 berths. The supper tables were then set out with a degree of splendour for which an English traveller would be altogether unprepared. Nearly amidships, on the main-deck, a grand staircase, sweeping both to the right and left, conducted to the great saloon, or state-room hall, nearly 300 feet in length, several yards in width, and having an upper gallery, with a second story of state-rooms—a lofty arched ceiling, glazed with ground and coloured glass, and supported by richly-carved columns, covering the whole. In its construction this steamboat (the New World) is totally unlike anything ever seen in British waters. It is of enormous size. Originally 376 feet long, it was afterwards lengthened to 468 feet over all. With a breadth of beam of 50 feet, the main-deck is extended by means of platforms, or "guards," projecting over the water to the full width across the paddle-boxes, 85 feet, being thus wider than the main-deck of the Great Eastern. Yet the vessel, which is flat bottomed, with bilges nearly or quite square, draws only 5½ feet of water, the whole displacement being about 2500 tons, and the immersed mid-section 275 square feet. All American boats have wooden hulls, and how to stiffen such a vast and shallow craft, flat-bottomed as Noah's Ark? There are no tubular cells, no 'double skins,' nor is there a hundredweight of boiler-plate, excepting in the boilers themselves, in the whole structure. As if to increase the strain, the boilers, weighing, with water, 75 tons each, are placed upon the "guards" outside the hull, and of course several feet above the load-line. To make the whole as rigid as a tubular girder, two enormous arched trusses, placed one over each side of the hull, extend over nearly 350 feet of the length of the boat. These great bows, like the arches of a bow-string bridge, are connected to king-posts and queen-posts, and strapped and fastened, so that the whole is as stiff as a man-of-war. Then there are four or five large king-posts, or masts, stepped upon the keel, and carrying the weight of the projecting 'guards' by long diagonal tension rods. These masts carry no spars, booms, or rigging of any kind, all of which would be so much top hamper, worse than useless, at a speed of 20 miles an hour. These posts, like nearly all the rest of the wood-work, are painted a dazzling white, and surmounted by gilded balls. The lines of the hull are very sharp, and at twenty-two statute miles an hour, a speed not unfrequently attained, there is only a thin spurt of water breaking into spray to mark the keen entrance of the cutwater."

We subjoin a list of those parts which are considered most necessary to be carried as SPARE GEAR for sea-going PADDLE-WHEEL ENGINES of a large class:—

100 bolts and nuts for paddle-wheels; 50 bolts and nuts for paddle-floats; 6 paddle-floats; 2 sets of gearing for paddle-floats (feathering-wheels); 1 connecting-rod for ditto, ditto; 1 driving-arm for ditto, ditto; 4 large pins and 2 small for brackets, ditto; 2 radius boss pins for ditto, ditto; 2 bushes for ditto, ditto; 8 brass washers for gearing, ditto; 4 bolts and nuts for radius-boss, ditto; 4 segments of paddle-centres; 4 arms for paddle-wheels; 18 iron washer-plates; 2 brass linings for outer-bearings; 120 brushes for boiler-tubes; 36 stoking-irons; 60 scrapers, circular and forked; 1 set of stocks, taps, and dies, from ¼ in 1¼ inch; 1 air-pump rod and nut; 1 cylinder-cover, bush, and gland; 1 piston and rod; 1 piston rod cap, complete; 2 complete sets of all India-rubber valves; ½ set of fire-bars; 1 set of bearing-bars for one furnace; boiler-plate, about 6 or 8 cwt.; 60 boiler-tubes; 300 ferrules for boiler-tubes; 8 handles for boiler-tube brushes; 24 drifts (short and long) for tubing; 12 mandrils for ditto; 1 crank-pin for engine; 1 eccentric-band, complete; 1 feed-pump rod, complete; 1 bilge-pump rod; 1 gross iron washers of various sizes; 120 bolts and nuts; 8 glass guage-tubes for boilers; 2 glass tubes for barometers.

The following is a list of SPARE GEAR for SCREW-ENGINES of a large class:—

1 Cylinder-cover, complete; 1 connecting-rod; 1 centre-bonnet, for cylinder; 1 air-pump rod; 1 piston and rod, complete; 1 feed-pump rod; 1 bilge-pump rod; 1 slide-rod, complete; 1 eccentric strap, complete; 1 spiral-spring, for escape-valve; 1 cross head; 1 guide-block and brass (if so made), complete; 1 cap for thrust-block, fitted with white metal; 2 screws for thrust-block; soft metal bearings, various; 2 complete sets of India-rubber valves; 1 wrench for piston-rod nuts; 1 set of taps and dies, complete; 50 bolts, assorted (iron and metal); 80 bolts and nuts (assorted); 40 spanners, various; ½ set of fire-bars; 60 fire-irons, assorted; 110 scrapers (50 circular and 60 forked); 3 bearing-bars; 100 boiler-tubes; 300 ferrules for boiler-tubes; 40 drifts and mandrils for boiler-tubes; 200 tube-brushes, and 4 handles; 140 washers for boiler-tubes; 3 boiler-plates; 16 glass gauge-tubes, and 60 India-rubber rings.

Actual Weights of Steam Machinery in the Royal Navy.

Name of the Vessel.	Nominal Horse-power.	Engines complete.	Boilers and apparatus.	Propeller and gear.	Coal-boxes.	Sundries.	Spare gear.	Total weight of machinery.	Water in boilers.	Grand Total.
	H.P.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Mersey	1000	213·4	263·7	65·9	17·3	25·8	43·7	629·8	136	765·8
Shannon	600	84·	128·6	51·2	8·1	15·	21·8	308·7	...	...
Melpomene	600	78·9	135·9	48·9	9·3	23·8	13·7	310·5	...	...
Algiers	450	128·4	169·2	46·9	12·7	13·5	...	370·8	85	455·8
Cornwallis	200	18·8	45·4	14·3	4·7	9·6	4·7	97·5	30	127·5
Marlborough	800	200·9	211·8	35·9	14·8	37·	26·4	526·8	112	638·8
Royal Sovereign	800	210·7	210·7	21·2	11·6	26·7	24·8	505·8	112	617·8
Victoria and Albert	600	183·2	170·4	*73·3	15·0	31·7	26·0	499·6	...	...

* Paddles.

DESCRIPTION OF THE PLATES.

PLATE XXIX. represents the usual type of the side-lever marine-engine. The principal parts are—A the cylinder, B the valve-chest, C the condenser, D the hot well, E the air-pump, F the feed and bilge pumps, GG the great lever, G′ its main gudgeon, H the cylinder side-rods, I the cross-head, K the piston-rod, LL the parallel motion, M the air-pump cross-head, N the air-pump side-rods, O the air-pump piston-rod, P the connecting-rod cross-tail links, Q the cross-tail, R the connecting-rod, S the crank, U the eccentric pulley or cam, *u u u* the eccentric-rod, V the valve-shaft, WW the valve-lever and counterbalance lever.

The apparatus for working the valves expansively is distinctly shown. On the crank-axle, T, is placed a series of cams *t t t*, which act upon the roller of the expansion-valve tumbler. Y *y y y* are the expansion-valve connecting-rods and levers. Z is the valve-chest, and the valve is of the kind called equilibrium-valves, or crown-valves.

PLATES XXX., XXXI., and XXXII. represent a pair of direct screw-engines of 500 horse-power (nominal), as constructed by Messrs Ravenhill, Salkeld, and Company, for various ships in the royal navy. The following vessels have been fitted with machinery on this plan, viz.—the Waterloo and Nelson, 98 guns, 500 H.P.; the Undaunted, Glasgow, and Newcastle, 50-gun frigates, and 600 H.P.; the Narcissus, 50 guns, and the Jason, 21 guns, each of 400 H.P. These engines have given much satisfaction, being at once compact, and at the same time easy of access to all the working parts.

The following are the principal dimensions of the 500-horse screw-engines:—

Diameter of the cylinders (two)	71 inches.
Length of stroke	3 feet.
Revolutions of engines and screw-shaft, per min.	50
Pressure of steam in the boilers per sq. inch	20 lb.
Diameter of the screw	18 feet.
Pitch of do. mean	20 feet.
Description of screw	Griffith's.
Mean draught of the ship (H.M.S. Nelson)	24 ft. 9½ in.
Speed at the measured mile	10 9 knots.
Indicated horse-power	2150 horses.

The various parts of the engines will be recognised by reference to the following letters:—AA are the cylinders; B the piston-rods, of which there are two to each cylinder; C the connecting-rods, working between the guiding surfaces DD, and giving motion to the main cranks EE; F is the screw-shaft; G, the thrust-block, on which the thrust of the screw is taken; H the coupling for disconnecting the shaft; I a worm-wheel for turning the engines by hand; K the steam-pipe from the boilers; L the throttle-valve; M the expansion-valves; N the cylinder slide-valves; O the exhaust-passages; P the condenser; Q the air-pump-rods, which work direct from the piston, passing steam-tight through the cylinder covers like small piston-rods. The air-pumps themselves cannot be seen, being concealed by the condenser. R the discharge-pipes; S the feed and bilge plunger pumps; T eccentrics and gear for working the slide-valves.

Plates XXXIII. and XXXIV. represent the engines and boilers of the screw-steamship Thunder, which are possessed of several interesting peculiarities and appliances for economizing fuel and steam. The vessel (built by Messrs Lungley of London) is of iron, 240 feet long, 30 feet beam, 22 feet 6 inches deep, and 1062 tons B.O.M. Her draught of water is 13 feet 8 inches aft, and 10 feet 8 inches forward. The engines are constructed by Messrs Dudgeon, of Millwall, London, and have the following dimensions:—

Diameter of cylinders (two)	55 inches.
Length of stroke	36 „
Revolutions of engines and screw per min.	58
Diameter of screw	15 feet.
Pitch of screw	29½ „
Nominal horse-power	210 horses.
Indicated horse-power with full steam ..... 950 to 1000	„
Do., with expansion when cutting off after ¼th ... 696	
Speed, with an immersed midship-section of 342 square feet and displacement of 1175 tons, the engines making 54 revolutions per minute, and cutting off steam after ¼th of the stroke	14 knots.
Maximum speed at trial with full power	15 „

The cylinders of these engines are inverted, and are fixed directly over the crank-shaft. They have separate expansion-slides, and double-port steam-slides. The exhaust is carried round the cylinders by broad belts (see O, Plate XXXIII.), into the condenser P, the belts thus acting as steam-jackets to the cylinders to preserve their temperature. The condensers themselves form part of the framing on which the cylinders stand. The shaft is forged with solid cranks, and the thrust of the screw is taken by the long collared bearing at C, which is supported independently of the engine framing. The pressure of steam in the boilers is 19 lb., the steam being cut off in the cylinders (when working most expansively) after one-fourth of the stroke.

The letters of reference, previously given, indicate the same portions of the machinery for this and all the remaining plates.

The boilers are tubular, two in number, with four furnaces, and are fired from each end. Each boiler has 360 tubes, 3¼ inches external diameter, and 7 feet long. The boilers are fitted with superheating apparatus (A), on Mr Beardmore's plan; each consists of two steam-chambers, placed one on each side of the chimney, connected by 172 tubes in each, each tube being 2 inches in diameter. The lower end of the chimney is expanded so as to encase the tubes, through which all the steam from the boilers passes on its way to the cylinders. These boilers generate steam with much facility. The advantage of having two funnels in this case is, that the draught thus becomes more direct, and therefore sharper than it would be with one large funnel. The temperature of the superheated steam is about 320°.

These engines have exhibited a very remarkable economy of fuel, the consumption, under favourable circumstances, not exceeding 1½ lb. per I.H.P. per hour; and when the vessel was deeply laden, this did not exceed from 2 to 2½ lb. during a ten days' voyage at sea. The Thunder ran from Plymouth to St Vincent in 9 days, 14 hours, the chief engineer writing thus from the latter place:—"We have run 285 miles during the last 24 hours; and our average speed has been throughout the voyage 11 knots per hour, on a consumption of 15 tons of coals per 24 hours. Pressure of steam 10 lb.; 44 revolutions per minute. Temperature of steam in superheaters, 310°." This is equal to a consumption of about 12 cwt. of coal per hour while steaming at the rate of 11 knots, which, for a displacement of 2000 tons, is an extraordinary result. Whilst on her trial trip her displacement was only half the above, when, under the most favourable circumstances, she went at the rate of 14 knots on a consumption of 8 cwt. per hour.

Plates XXXV. and XXXVI. represent a pair of "combined-cylinder" paddle-wheel engines of 320 horse-power collectively (nominal), as constructed by Messrs Randolph, Elder, and Company, of Glasgow, in the steamships Callao, Lima, and Bogotâ.

These vessels are 245 feet long, 36 feet broad, and 23 feet deep, and are designed with lines favourable for speed. Their tonnage is 1650 tons; draught of water, 11 feet forward, 12 feet aft; fitted with feathering wheels 25 feet 2 inches diameter.

The cylinders are four in number, viz., two of 52 inches diameter, and two of 90 inches diameter, and 5 feet stroke. It will be observed that they lie diagonally to each other. During the trial trips the engines made from 23 to 26 revolutions per minute, and indicated from 1000 to 1300 horse-power, the pressure of steam being 26 lb., and the speed of the ships from 12½ to 13 knots per hour. The boilers are tubular, and superheat the steam in the steam-chests by contact with the up-takes only, these being purposely divided and prolonged with this view. The cylinders are further provided with "jackets" kept well supplied with hot steam, to guard against condensation within the cylinders.

These engines have also been attended with a remarkable economy of fuel. The Bogotâ lately ran from Glasgow to St Vincent, a distance of 2470 nautical miles, in 9 days 21 hours, on a consumption of 232 tons of coal, thus giving an average speed of 10·42 knots, on a consumption of 19 cwt. per hour. The average I.H.P. being 950, this gives an average of 2¼ lb. of coal per I.H.P. per hour.

Plate XXXVII. represents a pair of combined-cylinder engines of the same description as shown in the preceding plates, and by the same makers, but designed for driving the screw-propeller. These, it will be observed, are geared engines, driving the screw-shaft by means of internal gearing.

The nature and presumed advantages of "combined-cylinder" engines have been already explained. It may be here repeated, however, that the steam is first admitted into the small cylinder for about one-third of the stroke; and after expanding during the remainder of the stroke in the small cylinder, it enters the large one, and completes its work there by further expanding to the end of its stroke.

Plate XXXVIII. is a section of inboard works of the paddle-steamer Delta, carrying the Indian mails from Southampton to Alexandria. (R. M—Y.)

Table of Steamers in the Merchant Service, compiled from Returns made to the Board of Trade.

Name of the Vessel.	Port of Departure.	When built.	By whom built.	Iron or Wood.	Length per Register.	Breadth per Register.	Depth per Register.	Tonnage. Register.	Tonnage. Gross.	Draft of Water. Forward.	Draft of Water. Aft.	Makers of the Machinery.	Description of Engines.	Nominal Horse-Power.	Paddle or Screw.	Diameter of Cylinder.	Number of Cylinders.	Length of Stroke.	Revs. of Engines per minute.	Description of Boilers.	Number of Boilers.	Pressure of Steam.	Coals carried.	Maximum Speed at Load Draft.	Service.
		Yr.			Feet.	Ft.	Ft.	Tns.	Tons.	F. In.	F. In.			H.P.		In.	No.	F. In.	No.		No.	lb.		Kts.	
African	Liverpool	1855	Smith & Rodgers	iron	280·8	34·2	23·7	1040	1529	20 0	21 0	Smith & Rodgers	Steeple 4 Piston-Rod	240	S. gear.	62	2	4 0	26	Tubular	2	14			Liverpool to Alexandria.
Agia Sofia	Liverpool	1857	Thomson	iron	259·3	34·6	22	977	1437	17 5	19 4	Thomson	Oscillating	193	S.direct	56	2	3 0	42	Tubular	2	25			Lpl. to Mediterranean.
Alhambra	Southampton	1855	Samuda	iron	209·3	27·1	16·3	373	642	12 4	13 4	Humphrys & Co.	Dble. P.-Rod	140	S.direct	50¼	2	3 0	34	Sheet-flue	2	16	10 days	11	Peninsular Mails.
Alliance	Southampton	1855	Mare & Co.	iron	175·5	23·7	14·6	168	360	9 6	10 0	Seaward	Atmospheric	225	Paddle	62	3	4 6	25	Tubular	2	16	50 hours	13	Channel Islands (Mails).
Arabia	Liverpool	1852	R. Steele	wood	284·2	37·3	27·6	1359	2393	20 0	21 0	R. Napier & Sons	Side-Lever	930	Paddle	103	2	9 0	15	Tubular	4	18			Lpl. to Boston (Mails).
Atrato	Southampton	1853	Caird & Co.	iron	336·6	40·9	33·7	1969	3126	21 0	21 3	Caird & Co.	Side-Lever	800	Paddle	96	2	9 0	15	Sheet-flue & Tubular	4	16	16 days	13½	West India Mails.
Ava	Southampton	1855	Tod & M'Gregor	iron	257·6	35·3	16·2	930	1373	15 3	15 9	Tod & M'Gregor	Vert. Trunk	320	S. gear.	70	2	4 0	30	Sheet-flue	2	13½	500 tons	12	China Mails.
Bahiana	Liverpool	1854	J. Laird	iron	245·5	35	22·8	936	1530	18 0	19 6	Fawcett & Co.	Oscillating	197	S. gear.	54	2	4 0	38	Tubular	2	12			Liverpool to India.
Behar	Southampton	1855	J. Laird	iron	265	36·1	25·5	1090	1603	18 0	18 0	Fawcett & Preston	Horizontal	300	S.direct	56	2	2 6	50	Sheet flue	4	16	12 days	11	Indian Mails.
Brighton	Weymouth	1857	Palmer & Co.	iron	183·5	20·9	10	180	285	6 0	7 6	Palmer & Co.	Oscillating	140	Paddle	44	2	4 0	34	Tubular	2	30	48 hours	12½	Channel Islands.
Celt	Southampton	1855	G. Lungley	iron	179	25	17	426	550	13 3	14 11	Summers & Day	Trunk	85	S. gear.	*34	2	2 9	36	Sheet-flue	1	12	45 days	9	Cape of Good Hope Mails.
Ceylon	Southampton	1858	Samuda	iron	306·1	40·9	27·8	1374	2020	20 0	20 6	Humphrys & Co.	Invert. Cylin.	450	S.direct	72	2	3 0	50	Sheet-flue	4	15	11½ days	12½	Alexandrian Mails.
China	Southampton	1855	J. Laird	iron	279	37·4	22·9	1366	2009	16 6	17 10	Humphrys & Co.	Invert. Cylin.	400	S.direct	64	2	2 8	62	Sheet-flue	4	20	14 days	11½	Alexandrian Mails.
City of Baltimore	Liverpool	1855	Tod & M'Gregor	iron	324·5	31·1	25·8	1224	2367	19 0	21 0	Tod & M'Gregor	Steep. 4 P.-R.	547	S. gear.	82	2	7 0	16	Tubular	4	14			Liverpool to New York.
C. of Washington	Liverpool	1855	Tod & M'Gregor	iron	319	40·1	19·2	1618	2380	20 0	21 0	Tod & M'Gregor	Steep. 4 P.-R.	460	S. gear.	76	2	6 0	17½	Tubular	4	12½			Liverpool to New York.
Colombo	Southampton	1853	R. Napier	iron	286·6	36	26·8	1190	1864	17 11	20 7	R. Napier & Sons	Beam	450	S. gear.	72	2	5 6	26	Sheet-flue	4	15	11½ days	12	Alexandrian Mails.
Courier	Southampton	1847	Ditchburn	iron	167	22·3	10·8	195	313	7 0	7 6	Maudslay & Field	Annular Pist.	200	Paddle	60¾	2	3 6	32	Tubular	2	15	32 hours	12	Channel Islands.
Cygnus	Weymouth	1854	Henderson	iron	177	24·6	16·7	421	530	13 1	14 6	M'Nab & Clark	Oscillating	120	Paddle	42	2	3 6	34	Tubular	2	25	48 hours	12	Channel Islands.
Delta	Southampton	1859	Thames Iron Ship-building Co.	iron	324·3	35·3	22·1	1019	1618	14 11	14 11	J. Penn & Son	Oscillating	400	Paddle	72	2	7 0	25	Sheet-flue	4	20	9 days	14	Alexandrian Mails.
Emerald	Southampton	1857	Summers	iron	105	14·1	8·1	43	69	4 10	5 2	Summers & Day	Oscillating	32	Paddle	23	2	2 9	42	Tubular	1	16	3 tons	10	Isle of Wight.
Empress	Dover	1855	Mare & Co.	iron	151·6	20	11	103	301	6 2	6 6	Ravenhill & Co.	Oscillating	100	Paddle	41	2	3 0	42	Tubular	1	25	12 tons	13½	Dover to Calais.
Etna	Liverpool	1855	Caird & Co.	iron	304·9	36	27	992	2215	21 0	22 0	Caird & Co.	Beam	438	S. gear.	76¾	2	5 3	24	Tubular	4	14			Liverpool to New York.
Euxine	Southampton	1847	Caird & Co.	iron	222·7	29·4	18·5	729	1164	17 6	18 0	Caird & Co.	Oscillating	400	Paddle	75	2	7 0	15	Sheet-flue	4	15½	10 days	12	Mediterranean Mails.
Garland	Glasgow	1855	R. Napier	iron	165·8	23·1	12·2	192	282	9 0	11 0	R. Napier & Sons	Hor. Trunk	80	S.direct	36	2	3 0	80	Tubular			30 tons	11	Coasting Trade.
Great Britain	Liverpool	1843	Patterson	iron	274	48·2	31·5	1733	3209	21 0	21 0	J. Penn & Son	Oscillating	500	S. gear.	82½	2	6 0	20	Tubular	6	10			Liverpool to Australia.
Great Eastern	Southampton	1859	J. Scott Russell	iron	680	83	55		22,500	25 0	25 0	Scott Russell,	Oscillating	1000	Paddle	74	4	14 0	12	Tubular	4	25	10,000 tons	15	
												J. Watt & Co.	Horizontal	1600	S.direct	84	4	4 0	48	Tubular	6	25			
Great Western	Bristol	1838	Patterson	wood	210	35·4	23·3		1340	16 0	17 0	Maudslay & Field	Side-Lever	450	Paddle	73	2	7 0					700 tons	11	First Transatlantic Str.
Havelock	Glasgow	1858	Thomson	iron	215	26	14·9	339	628	9 6	10 0	Thomson	Side-Lever	344	Paddle	62	2	5 6	26	Tubular		20	60 tons	12½	Coasting Trade.
Havre	Southampton	1856	Mare & Co.	iron	184·7	24	14·5	200	387	9 8	10 0	Seaward	Atmospheric	220	Paddle	62	3	4 6	25	Tubular	2	16	50 hours	14½	Hâvre Mails.
Her Majesty	Portsmouth	1850	Robinsons & Russell	iron	129·1	14	7·2	66	92	3 9	4 6	Robinsons & Russell	Oscillating	40	Paddle	27	2	2 6	55	Tubular	1	16	18 hours	12	Portsmouth and Ryde.
Himalaya	(Governmt.)	...	Mare & Co.	iron	341·0	46·4	35·0	2327	3438			J. Penn & Son	Horizontal	700	S. gear.	84¾	2	3 6	59	Sheet-flue	4	14	1000 tons	13½	Government Transport.
Imperador	Liverpool	1854	J. Laird	iron	263·5	35·2	24·2	1315	1739	16 0	17 0	Fawcett & Co.	Inverted	173	S.direct	54	2	2 9	60	Tubular	2	15			Liverpool to India.
Indian	Liverpool	1854	Denny	iron	277·7	33·8	23·9	1154	1873	16 9	18 0	Tulloch & Denny	Inverted	250	S.direct	62	2	3 6	40	Tubular	2	12	(lost)		Liverpool to Quebec.
Indiana	London	1852	Ditchburn	iron	239	38·2	32·4	1798	2364	19 6	19 6	Maudslay & Field	Diagonal	300	S.direct	55	2	2 6	50	Tubular	2	12	20 days	9	Steam Transport.
Indus	Southampton	1847	Wigram	iron	241·2	34·1	29·7	1302	1950	17 6	18 6	Miller & Ravenhill	Oscillating	450	Paddle	75	2	7 0	15	Sheet-flue	4	13	11 days	10	Alexandrian Mails.
Iona	Glasgow	1858	Thomson	iron	225	20·4	9	173	324	4 6	4 6	Thomson	Oscillating	120	Paddle	46¼	2	4 0	35	Tubular		34	25 tons	16	Cumbray and Skipness.
Ionia	Liverpool	1856	Marshall	iron	244·4	32·1	25·9	943	1388	18 0	20 0	Marshall	Inverted	210	S.direct	46	3	3 0	52	Tubular	3	16			Lpl. and Mediterranean.
Iron Duke	Liverpool	1844	T. Wilson	iron	225·2	28	17·1	385	732	10 0	11 0	Fawcett & Co.	Side-Lever	320	Paddle	63	2	7 0	17	Combined	2	15			Liverpool to Dublin.
Jeddo	Southampton	1859	J. Laird	iron	277·3	35·8	16·2	1109	1631	16 7	17 0	R. Napier & Sons	Hor. Trunk	450	S.direct	70	2	3 0	60	Sheet-flue	4	16	12 days	11½	China Mails.
Jupiter	London	1849	Pascoe	iron	165·0	18	9	91	145	4 3	4 9	Miller & Co.	Oscillating	80	Paddle	37	2	3 0	42	Tubular	1	20	10 tons	13½	Dover to Ramsgate.
Jura	Liverpool	1854	Thomson	iron	313·8	35·8	27·6	1067	2190	21 0	22 0	Thomson	Beam	433	S. gear.	76	2	5 5	26	Tubular	4	15			Liverpool to New York.
La Plata	Southampton	1851	R. Steele	wood	280·5	37·4	27·6	1474	2404	20 6	22 0	R. Napier & Sons	Side-Lever	875	Paddle	103	2	9 0	13	Tubular	4	16	14 days	12½	West India Mails.
Lyons	Newhaven	1856	Scott Russell	iron	192	22	10	139	269	6 2	6 7	Scott Russell	Oscillating	160	Paddle	48	2	4 6	36	Tubular	2	30	50 tons	14½	Newhaven to Dieppe.
Magdalena	Southampton	1851	Pitcher	wood	266	38·1	33·5	1866	2943	21 0	22 0	R. Napier & Sons	Side-Lever	800	Paddle	96	2	9 0	11	Rect.-flue	4	12	17 days	11½	West India Mails.
Mauritius	Southampton	1852	Mare & Co.	iron	251	39	25·7	1451	2184	19 0	20 0	Bolton & Watt	Horizontal	300	S.direct	55	2	2 6	50	Tubular	2	15	15 days	10	French Transport Serv.
Mersey	Southampton	1859	Samuda	iron	260·4	30·2	16·5	729	1001	18 0	19 0	Maudslay & Field	Oscillating	250	Paddle	60	2	5 0	30	Tubular	4	20	12 days	11½	West India Mails.
Northam	Southampton	1858	Summers & Co.	iron	274	34·7	21	904	1337	17 11	19 4	Summers & Day	Horizontal	400	S.direct	64	2	3 0	60	Sheet-flue	4	18	12 days	12½	Indian Mails.
North Briton	Liverpool	1858	Denny	iron	298·4	38	17·8	1487	2187	19 9	20 3	Tulloch & Denny	Inverted	280	S.direct	66	2	3 6	40	Tubular	4	18			Liverpool to Quebec.
Oneida	Southampton	1855	Scott & Sons	iron	306	38·9	19·2	1372	2285	20 2	20 7	A. & J. Inglis	Vert. Trunk	530	S. gear.	†82	2	4 6	26	Tubular	4	17	15 days	13	West India Mails.
Orissa	Southampton	1856	J. Laird	iron	264·6	35·9	26·6	1119	1646	18 0	18 0	Fawcett & Co.	Horizontal	300	S.direct	52	2	2 6	50	Tubular	4	15	11 days	10	East India Mails.
Parana	Southampton	1852	Wigram	wood	300	36·8	33·2	2048	3070	21 9	22 3	Caird & Co.	Side-Lever	800	Paddle	96	2	9 0	11	Rect.-flue	4	12	17 days	11½	West India Mails.
Parramatta (lost)	Southampton	1858	Thames Iron Ship-building Co.	iron	330	44·4	26·7	2166	3438	20 6	22 9	Maudslay & Field	Dble. Cylin.	764	Paddle	68	4	9 0	17	Tubular	4	16	17 days	13½	West India Mails.
Pera	Southampton	1855	Mare & Co.	iron	303·5	42·1	27·1	1261	2013	18 0	19 6	G. & J. Rennies	Trunk	450	S. gear.	*70¼	2	4 0	32	Sheet-flue	4	16	12 days	12	Alexandrian Mails.
Persia	Liverpool	1855	R. Napier	iron	376	45·3	30	2079	3300	21 0	22 0	R. Napier & Sons	Side-Lever	950	Paddle	100	2	10 0	15	Tubular	8	23			Liverpool to New York.
Prince Consort	Portsmouth	1859	J. Scott Russell	iron	154·5	15·1	6·7	65	103	3 6	4 0	Scott Russell	Oscillating	50	Paddle	30	2	2 6	44	Tubular	1	20	20 hours	11	Portsmouth and Ryde.
Princess Royal	Portsmouth	1850	J. White	wood	107	13·4	8·3	57	88	4 6	5 6	Seaward	Oscillating	40	Paddle	28½	2	2 6	36	Tubular	1	13	20 hours	10½	Portsmouth and Ryde.
Prince Frederick William	Dover	1857	Thames Iron Ship-building Co.	iron	172	20	11	100	214	6 2	6 8	Ravenhill & Co.	Oscillating	120	Paddle	46	2	3 0	41	Tubular	2	25	20 tons	14	Dover to Ostend.
Queen	Dover	1855	Mare & Co.	iron	151·6	20	11	103	301	6 2	6 6	Ravenhill & Co.	Oscillating	100	Paddle	41	2	3 0	42	Tubular	1	25	12 tons	13½	Dover to Calais.
Rhone	Liverpool	1856	Smith & Rodgers	iron	257·2	34·6	22·5	943	1387	18 6	21 0	M'Nab & Clark	Inverted	166	S.direct	52	2	3 0	38	Tubular	2	17			Mediterranean Ports.
Ripon	Southampton	1846	Mare & Co.	iron	281·3	33·9	28·4	1308	1925	17 4	18 4	Miller & Ravenhill	Oscillating	450	Paddle	75	2	7 0	14½	Sheet-flue	4	13½	10 days	11	Alexandrian Mails.
Shannon	Southampton	1859	R. Napier	iron	330·4	44·5	26·2	2187	3471	19 6	21 0	R. Napier & Sons	Side-Lever	774	Paddle	97	2	9 0	18	Tubular	4	22	18 days	14	West India Mails.
Stag	Glasgow	1854	Denny	iron	213	23·6	13·3	314	498	9 0	9 6	Thomson	Side-Lever	240	Paddle	57	2	5 6	22	Tubular		18	72 tons	12	Home Trade.
Sultan	Southampton	1847	Tod & M'Gregor	iron	231	32	17·8	808	1124	10 6	11 6	Caird & Co.	Trunk	200	S.direct	42	2	4 0	55	Sheet-flue	2	15	12 days	10½	Peninsular Mails.
Tagus	Southampton	1837	Scott & Sons	wood	182	26	17·4	497	782	13 3	14 8	Scott & Sinclair	Side-Lever	280	Paddle	62½	2	5 10	19	Sheet-flue	2	12	10 days	9½	Peninsular Mails.
Tamar	Southampton	1854	Pitcher	wood	287·5	33·7	26·5	1501	1963	17 6	18 6	J. Penn & Son	Oscillating	400	Paddle	72	2	7 0	16½	Tubular	4	15½	13½ days	13	Brazil Mails.
Tasmanian	Southampton	1858	Laurence Hill & Co.	iron	346	39·2	20·1	1274	2253	20 0	20 0	A. & J. Inglis	Trunk	744	S.direct	71	3	3 6	50	Tubular	6	16	14 days	13½	Brazil Mails.
Thistle	Glasgow	1859	Laurence Hill & Co.	iron	184·5	25·2	12·5	206	386	9 0	11 6	A. & J. Inglis	Beam	155	S. gear.	44½	2	3 6	38	Tubular		19½	66 tons	11½	Home Trade.
Tyne	Southampton	1854	Miller & Ravenhill	iron	296·6	36·2	27·1	1788	2184	16 6	17 9	Miller & Co.	Oscillating	400	Paddle	72	2	7 0	16	Tubular	4	16	15 days	11	Brazil Mails.
Valetta	Southampton	1853	Mare & Co.	iron	225	27·6	17	507	769	12 0	13 3	J. Penn & Son	Oscillating	260	Paddle	62	2	4 6		Sheet-flue	2	20	10 days	14	Marseilles Mails.
Vectis	Southampton	1853	J. White	wood	229·5	30·4	16·9	473	751	12 3	13 0	J. Penn & Son	Oscillating	260	Paddle	62	2	4 6		Sheet-flue	2	20	10 days	14	Marseilles Mails.
Vivid	Dover	1846	Ditchburn	iron	141	21	11		92	6 0	6 6	J. Penn & Son	Oscillating	120	Paddle	43½	2	4 0	32	Tubular	2	18	15 tons	13	Dover to Ostend.
Windsor Castle	Glasgow	1859	Caird & Co.	iron	191·3	20	7·6	93	190	3 1½	3 3	Caird & Co.	Diagonal	115	Paddle	40	2	5 0	45	Tubular		40	10 tons	16½	Cumbray and Skipness.

Note.—The dimensions "per Register" are all *inside* measurements.—* The "Diameters of Cylinders" marked with an asterisk are "effective."—† The diameter of the trunk in the Oneida is 36¾ inches.

TABLE OF SCREW-STEAMERS IN THE ROYAL NAVY,

SHIP. Name.	Tonnage.	Speed.	Date of Trial.	Where tried.	Length between the Perpendiculars.	Breadth Extreme.	Draught of Water. Forward.	Draught of Water. Aft.	Area of Midship Section.	Displacement.	ENGINES. Description of Engines.	Name of Manufacturer.	Cylinders. Number.	Cylinders. Diameter.	Length of Stroke.	Number of Revolutions per minute.	Weight per square inch on the safety-valve.	Horse-Power Nominal.	Horse-Power Indicated.
	Tns.	Knts.			ft. in.	ft. in.	ft. in.	ft. in.	sq. ft.	Tns.				inches.	ft. in		lbs.	hrs.	hors
Agamemnon	3074	11	2 Oct. 1852	Nore	230 0	55 4	17 7	20 4	816	3750	Horizontal, Trunk	John Penn and Son	2	=70¾	3 6	60	17	600	1838·
Ditto	3074	11·243	3 May 1853	Stokes Bay	230 0	55 4	23 1	23 8	1060	5080	Horizontal, Trunk	John Penn and Son	2	=70¾	3 6	63	20	600	2268
Algiers	3347	9	1 June 1854	Plymouth	218 7	60 0	24 6	25 7	1053	4730	Horizontal	Fairbairn and Sons	4	61	3 3	27	10	450	1117
Arrogant	1872	8·646	9 July 1853	Stokes Bay	200 0	45 8¾	19 1½	20 2½	615	2615	Horizontal, Trunk	John Penn and Son	2	=55	3 0	61	12	360	774
Arrow	477	11	22 Aug. 1854	Spithead	160 0	25 4	10 0	11 8	209	586	Horizontal	Humphrys, Tennant, & Co.	2	42	1 9	93	20	160	594
Assurance	670	11·142	16 June 1856	Stokes Bay	180 0	28 4	10 4	11 4	240	781	Horizontal	Miller, Ravenhill, and Co.	2	45	2 0	87	20	200	744·
Cæsar	2767	10·274	3 Mar. 1854	Stokes Bay	207 4	56 0¾	19 5	22 8	726	3250	Horizontal, Trunk	John Penn and Son	2	=58	3 3	60	22	400	1420
Colossus	2590	9·312	16 Oct. 1854	Stokes Bay	190 0	57 0	23 2	25 7	892	3691	Horizontal, Trunk	John Penn and Son	2	=58	3 3	60	20	400	1458
Conflict	1038	8·837	16 July 1853	Stokes Bay	192 6½	34 4	15 9½	17 4½	472	1752	Horizontal	Seaward and Capel	4	46¼	2 0	73	10	400	752
Ditto	1038	9·425	22 Aug. 1853	Stokes Bay	192 6½	34 4	15 9	17 3	470	1740	Horizontal	Seaward and Capel	4	46¼	2 0	77	10	400	784
Ditto	1038	9·424	23 Aug. 1853	Stokes Bay	172 6½	34 4	15 9	17 5	472	1752	Horizontal	Seaward and Capel	4	46¼	2 0	75·75	10	400	812
Ditto	1038	9·772	21 Sept. 1853	Stokes Bay	192 6½	34 4	15 10	17 4	472	1752	Horizontal	Seaward and Capel	4	46¼	2 0	61·5	10	400	776
Ditto	1038	9·428	30 Sept. 1853	Stokes Bay	192 6½	34 4	15 9	17 4	471	1746	Horizontal	Seaward and Capel	4	46¼	2 0	62·5	10	400	772
Ditto	1038	9·913	18 Oct. 1853	Stokes Bay	192 6½	34 4	15 9	17 4	471	1746	Horizontal	Seaward and Capel	4	46¼	2 0	67·25	10	400	799
Ditto	1038	9·571	2 Nov. 1853	Stokes Bay	192 6½	34 4	15 10	17 4	472	1752	Horizontal	Seaward and Capel	4	46¼	2 0	66	10	400	784
Ditto	1038	9·772	7 Nov. 1853	Stokes Bay	192 6½	34 4	15 9	17 4	471	1746	Horizontal	Seaward and Capel	4	46¼	2 0	66·5	10	400	760
Conqueror	3224	10·806	16 June 1856	Plymouth	240 0	55 4	24 3	26 4	1122	5665	Horizontal, Trunk	John Penn and Son	2	=82	4 0	55	20	800	2812
Coquette	670	10·902	15 May 1856	Stokes Bay	180 0	28 4	10 1	11 5	238	772	Horizontal	Miller, Ravenhill, and Co.	2	45	2 0	86·75	20	200	709·4
Curacoa	1571	10·793	26 Sept. 1854	Stokes Bay	192 0	43 0¼	14 4	17 6	467	1735	Horizontal	Maudslay, Sons, and Field	2	57½	2 9	64	20	350	1124
Dauntless	1575	10 016	12 Sept. 1850	Stokes Bay	219 6	39 9	16 4	16 10	542	2150	Horizontal, Geared	Robert Napier and Sons	2	84	4 0	31	10	580	1347
Ditto	1575	10·133	12 Oct. 1850	Stokes Bay	219 6	39 9	16 8	71 10	570	2480	Horizontal, Geared	Robert Napier and Sons	2	84	4 0	30·5	10	580	1327·6
Desperate	1037	10·766	18 July 1850	Nore	192 4	34 4½	13 6	14 10	388	1393	Horizontal, Geared	Maudslay, Sons, and Field	4	55	2 6	37·77	8	400	892 5
Ditto	1037	9·86	11 Mar. 1852	Plymouth	192 4	24 4¼	14 7	15 9	424	1545	Horizontal, Geared	Maudslay, Sons, and Field	4	55	2 6	38	8	400	810·9
D. of Wellington	3759	10·15	11 Apr. 1853	Stokes Bay	240 6	60 0	23 0	24 3	988	5080	Horizontal, Geared	Robert Napier and Sons	2	93⅞	4 6	29 6	15	700	1979
Encounter	953	10 699	10 June 1853	Stokes Bay	190 0	43 2½	13 7	13 10	382	1459	Horizontal, Trunk	John Penn and Son	2	=55	2 3	81·75	12	360	44
Ditto	1169	9·439	3 Jan. 1855	Stokes Bay	192 0	36 3	15 7	17 2	470	1757	Inclined, Oscillating	J. Scott Russell and Co.	2	50	2 9	65·5	18	250	857
Ditto	1169	9·219	8 Jan. 1855	Stokes Bay	192 0	36 3	15 7	17 2	470	1757	Inclined, Oscillating	J. Scott Russell and Co.	2	50	2 9	63	18	250	592
Fairy	312	11·309	19 Sept. 1853	Stokes Bay	144 8	21 1½	5 1	7 1	86	210	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	35·5	11	128	359·5
Ditto	312	12·26	24 Dec. 1853	Stokes Bay	144 8	21 1½	5 1	7 1	86	210	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	34·8	11	128	348·8
Ditto	312	12·137	27 Dec. 1853	Stokes Bay	144 8	21 1½	5 1	7 1	86	210	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	35·25	11	128	358·4
Ditto	312	11·699	29 Dec. 1853	Stokes Bay	144 8	21 1½	5 1	7 1	86	210	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	45·25	11	128	335·1
Ditto	312	11·658	28 Mar. 1854	Stokes Bay	144 8	21 1½	4 9½	7 3½	85·4	207·4	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	37·5	14	128	383·5
Ditto	312	13·033	24 June 1854	Stokes Bay	144 8	21 1½	4 10	7 1	84	203	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	41·5	15	128	410
Ditto	312	13·27	11 July 1854	Stokes Bay	144 8	21 1½	4 10	7 1	84	203	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	42 5	15	128	410
Ditto	312	13·229	14 Apr. 1855	Stokes Bay	144 8	21 1½	4 11½	7 0½	85	205	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	41	15	128	406·8
Ditto	312	13·216	17 Apr. 1856	Stokes Bay	144 8	21 1½	5 1	7 1	86	210	Vertical, Oscillg., Geared	John Penn and Son	2	42	3 0	40·5	15	128	416
Flying Fish	868	11·585	13 May 1856	Stokes Bay	200 0	30 4	10 9	12 3	281	1090	Horizontal	Maudslay, Sons, and Field	2	58	2 3	82	20	350	1302·3
Ditto	868	11·736	20 June 1856	Stokes Bay	200 0	30 4	10 4	12 11	272	1050	Horizontal	Maudslay, Sons, and Field	2	58	2 3	75	20	350	1166·8
Ditto	868	11·603	3 July 1856	Stokes Bay	200 0	30 4	10 8	12 11	277	1072	Horizontal	Maudslay, Sons, and Field	2	58	2 3	74·5	20	350	1160·6
Forth	1228	9·384	16 May 1856	Stokes Bay	159 0	42 2	17 7	18 9	516	1792	Horizontal, Tk., High Prs.	John Penn and Son	2	=30½	2 6	114	60	200	833·6
Glatton, *Bat.*	1535	4·5	4 July 1855	Nore	172 6	45 2½	8 4	8 8	379	1640	Horizontal, High Press.	Miller, Ravenhill, and Co.	2	25½	2 0	127	62	150	693·4
Hannibal	3136	8 6	12 Apr. 1854	Nor	217 6	48 1⅝	20 6	20 7	777	3300	Horizontal, Geared	Scott, Sinclair, and Co.	2	71¼	4 0	27·5	12	450	1071·2
Highflyer	1153	9·399	10 Apr. 1852	Thames	192 0	36 4	15 8	17 4	476	1775	Horizontal	Maudslay, Sons, and Field	2	55 3-16	2 6	53·37	14	250	702
Hogue	1846	7·809	13 Dec. 1850	Stokes Bay	184 0	48 4½	20 10	23 10	799	3054	Horizontal	Seaward and Capel	4	51½	3 0	47	10	450	792·6
Ditto	1846	8·328	18 Dec. 1850	Stokes Bay	184 0	48 4½	21 2	23 10	805	3081	Horizontal	Seaward and Capel	4	51½	3 0	56	10	450	797·3
Horatio	1090	8·855	17 June 1850	Nore	154 3	40 2½	12 1	18 8	391	1175	Horizontal, Geared	Seaward and Capel	2	54	3 0	41·28	13	250	553·1
Imperieuse	2355	10·673	11 Jan. 1853	Nore	212 0	50 0	16 1	18 3	524	2225	Horizontal, Trunk	John Penn and Son	2	=55	3 0	67·7	13	360	1080 7
James Watt	3083	9·361	30 Mar. 1855	Stokes Bay	230 0	55 5	23 3	23 10	1040	4950	Horizontal	James Watt and Co.	4	52	3 0	51	16	600	1543·6
Lapwing	670	11·021	27 May 1856	Stokes Bay	180 0	28 4	10 2	11 6	240	781	Horizontal	Miller, Ravenhill, and Co.	2	45	2 0	85	20	200	689·2
Marlborough	4000	11·866	12 May 1856	Stokes Bay	245 6	61 2½	21 1	22 10	928	4510	Horizontal	Maudslay, Sons, and Field	2	82	4 0	53·5	20	800	2683·5
Megæra	1395	10·241	28 Mar. 1850	Thames	207 0	37 10	11 4	15 3	383	1554	Horizontal	George and John Rennie	4	49½	2 0	74·21	8	350	925·6
Meteor, *Battery*	1469	5·77	16 May 1855	Thames	172 6	43 11	6 5	8 0	310	1346	Horizontal, High Press.	Maudslay, Sons, and Field	2	26⅛	2 0	139	60	150	529·6
Miranda	1039	10·75	2 July 1853	Nore	196 0½	34 0	12 3	12 6	336	1350	Horizontal, Geared	Robert Napier	2	56⅜	3 9	28·5	13	250	613·1
Mohawk	670	10·721	4 June 1856	Stokes Bay	180 0	28 4	10 3	11 6	242	785	Horizontal	Humphrys, Tennant, & Co.	2	42¼	2 2	88	20	200	641·5
Orion	3232	11·446	2 May 1856	Stokes Bay	238 0	55 9	24 5	26 10	982	5070	Horizontal, Trunk	John Penn and Son	2	=70¾	3 6	62·75	20	600	2328·6
Pearl	1462	11·313	20 May 1856	Stokes Bay	200 0	40 4	16 2	19 9	540	2115	Horizontal, Trunk	John Penn and Son	2	=58 1-16	3 3	59	20	400	1324
Ditto	1462	10·669	27 May 1856	Stokes Bay	200 0	40 4	16 4	19 9	544	2130	Horizontal, Trunk	John Penn and Son	2	=58 1-16	3 3	49	20	400	1097·6
Pioneer	868	11·366	20 May 1856	Stokes Bay	200 0	30 4	10 6	12 0	273	1056	Horizontal	Miller, Ravenhill, and Co.	2	55	2 6	82	20	350	1192·5
Plumper	490	7·218	21 July 1853	Stokes Bay	140 0	27 6	10 5½	10 7½	194	510	Vertical, Oscillating, Grd.	Miller, Ravenhill, and Co.	2	27	2 0	55·5	14	60	135
Princess Royal	3129	11·031	2 Nov. 1853	Stokes Bay	217 0	58 1½	20 2½	21 7½	805	3400	Horizontal	Maudslay, Sons, and Field	2	64⅛	3 0	58	20	400	1491
Pylades	1278	10·119	31 Mar. 1855	Stokes Bay	192 9	38 5	16 0	19 0	522	1956	Horizontal, Trunk	John Penn and Son	2	=55	3 0	62·5	20	350	1106
Rattler	888	9·77	5 Sept. 1851	Thames	176 6	32 8½	10 11	12 1½	266	840	Vertical, Dbl. Cylrs., Grd.	Maudslay, Sons, and Field	4	40⅛	4 0	25·76	10	200	499·7
Rifleman	486	7·15	25 Nov. 1853	Thames	150 0	26 7	11 3	11 10	233	678	Vertical, Oscillating, Grd.	Miller, Ravenhill, and Co.	2	34	2 9	35·57	10	100	166·5
Ringdove	670	10·824	20 May 1856	Stokes Bay	180 0	28 4	9 2	11 3	223	714	Horizontal	Miller, Ravenhill, and Co.	2	45	2 0	84	20	200	676·8
Royal Albert	3726	10	21 Nov. 1854	At Sea	232 9	61 0	24 8	27 4	1160	5571	Horizontal, Trunk	John Penn and Son	2	=64½	3 4	69	20	500	1800·6
Royal George	2616	9·375	13 Dec. 1853	Nore	205 7	54 6½	22 10	23 10	945	4110	Horizontal, Trunk	John Penn and Son	2	=58	3 3	62	20	400	...
St Jean D'Acre	3200	11·199	3 Dec. 1853	Stokes Bay	238 0	55 4	23 6	25 0	1067	5340	Horizontal, Trunk	John Penn and Son	2	=70¾	3 6	61	20	600	2136
Sans Pareil	2339	9·3	12 Aug. 1855	At Sea	200 0	52 3	22 8	25 7½	994	3800	Horizontal	James Watt and Co.	2	64	3 0	58	15	400	1471
Satellite	1462	11·4	18 June 1856	Plymouth	200 0	40 4	12 8	16 4	404	1500	Horizontal, Trunk	John Penn and Son	2	=58	3 3	63	20	400	1362
Seahorse	1212	9·298	16 May 1856	Stokes Bay	159 0	41 10	17 8	18 9	518	1799	Horizontal, Tk., High Prs.	John Penn and Son	2	=30½	2 6	112·25	60	200	832·4
Shannon	2651	11·807	5 June 1856	Stokes Bay	235 0	50 0	18 0	19 0	626	2948	Horizontal, Trunk	John Penn and Son	2	=70¼	3 6	56	20	600	2005·7
Sharpshooter	503	9·327	9 Nov. 1852	Stokes Bay	150 5	26 7½	11 0	10 9	237·5	653	Horizontal, Geared	Miller, Ravenhill, and Co.	2	46	3 0	38·25	10	200	348
Simoom	1980	8·747	8 Feb. 1851	Stokes Bay	246 0	41 0	15 5	17 10	555	2700	Horizontal, Oscillating	Boulton and Watt	4	43⅜	2 6	52·5	10	350	539·6
Ditto	1980	10·647	16 Oct. 1855	Stokes Bay	246 0	41 0	15 3	19 2	578	2830	Horizontal	Portsmth. Yard (refitted)	2	62½	3 0	55	20	400	1242
Sparrowhawk	670	11·065	16 June 1856	Stokes Bay	180 0	28 4	10 3	11 5	240	781	Horizontal	Humphrys, Tennant, & Co.	2	42¼	2 2	92	20	200	725·6
Surprise	670	11·149	14 July 1856	Stokes Bay	180 0	28 4	10 6	11 6	244	790	Horizontal	Miller, Ravenhill, and Co.	2	45	2 0	88	20	200	778·2
Termagant	1547	8·781	2 Sept. 1852	Stokes Bay	210 1	40 6	15 6	17 6	562	2270	Horizontal, Geared	Seaward and Capel	4	62½	3 6	34·5	14	200	1119
Ditto	1547	9·593	9 Oct. 1854	Stokes Bay	210 1	40 6	15 3	18 8	552	2230	Horizontal	Portsmth. Yard (refitted)	2	62½	3 0	53	15	400	1082
Tribune	1570	10·418	9 Nov. 1853	Stokes Bay	192 0	43 0	17 8	19 4	578	2220	Horizontal	Maudslay, Sons, and Field	2	55	2 6	72·5	20	300	1068
Victor	851	11·583	12 May 1856	Stokes Bay	200 0	30 2	10 3	12 0	264	1019	Horizontal	Miller, Ravenhill, and Co.	2	55	2 6	82	20	350	1165·9
Viper	477	11·86	27 Sept. 1854	Nore	160 0	25 4	10 0	12 0	215	600	Horizontal	Maudslay, Sons, and Field	2	40½	2 0	86·5	20	160	672·9
Wanderer	670	10·733	13 May 1856	Stokes Bay	180 0	28 4	9 7	11 5	231	745	Horizontal	Maudslay, Sons, and Field	2	45	2 0	83·25	20	200	706·8

COMPILED BY THE STEAM DEPARTMENT OF THE ADMIRALTY.

PROPELLER. Dimensions. Diameter.	Pitch.	Length.	Centre above bottom of false keel.	Immersion of centre at the time of trial.	Number of Revolutions per minute.	Rate in Knots per hour.	Slip. In Knots per hour.	Slip. Per Cent.	RATIO OF Vessel's length to breadth.	Screw's pitch to Diameter.	Midship Section to Screw's disc.	Indicated Power. To Midship Section.	Indicated Power. To Displacement $\frac{2}{3}$.	$\frac{\text{Speed}^3 \times \text{Mid. Sec.}}{\text{Indicated Power.}}$	$\frac{\text{Speed}^3 \times \text{Dispt.}^{\frac{2}{3}}}{\text{Indicated Power.}}$	REMARKS.
ft. in.	ft. in.	ft. in.	ft. in.	ft. in.		knts.	knts.									
18 0	20 6	3 4	11 5	8 11	60	12·133	1·133	9·34	4·16	1·14	3·21	2·25	7·62	590·7	174·7	Weather not favourable.
18 0	20 6	3 4	11 5	12 3	63	12·739	1·496	11·74	4·16	1·14	4·17	2·14	7·67	664·2	185·2	Weather very favourable.
17 0	14 0	2 4	11 9	13 10	69·12	9·545	0·545	5·71	3·65	0·80	4·64	1·06	3·96	687·2	183 9	Speed by common log.
15 6½	15 2⅜	2 5	10 1	10 1½	61	9·163	0·517	5·64	4·37	0·98	3·24	1·26	4·08	513·5	158·5	Slide-valve of forward engine defective.
11 0½	13 0	2 3⅜	7 1	4 7	93	11·926	0·926	7·76	6·32	1·18	2·18	2·85	8·48	468·3	156·9	Speed by patent log.
11 0	16 0	2 6	7 1	4 3	87	13 731	2·589	18·86	6·35	1·45	2·53	3·10	8·78	445·8	157·5	Calm.
17 1¼	18 10⅜	2 11¼	11 3	11 5	60	11·183	0·909	8·13	3·70	1·10	2·16	1·96	6·47	554·5	167·6	Wind No. 1.
17 1¼	18 5¼	2 10¼	11 4	14 3	60	10·924	1·612	14·76	3·33	1·08	3·87	1·63	6·10	494·0	132·3	Wind No. 3 to No. 4.
13 5¾	15 2	2 6¼	8 10	8 6¼	73	10·921	2·084	19·08	5·61	1·13	3·31	1·593	5·174	433·2	133·4	Spare propeller (cut). Wind No. 5.
13 5¾	15 2	2 6¼	8 10	8 5	77	11·520	2·094	18·18	5·61	1·13	3·29	1·668	5·419	501·9	154·5	Spare propeller, with wooden sphere attached to boss. Calm.
13 5¾	15 2	2 6¼	8 10	8 7	75·75	11·333	1·909	16 84	5·61	1·13	3·31	1·720	5·587	486·5	149·8	Same propeller as on the trial of the 16th July 1853.
13 8	19 10⅜	2 7	8 10	8 6	61·5	12·063	2·291	18·99	5 61	1·46	3·22	1·644	5·34	567·6	174·8	Common propeller (uncut). Calm.
13 8	19 10⅜	2 7	8 10	8 6	62·5	12·259	2·831	23·09	5·61	1·46	3·21	1·639	5·324	511·3	157·4	Common propeller, 1 foot cut off each corner of each blade. Wind No. 3 [to No. 4.
13 7	20 1	2 10⅜	8 10	8 6	67·25	13·322	3·409	25·59	5·61	1·48	3·25	1·696	5·51	574·2	176·8	Bomerang propeller. Wind No. 1. [No. 3 to No. 5.
13 8	19 10⅜	2 6	8 10	8 6	66	12·946	3·375	26·07	5·61	1·46	3·22	1·661	5 395	527·8	162·5	Common propeller, surface reduced to that of Bomerang propeller. Wind
13 8	19 10⅜	2 6	8 10	8 6	66·5	13·044	3·272	25·08	5·61	1·46	3·21	1·614	5 242	578·3	178·0	Common propeller, and edges of blades bevelled. Wind No. 1.
19 0	26 9	3 6	13 4	13 0	55	14·513	3 707	25·54	4·34	1·41	3·96	2·51	8·65	503 5	142·6	Strong breeze, with swell. Trial not considered satisfactory.
11 0	16 0	2 6	7 1	4 4	86·75	13·691	2·789	20·37	6·35	1·45	2·50	2·98	8·43	434·7	153·7	Wind No. 5 to No. 6.
14 1½	20 1	3 0¼	9 6	8 0	64	12·678	1·885	14·87	4·46	1 42	2·98	2·41	7·78	522·4	161·5	Nearly a calm.
14 8¾	16 4	2 10	9 7	7 3	70·556	11·368	1·352	11·89	5·52	1·11	3·18	2·48	7·62	404·3	131·9	
14 8¾	17 3	3 0	9 7	8 8	69·418	11·812	1·679	14·21	5·52	1·17	3·35	2 23	7·25	446·7	143·6	
13 0	14 0	2 4	8 6	6 4	82·414	11·381	0·615	5·40	5·60	1·08	2·92	2·30	7·16	542 5	174·4	
13 0	14 0	2 4	8 6	7 3	82·916	11·450	1·590	13·89	5·60	1·08	3·19	1·91	6·07	501·2	158·0	Wind No. 5, with some swell.
18 0	16 3	2 9⅜	12 4	11 11	66·6	10·675	0 525	4·92	4·01	0·90	3·88	2·00	6·70	522·0	156·1	Wind No. 4.
12 0	15 9¼	2 8	7 3½	6 6½	81·75	12·735	2·036	15·99	5·72	1·32	3·38	2·21	6·56	554·3	186·7	Calm. Ship fully rigged.
12 2½	18 9¾	3 2	9 2	8 0	68·5	12 712	3·273	25·75	5·30	1·54	4·02	1·40	4·51	601·6	186·4	Griffiths's patent screw propeller. Wind No. 2.
12 0	20 0	3 2	9 2	8 0	63	12·429	3·210	25·83	5·30	1·67	4·16	1·26	4·07	622 1	192 7	Common propeller. Wind No. 2.
6 6	8 0	1 9	3 0	4 1	177·5	14·007	2·698	19·26	6·85	1·23	6·33	4·18	10·17	346·0	142·1	Scott's propeller. Calm.
6 6	9 9¾	1 6	3 0	4 1	174	16·843	4·583	27·21	6·85	1·51	6·33	4·06	9·87	544·1	186·7	Common propeller, cut with blades like Griffiths's propeller. Wind No. 4.
6 6	9 9¾	1 6	3 0	4 1	176·25	17·060	4·923	28·86	6·85	1·51	6·33	4·11	10·00	435·1	178·7	Common propeller, same as 24th Dec. 1853, with sphere attached to the [boss. Wind No. 4.
5 10	7 8	2 4¾	3 0	4 1	226·25	17·110	5·411	31·62	6·85	1·31	3·22	3 90	9·49	410·9	168·8	Bomerang propeller. Wind No. 4.
5 6¾	14 1¼	1 8	3 0	4 3¼	187·5	26·124	14·466	55·37	6·85	2·54	3·51	4·49	10·95	352·8	144·8	Lowe's propeller. Calm.
6 0	7 11¾	0 9½	3 0	4 1	207·5	16·332	3·299	20·20	6·85	1·33	2·97	4·88	11·87	453·6	186·5	Fisher's Venetian propeller with flange.
6 5¾	8 3	1 7	3 0	4 1	212·5	17·298	4·023	23·26	6 85	1·27	2·55	4·88	11·87	478·7	196·9	Griffiths's propeller. Wind No. 1.
6 5¾	7 10⅜	1 10	3 0	4 0¾	205	15·967	2·738	17·15	6·85	1·22	2·60	4·76	11·69	484·3	198·1	Common propeller cast at Portsmouth in 1850. Wind No. 1 to No. 2.
6 3⅜	10 0	1 8¼	3 0	4 1	202 5	19 975	6·759	38·84	6·85	1·58	2·75	4·84	11·77	477·2	196·0	Lewsey's blades fitted in boss of Griffiths's propeller.
11 0	21 4	3 0	6 10	5 5	82	17·255	5·670	32·86	6·59	1·94	2·86	4·63	12·30	335·5	126·5	Wind No. 3.
13 2	19 11¼	3 0	7 4¼	5 6¼	75	14·765	3·029	20·51	6·59	1·52	2·00	4·29	11·29	376·8	143·1	Wind No. 4 to No. 5. Additional false keel aft.
13 2	19 11¼	3 0	7 4¼	5 6¼	74·5	14·667	3·064	20·89	6·59	1·52	2·03	4·19	11·08	372·8	141·0	Wind No. 3. Sea moderately calm.
12 0	10 0	1 8	7 8	11 1	114	11·245	1·861	16·55	3·77	0·83	4·56	1·62	5·65	511·5	146·3	Wind No. 3 to No. 4.
6 2½	14 0	2 3¼	3 6	5 2	127	17·539	13·039	74·35	3·82	2·25	12·48	1·53	4·99	49·8	18·3	Speed by common log.
17 0	12 6	2 1	11 9	8 10	64·87	7·999	0·601	7·51	3·74	0 74	8·42	1·38	4·83	461·4	131·6	Speed by common log. Launching cleets not removed. Negative slip.
12 0¾	9 8¼	1 8	9 0	8 4	106·74	10·222	0·823	8·05	5·28	0·80	4·17	1·47	4·79	563·0	173·0	
16 1	21 1¾	3 2	11 5	12 5	47	9·799	1·990	20·31	3·80	1·31	3·93	0·99	3·77	480·0	126·5	Fully rigged and complete with sea stores.
16 0¾	18 9	3 4	11 5	12 5	56	10·357	2·029	19·59	3·80	1·17	3·97	0·99	3·77	583·2	153·4	Fully rigged and complete with sea stores.
14 0	13 0	2 2	10 0	8 8	80·37	10·306	1·451	14·08	3·83	0·93	2·54	1·41	4·97	490·8	139·8	Preliminary trial; vessel not in trim.
16 0	16 0	2 8	10 7	7 8	67·7	0·685	0·012	0·11	4·24	1·00	12·61	2·06	6·34	589·5	191·7	Fresh breeze.
17 0	24 4	3 1	12 2	11 8	51	12·241	2·880	23·53	4·15	1·43	4·58	1·48	5·31	552·7	154·3	Wind No. 4.
11 0	15 7¼	2 6	7 1	4 5	185	13·101	2·080	15·88	6·35	1·42	2·53	2·87	8·13	466·2	164·7	Wind No. 2.
19 1	26 9	3 6¾	12 8	10 2	58·5	14·117	2·251	15·95	4·01	1·40	3·24	2·89	9·83	577·8	170·0	Wind variable, No. 1 to No. 2.
14 5¼	16 0	2 8¾	8 7	6 8	74·21	11·711	1·470	12·55	5·47	1·11	2·34	2·42	6·90	444·4	155·7	
6 0	12 6	...	3 6	4 6	39	17·139	11·369	66·33	3·93	2·08	0·96	1·71	4·34	112·4	44·2	[Negative slip.
12 0	11 6	1 11	7 8	5 3	87·87	9·968	0·782	7·85	5·77	0·96	2·97	1·82	5·02	680·8	247·5	Speed by patent log. Wind No. 5 abeam. Propeller 11 in. out of the water.
11 1	14 3	2 6¾	7 1	4 5	88	12·370	1·649	13·13	6·35	1·29	2 51	2·65	7·54	464·9	163·5	Wind No. 2 to No. 3.
18 0	23 0	3 2	12 3	14 7	62·75	14·236	2·790	19·60	4·27	1·28	3·86	2·37	7·89	632·4	190·1	Wind varying from No. 1 to No. 3.
16 0	23 6	3 0	10 7	9 2	59	13·677	2·364	17·29	4·96	1·47	2·69	2·45	8·04	590·5	180·2	Common screw.
16 0	25 6	...	10 7	9 2	49	12·325	1·656	13·44	4·96	1·59	2·71	2·02	6·63	601·9	183·2	Griffiths's propeller.
11 0	20 6	3 0	6 10	5 2	82	16·582	5·216	31·46	6·59	1·86	2·87	4·37	11·50	336·1	127·7	Wind No. 1.
8 8¼	6 0⅜	0 11¼	6 1	4 6½	111	6·627	0·591	8·92	5·09	0·69	3·26	0·70	2·11	540·4	177·8	Wind No. 3 to No. 4 abeam. No guns on board. Negative slip.
17 1	21 6¼	3 0	11 10	9 9½	58	12·324	1·293	10·49	3·73	1·26	3·51	1·85	6·59	724·7	203·6	Wind No. 3 to No. 5.
15 9	20 0	3 0	10 2	8 10	62·5	12·330	2·211	17·93	5·02	1·27	2·68	2·12	7·04	489·0	147·2	Wind No. 4.
10 0	11 0	1 3	7 0	5 1½	103·04	11·18	1·410	12·61	5·39	1·10	3·39	1·88	5·61	496·4	166·2	Partly rigged; no yards.
9 0	8 5	1 5⅜	5 4	6 6	89·64	7·441	0·291	3·91	5·64	0·94	3·66	0·71	2·16	511·5	169·4	Fully rigged and ready for sea.
11 0	15 8¼	2 6	7 1	4 2	84	13·016	2·192	16·84	6·35	1·43	2·35	3·04	8·47	417·8	149·7	Wind No. 1.
17 0	19 2	3 2	12 5	14 11	69	13 045	3·045	23·34	3·82	1·13	5·11	1·55	5·73	644·2	174·5	Calm, smooth water. Ship fully rigged and equipped. [broken.
17 0	17 0	3 0	11 4	12 6	62	10·397	1·022	9·83	3·77	1·00	4·16	...	...	...	...	Speed could not be accurately ascertained. Mean of two runs. Indicator
18 0	21 8	3 6	11 9	13 3	61	13·037	1·888	14·10	4·30	1·20	4·19	2 00	6·99	701·6	200·9	Wind No. 1. 476 tons of coal on board.
16 0	23 0	3 0	11 5	14 2½	58	13·159	3·859	29·33	3·83	1·44	4·94	1·48	6·04	543·5	133·2	Speed by patent log. Weather calm; water smooth. [swell
16 0	23 6	3 0	10 7	5 9	63	14·604	3·204	21·94	4·96	1·47	2·01	3·37	10 39	439·5	142·5	Upper edge of propeller 2 feet 4 in. out of the water. Wind No. 4; a little
12 0	10 0	1 8	7 8	11 1	112·25	11·072	1·774	16·02	3·80	0·83	4·58	1·61	5·63	500·2	142·8	Wind No. 3.
18 1	25 3	3 6	11 8	7 4	56	13·948	2·141	15·35	4·70	1·40	2·44	3·20	9·76	513·7	168·7	Upper edge of propeller 1 foot 8¼ inches out of the water. Wind No. 4.
8 10	9 10⅜	1 5¼	5 3½	5 5½	114·75	11·166	1·889	16·47	5·65	1·12	3·88	1·47	4·62	553·7	175·5	
15 11½	16 6	2 7½	9 3	8 7	52·5	8·545	0·202	2·36	6·00	1·03	2·78	0·97	2·78	688·5	240·5	Vacuum imperfect. Negative slip. [the stern.
15 1	24 7	2 8¼	9 3	9 11	55	13·337	2·690	20·17	6·00	1·54	2·90	2·15	6·21	561·7	194·4	Wind No. 4. Speed not considered an average, vessel being so much by
11 0	14 3	2 7	7 1	4 4	92	12 932	1·867	14·44	6·35	1·30	2·53	3·02	8·56	448·1	158·3	Wind No. 2 to No. 3.
11 0	16 0	2 6	7 1	4 5	88	13·889	2·740	19·73	6·35	1·45	2·57	3·19	9·04	434·5	153·3	Wind No. 2.
15 6¼	18 0	3 0	9 6	7 11	69	12·251	3·470	28·32	5·19	1·16	2·97	1·99	6·48	340·0	104·5	Wind No. 2 to No. 5. Variable.
15 7½	24 0	2 10¼	11 0	7 8	53	12·547	2·954	23·54	5·19	1·54	2·88	1·96	6·34	450·4	139·3	Wind No. 3.
14 1	17 7	2 10¼	9 6	9 10	72·5	12·575	2·157	17·15	4·47	1·25	3 71	1·85	6·28	611·9	180·2	Wind No. 2.
11 0	20 6	3 0	6 9	5 3	82	16·581	4·998	30·14	6·63	1·86	2·78	4·42	11·51	351·9	135·0	Wind No. 1.
11 0⅜	14 10¼	2 6¼	7 1	4 11	86·5	12·692	0·832	6·56	6·32	1·35	2·24	3·13	9·46	533·0	176·4	
11 0	16 0	2 6	7 1	4 4	83·25	13·139	2·406	18·31	6·35	1·45	2·43	3·06	8·60	404·1	143·8	Wind No. 4 to No. 5.

Steel || Steele, Sir Richard.

STEEL. See CUTLERY and IRON.

STEEL-YARD. See WEIGHING-MACHINES.

STEELE, SIR RICHARD, was born at Dublin in the year 1671. One branch of the family was possessed of a considerable estate in the county of Wexford. His father, a counsellor-at-law in Dublin, was private secretary to James duke of Ormond; but he was of English extraction; and his son, while very young, being carried to London, he put him to school at the Charter-House, whence he was removed to Merton College in Oxford. He left the university without taking any degree, in the full resolution to enter the army. This step was highly displeasing to his friends; but the ardour of his passion for a military life rendered him deaf to any other proposal. Not being able to procure a better station, he entered as a private gentleman in the Horse Guards, notwithstanding he thus lost the succession to his Irish estate. However, as he had a flow of good-nature, a generous openness and frankness of spirit, and a sparkling vivacity of wit, these qualities rendered him the delight of the soldiery, and procured him an ensign's commission in the guards. In the meantime, as he had made choice of a profession which set him free from all the ordinary restraints of youth, he spared not to indulge his inclinations in the wildest excesses. Yet his gaieties and revels did not pass without some cool hours of reflection; it was in these that he drew up his little treatise entitled *The Christian Hero*, with a design, if we may believe himself, to be a check upon his passions. For this purpose it had lain for some time by him, when he printed it in 1701, with a dedication to Lord Cutts, who had not only appointed him his private secretary, but procured for him a company in Lord Lucas's regiment of fusiliers.

During the same year he brought out his comedy, called *The Funeral, or Grief à la Mode*. This play procured him the notice of King William, who resolved to give him some essential marks of his favour; and though, upon that prince's death, his hopes were disappointed, yet, in the beginning of Queen Anne's reign, he was appointed to the profitable place of gazetteer. This post he owed to the friendship of Lord Halifax and the Earl of Sunderland, to whom he had been recommended by his schoolfellow Mr Addison. That gentleman also lent him a helping hand in promoting the comedy called *The Tender Husband*, which was acted in 1704 with great success. But his next play, *The Lying Lover*, had a very different fate. Upon this rebuff from the stage, he turned the same humorous current into another channel; and early in the year 1709, he began to publish the *Tatler*, in concert with Dr Swift. His reputation was perfectly established by this work; and, during the course of it, he was made a commissioner of the stamp-duties in 1710. Upon the change of the ministry the same year, he joined the Duke of Marlborough, who had several years entertained a friendship for him; and upon his Grace's dismission from all employments in 1711, Mr Steele addressed a letter of thanks to him for the services which he had rendered to his country. As, however, he still continued to hold his place in the stamp-office under the new administration, he wisely declined the discussion of political subjects; and, adhering more closely to Addison, he dropped the *Tatler*, and afterwards, by the assistance chiefly of that steady friend, he carried on the same plan, much improved, under the title of the *Spectator*. The success of this paper was equal to that of the former; and before the close of it, he was thus encouraged to proceed upon the same design in the character of the *Guardian*. This was begun in the beginning of 1713, and was laid down in the ensuing October. But in the course of the year his thoughts took a stronger turn to politics: he engaged with great warmth against the ministry; and being determined to prosecute his views by procuring a seat in the House of Commons, he immediately removed all the obstacles that stood in his way. For that purpose he took care to prevent a forcible dismission from his post in the stamp-office, by a timely resignation of it to the Earl of Oxford; and at the same time gave up a pension which had hitherto been paid to him by the Queen as a servant to the late Prince George of Denmark. He now wrote the famous paper in the *Guardian* upon the demolition of Dunkirk. It was published August 7, 1713; and the parliament being dissolved next day, the same journal was soon followed by several other warm political tracts against the administration. Upon the meeting of the new parliament, Steele having been returned a member for the borough of Stockbridge in Hampshire, took his seat accordingly in the House of Commons; but was expelled in the course of a few days, for writing a paper called the "Englishman," and another entitled the "Crisis." Presently after his expulsion, he published proposals for writing the history of the Duke of Marlborough. At the same time he also wrote the *Spinster;* and in opposition to the *Examiner*, he set up a paper called the *Reader*, and continued publishing several other papers and tracts in the same spirit till the death of the queen. As a reward for these services, he was immediately taken into favour by her successor to the throne, King George I.; was appointed surveyor of the royal stables at Hampton Court, and governor of the royal company of comedians, was put into the commission of the peace for the county of Middlesex, and in 1715 received the honour of knighthood. In the first parliament of that king, he was chosen member for Boroughbridge in Yorkshire: and, after the suppression of the rebellion in the north, was appointed one of the commissioners of the forfeited estates in Scotland. In 1718, he buried his second wife, who had brought him a handsome fortune with a good estate in Wales; but neither this, nor the ample addition lately made to his income, was sufficient to answer his demands. The thoughtless vivacity of his spirit often reduced him to little shifts of wit for its support; and he was constantly engaged in speculative projects that generally ended in failure.

The following year he opposed the remarkable peerage bill in the House of Commons; and, during the course of this opposition to the court, his license for acting plays was revoked, and his patent rendered ineffectual at the instance of the Lord Chamberlain. He did his utmost to prevent so great a loss; and finding every direct avenue of approach to his royal master effectually barred against him by his powerful adversary, he had recourse to the method of applying to the public, in hopes that his complaints would reach the ears of his sovereign, though in an indirect course, by that channel. In this spirit he formed the plan of a periodical paper, to be published twice a-week, under the title of the *Theatre;* the first number of which appeared on the 2d of January 1719-20. In the meantime, the misfortune of being out of favour at court, like other misfortunes, drew after it a train of more. During the course of this paper, in which he had assumed the feigned name of *Sir John Edgar*, he was outrageously attacked by Dennis, the notorious critic, in a very abusive pamphlet, entitled *The Character and Conduct of Sir John Edgar.* To this insult he made a humorous reply in the *Theatre.*

While he was struggling with all his might to save himself from ruin, he found time to turn his pen against the mischievous South Sea scheme, which had nearly brought the nation to ruin in 1720; and the next year he was restored to his office and authority in the play-house in Drury Lane. Of this it was not long before he made an additional advantage, by bringing his celebrated comedy called the *Conscious Lovers* upon that stage, where it was acted with prodigious success; so that the receipt there must have been very considerable, besides the profits accruing by the sale of the copy, and a purse of L.500 given to him by the

Steen.

king, to whom he dedicated it. Yet notwithstanding these ample supplies, about the year following, being reduced to the utmost extremity, he sold his share in the play-house; and soon after commenced a lawsuit with the managers, which, in 1726, was decided against him. Having now again, for the last time, brought himself by the most heedless profusion into a desperate condition, he was rendered altogether incapable of retrieving the loss, by being seized with a paralytic disorder, which greatly impaired his understanding. In these unhappy circumstances, he retired to his seat at Llangunnor near Caermarthen in Wales, where he died on the 1st of September 1729, and, according to his own desire, was privately interred in the church of Caermarthen. Among his papers were found the manuscripts of two plays, one called *The Gentleman*, founded upon the *Eunuch* of Terence, and the other entitled *The School of Action*, both nearly finished.

Sir Richard was a man of undissembled and extensive benevolence, a friend to the friendless, and, as far as his circumstances would permit, the father of every orphan. His works are chaste and manly. He was a stranger to the most distant appearance of envy or malevolence; never jealous of any man's growing reputation; and so far from arrogating any praise to himself from his conjunction with Addison, that he was the first who desired him to distinguish his papers. His great fault was want of economy; and it has been said of him, he was certainly the most agreeable and the most innocent rake that ever trode the rounds of dissipation.

Thackeray, in his *Lectures on the English Humorists*, 1858, winds up his remarks on Steele in these words—"We are living in the nineteenth century, and poor Dick Steele stumbled and got up again; and got into jail and out again; and sinned and repented; and loved and suffered; and lived and died scores of years ago. Peace be with him! Let us think gently of one who was so gentle; let us speak kindly of one whose own breast exuberated with human kindness."

STEEN, Jan, a celebrated Dutch painter, was born in Leyden in 1636. His father, who was a brewer, observing his son's predilections for art, had him apprenticed to one Knupfer, a German artist of note. He subsequently received lessons from Van Goyen, and the hand of his daughter Margaret in marriage. Steen soon rose into considerable reputation as a painter, but his tastes unfortunately were much too expensive for the income of a prosperous young artist. He spent too much of his time in taverns, and was a great patron of brawls. While the drinking-shops fattened, poor Jan Steen got much out at elbows, and threw down his pencil in despair. What could man do more than he had done, and see what had come of it? His relations assisted him to set up a public-house, which met with great success, but Jan Steen drank as hard as ever. He resumed his pencil, and plied it with great success. More than 300 paintings came from his hand, and he is known to have painted with great care. His pieces represent merry-makings, sick-rooms, and scenes of debauchery; schools, alchemists' laboratories, and card parties; taverns, tabâgies, and prodigality; gluttony, wine-bibbing, and wretchedness; all delineated with such exceeding truthfulness and power that one could pardon the satirist even though the moral were wanting. In his drawing he is correct: in his colouring, rich and transparent; and he displays a delicacy of execution equal to Metzen. He sometimes attempted historical subjects, but he was much too great a humorist to succeed in them. He lived and died a spendthrift. After his decease, which occurred in 1689, his works rose rapidly in value, and they are now sold at exceedingly high prices. Fine specimens of this master are to be seen in the collections of the Duke of Wellington, Sir Robert Peel, Lord Ashburton, Her Majesty, the Earl of Ellesmere, Mr Hope, Mr Lonsdale, the Earl of Carlisle, and others. The galleries at the Hague, Amsterdam, and St Petersburg contain also many excellent specimens of his painting.

Steevens || Steffani.

STEEVENS, George, was born at Stepney, in the county of Middlesex, in 1736. His father, who was a London merchant, and a director of the East India Company, placed his son at a school in Kingston-upon-Thames, where he had Gibbon, the future historian, as his companion. Steevens was subsequently placed on the foundation at Eton, and afterwards became a scholar of King's College, Cambridge, in 1754. His first publication was a four-volume edition of *Twenty of the Plays of Shakespeare, being the whole number printed in quarto during his lifetime*, 1766. On the whole, this reprint was exceedingly faithful; and in several instances of doubtful meaning, the various readings of other editions of the great dramatist were added in the foot-notes. The reputation which Steevens gained by this edition of Shakspeare, for minute, accurate, verbal acquaintance with early English literature, brought him into contact with Johnson and his literary acquaintances, and led to his association with the great lexicographer in the edition of Shakspeare which appeared in 1773 with their joint names. In 1778 Malone had rendered some assistance to Johnson and Steevens in the second edition of the works of Shakspeare, and in 1780 he published by way of Supplement an edition of the doubtful plays and poems of the poet. For this act Steevens, who fancied his vanity was hurt in the most vital part, resolved to be avenged of Malone, and accordingly set to work with an open contempt for all the Malones and their plodding diligence, to give to the English public a new Shakspearean metre, purged alike of "useless and supernumerary syllables, and an occasional supply of such as might fortuitously have been omitted." So great was his zeal in this new project which he had undertaken, that for eighteen months he went every morning before day-break from his house in Hampstead to his printers in London to correct the proof-sheets. This work was completed in 15 volumes in 1793. His experiment, strange to say, met with great success, and except Malone's edition of 1821, no popular issue of the works of Shakspeare attempted anything different till that of Knight appeared in 1838. Steevens, whose ample means put him beyond the necessity of literary labour, published very little else beyond his editions of Shakspeare. He assisted Nichols in his *Biographical Anecdotes of Hogarth*, and Isaac Reid in his *Biographia Dramatica*, and occasionally ventilated his acute and sarcastic mind in the pages of the *St James's Chronicle* and the *Critical Review*. In those journals he made the bitterest attacks on many literary characters to whom, when stripped of the guise of anonymity, he was all smiles, and bows, and courtesy. Whether or not this conduct can be freed from the charge of malignity, and be set down to the less guilty one of mere mischief, as Johnson asserted to Topham Beauclerk, it is at least certain, that if such doings could gratify his sense of power, the soul was a very mean one that could be touched by such base appliances. Among his numerous dirty tricks was his setting up Amner and Collins as literary scape-goats on whom he might father some of his more objectionable annotations, and ascribed a fierce attack on Capell to his less decided and more timid rival, Malone. Steevens died at Hampstead in 1800.

STEFFANI, Agostino, commonly known under the name of the Abbate Steffani, a celebrated composer of vocal music, was born in 1655, at the small town of Castelfranco, in the Venetian States. The fine quality of his voice obtained for him early employment in some of the churches of Venice. There, a German nobleman hearing him sing, was so delighted with the youth's musical talent, that he offered to take him to Munich and provide for him. Steffani accompanied his German patron to Munich, where he was placed under the famous Roman composer Giuseppe Ercole Ber-

nabei, then chapel-master in the service of the Bavarian court. From that master, one of a celebrated musical family, Steffani rapidly acquired skill in writing for voices; an art in which the Roman school was greatly distinguished. Having early entered into holy orders, he was, in due time, made abbot of Lipsing, and apostolic prothonotary; and, finally, Bishop of Spiga in Spanish America. These appointments he owed partly to his musical talents, partly to his diplomatic services. Besides composing several masses for the Elector of Bavaria's chapel, and motets for three voices and figured bass, he wrote the music of eleven operas, of which *Servio Tullio* was reckoned the finest. This opera induced the Elector of Brunswick to offer the place of chapel-master to Steffani, which he accepted. His new patron became afterwards Elector of Hanover. Steffani composed also sonatas for two violins, viola, and figured bass (*basso continuo*). In 1698 he published a small work in Italian, on *The Certainty of the Principles of Music, and its estimation among the Ancients.* His earliest publication was a collection of Psalms for eight voices, with a figured organ-bass. These appeared in 1674, when Steffani was only nineteen years old, and are masterly compositions. Padre Martini published one of them in the second part of his *Saggio di Contrappunto*, pp. 311–315. Padre Martini (ibid.) writes in the highest terms of the Abate Steffani's compositions, and particularly mentions his duets for two voices, soprano and contralto, with figured bass, printed in 1683: "Held," says Martini, "in great esteem by all professors of music, and in which are wonderfully displayed his deep knowledge, his great practical skill, and especially in double counterpoint of all kinds." These celebrated duets seem to have been studied as models by Clari, the author of charming works of the same kind, as well as of trios for three voices with figured bass. Handel gained much by studying the compositions of Steffani, Clari, and Scarlatti. In 1710, Steffani left his places of chapel-master and music-director at Hanover; pointing out Handel as his successor. After a long absence from Italy, he returned thither in 1729, and passed the winter at Rome in the society of Cardinal Ottoboni, that great patron of musical talent. Returning to Hanover, he was soon afterwards obliged to go to Frankfort, where he fell sick, and died in a few days, in the year 1730, aged seventy-five. Unfortunately, many of his works, composed for the court of Brunswick and Hanover, are now unknown. Among these were several oratorios, of which even the titles are forgotten. Might not some of these valuable manuscripts be even now recovered by careful research? (G. F. G.)

STEFFENS, HEINRICH, an eminent thinker of the last half-century, was born at Stavanger in Norway on the 2d of May 1773. Passing to Helsingör and Copenhagen, he entered the university of the latter city in 1790, and received a travelling prize four years afterwards. He resided successively at Bergen, Hamburg, Kiel, and Jena, and while in the latter town he became an enthusiast in the new philosophy which Schelling was then engaged in elaborating. Having been created adjunct professor of philosophy to the University of Jena, he then repaired to Freiberg, where he wrote his *Geognostisch-Geologischen Aufsätze*, which did not appear till 1810, and he elaborated his *Handbuch der Oryktognosie*, 1811–19. Returning to Denmark in 1802, he delivered a course of able lectures, but finding himself more at home in the lecture-halls of Germany, he accepted an invitation in 1804 from the University of Halle, where he became professor, and published his *Grundzüge der Philosophischen Naturwissenschaft* in 1806. During the succeeding years he took a very active share in the political struggles in which Prussia was then engaged with France. In 1813 he was made professor of physics and natural history at Breslau, and in 1831 he removed to a similar chair at Berlin, where he remained till his death in 1845.

As illustrations of the labours of Steffens in behalf of Schelling's philosophy, we may point to his *Anthropologie*, published in 1822, and to his *Polemische Blättern zur Beförderung der Speculativen Physik*, 1825–35. Besides occasional essays on subjects more immediately connected with the university, he likewise engaged in the religious controversies of the time, and wrote on the Pietistic side with much more than the average amount of thought and originality. He subsequently engaged in a series of novels, which, while portraying with much lively interest the deep religious feeling of his sect, and displaying very correct delineations of picturesque scenery, nevertheless are tainted by too much egotism and display of the feelings and opinions of the writer. During the last five years of his life he was engaged on an autobiography *Was ich erlebte*, which was subsequently published in 10 vols. Schelling wrote a preface to the posthumous works of Steffens.

STEIN, HEINRICH FRIEDRICH KARL, BARON VON, a distinguished Prussian statesman, was born at Nassau on the 15th of October 1757. He was sprung from a very old and noble family of Germany, who were in possession of large estates and of wide influence in the Prussian empire. He studied successfully at Göttingen, at Wetzlar, and at Vienna, and in 1779 he entered the Prussian service as a director of mines. On the death of Frederick the Great in 1786, Stein visited England, and spent much of his time and attention in inquiring into the social and political condition of the country. He was much impressed, it is said, by the spectacle of popular institutions and of popular freedom which everywhere met his eye. Stein returned to Prussia a wiser man than he left it, resumed his business in connection with the mines, and married the Countess of Wallmoden-Gimborn, by whom he inherited large property. He was subsequently appointed commissioner, director, president, and supreme president successively of the Westphalian Chambers of Wesel, Hamm, and Minden, and in this capacity he originated and executed numerous improvements in agriculture, roads, and general social economy.

Stein had not yet sufficient scope for the magnificent administrative schemes which were simmering in his brain. He had been appointed, in 1804, minister of indirect taxation, commerce, and the public debt, and he had set vigorously to work to introduce various reforms, when the misunderstandings between Napoleon and Frederic William III. brought his work to a stand-still. Stein, who from the first took a thoroughly patriotic view of the question, had to yield up his office in 1807. When he reappeared, the kingdom was shorn of much of its territory. Having been solicited to his side by his desponding master, Frederick William III., he developed his plan for the restoration of Prussia to a high place in the councils of Europe. "What the state loses," says Stein, "in *extensive* greatness, it must make up by *intensive* strength." He proposed to reorganize the entire administrative system of Prussia. He would lay his hand upon the people, as upon the real strength of the nation, and by emancipating them from the burdens to which they had been so long subjected, would destroy in a great measure the antiquated system of villeinage and of class distinctions under which so many of them had groaned for centuries. He proposed, also, to adopt a new scheme of militia service throughout the kingdom of Prussia. As a man of genius, with a strong will to guide his movements, generally overmasters other minds, as if by storm, so Stein in this instance got the ear of the king, and succeeded in apparently convincing him that the new scheme which he had just laid before him would materially improve his country and set Prussia in the front rank of nations. Stein's "system" accordingly got set on foot as warily as possibly, for Napoleon had no difficulty in seeing far over his own immediate horizon, and its operation was attended with the best

Stein-Am-Anger || Stenography.

results. The sleepless Napoleon had heard, however, of the doings of "one Stein" on the other side of the Rhine, and in November 1808 he was obliged to resign and take refuge in Austria. The military and municipal parts of his system were left to another to execute, and he began to concoct and bring forth the *Tugend-bund* or "Moral Union," a society which had in view the ultimate liberation of the entire German people. After spending some time in Russia, he accompanied the allies to Paris in 1814, and drew up his opinions on the re-organization of Germany. His enlarged views of free institutions, of popular election, and so forth, did not meet the taste of the Congress, and on Napoleon's fall, the weak king of Prussia, who had in his extreme need given in his adherence to the system of Stein, now that the enemy was chained to a lonely island of the sea, thought fit to bid good-bye to him and his system, and took refuge in the hereditary arms of absolutism. Baron Von Stein's name, however, shall live for ever among all who reverence free institutions, free representations, and free governments throughout the world. He received the Order of the Prussian Eagle in 1816, he had a place at the Congress of Aix-la-Chapelle in 1818, he was made a member of the Prussian Council of State in 1827, and he published the same year a critical review of Bourienne's *Life of Napoleon*, in some portions of which his own conduct had been commented on. The Baron died on the 29th of June 1831, leaving a name for statesmanlike qualities such as many in Germany will not willingly let die.

STEIN-AM-ANGER, a town of Hungary, in the government of Eisenburg, on the river Güns, and 12 miles E.S.E. of the town of that name. It has a splendid cathedral, three convents, an episcopal palace, philosophical seminary, gymnasium and other schools, and a museum of antiquities. Stein-am-Anger occupies the site of the ancient Roman colony Sabaria. Pop. 4300.

STELVIO, a celebrated pass across the Alps where they separate the Tyrol from Lombardy. It leads from Bormio in Italy to Glurns in the Tyrol, and the carriage-road by this pass, which was opened in 1824, is the loftiest in Europe, being at its highest point 9100 feet above the sea.

STENDAL, a town of the Prussian monarchy, capital of the Altmark in Saxony, in a fertile valley on the Uchte, near the left bank of the Elbe, 35 miles N. of Magdeburg. It is walled and entered by five gates; and it contains, among other buildings, a fine cathedral of the fifteenth century, four other Protestant churches, a Roman Catholic church, with numerous towers, a gymnasium, and an orphan hospital. Woollen cloth is manufactured here; and there is an active trade in linen. Stendal was at one time the residence of the margraves of Brandenburg. Winckelmann the antiquary was born here. Pop. 7484.

Roman shorthand.

STENOGRAPHY. The invention of the stenographic or swift mode of writing, by signs, employed by the Roman notarii in the time of the Cæsars, has been assigned by various authors to different persons. Diogenes Laërtius has been made to say that Xenophon first took down the sayings of Socrates in notes; but the original text may mean, that he merely noted down the sayings of Socrates. The Latins, however, claimed for themselves the invention of the Roman Notes. Ennius, about 150 B.C., is said to have invented 1100 common notes, or abbreviations; called common, because intended for general use. Plutarch rejects Ennius, and is in favour of Cicero. Eusebius gives the merit of the invention to Tyro, a freedman of Cicero's; and Seneca ingenuously attributes the invention and the cultivation of this species of writing to freedmen and slaves (as Tyro, Persennius, Aquila), whose performances were, according to the usage of the times, attributed to their patrons.

Tyro's notes.

These notes are constructed on the principle of extreme abbreviation of the letters of the Roman alphabet; for, though every letter of the alphabet is employed, very few words, comparatively, are written in full. Indeed, the characters are so ill adapted for joining, that hundreds of examples are found wherein, apparently to preserve the writing horizontal, the shape, slope, and size of the letters are variously modified, and the letters themselves either disconnected or written across each other. The Roman shorthand alphabet, with a specimen of Tyro's "Notes," written in it, is given in Pitman's *History of Shorthand*, in the *Phonotypic Journal* for 1847.

In this first system of shorthand of which we have any account, all the principles of stenography, as at present practised, were acknowledged; namely, the adoption of simpler forms than the common letters of the alphabet; making each letter the representative of some common word; leaving out such letters as could be spared, particularly the vowels, in order to save time; and sometimes joining or intersecting the initial letters of several words, so as to express them by one series of forms, and, if possible, without removing the hand from the paper or tablet. All that the authors of modern systems have gained in brevity over the ancients has been effected by the adoption of a simpler alphabet. The letters of Tyro's (or perhaps Cicero's) system of shorthand, were made by abridging the Roman alphabet; some of them were, therefore, necessarily complex. Modern stenographers have preferred a new alphabet, made of the simplest geometrical forms; and by sometimes classing under one sign two sounds that are nearly related to each other (as *f* and *v*, *s* and *z*), a right line and a curve in various positions, with the occasional addition of a small circle or hook at the commencement, have supplied a sufficient variety of signs for the letters of the alphabet.

Cato's speech on the Catilinian conspiracy taken down in shorthand.

By Tyro's system, according to Plutarch, was preserved the oration of Cato relative to the Catilinian conspiracy. In his life of Cato the younger, he remarks, "This, it is said, is the only oration of Cato's that is extant. Cicero had selected a number of the swiftest writers, whom he had taught the art of abbreviating words by characters, and had placed them in different parts of the senate-house. Before his consulate they had no shorthand writers." Soon after this, shorthand came into general repute among the Romans, and was patronised and practised by the emperors themselves. Augustus and Titus were proficients in it, and some of the authors of that age allude to the art in their works. Ovid, in speaking of Julius Cæsar, who wrote to his friends in shorthand, says, "By these marks, secrets are borne by land and by sea." Some passages in the Latin writers, that have been supposed to refer to shorthand, appear to refer to writing in cipher.

Early English systems

To England belongs the honour of having revived in modern times the useful art of shorthand writing, no original system having been published on the continent that can be compared with the popular English stenographies of the seventeenth and eighteenth centuries.

Summary of the history of English stenography.

There are four principal periods in the improvement and dissemination of the art since the revival of learning in the fifteenth century. The *first* period extends from the publication of the first alphabetic system by John Willis, in 1602, to the publicatian of the matured system of Mason, in 1682. During this period the system most used was that invented by Rich, afterwards practised, amended, and republished by Dr Doddridge. (Before Willis's shorthand alphabet appeared, Timothy Bright, in the reign of Elizabeth, 1588, produced a system of arbitrary shorthand characters that represented *words*. This, as far as is known, was the first treatise on the art in modern times.) The *second* period extends from 1682 to the appearance of Taylor's system in 1786, and during this time Mason's system enjoyed the greatest share of the public favour. It was republished by Thomas Gurney, in 1751, and is practised

by his descendants, as reporters to the government, to the present day. The *third* period reaches from 1786 to 1837, the date of the publication of Pitman's *Phonography*, or Phonetic shorthand. During this period Taylor's system was perhaps used more than any other; but many persons wrote the systems invented by Byrom (1767), Mavor (1789), and Lewis (1815). The *fourth* period reaches from 1837 to the present time. In these twenty-three years the practice of *Phonetic* shorthand has extended to almost every town and every large village in Great Britain and Ireland, and in the United States. This system we now proceed to explain, premising that it is as legible as ordinary writing, and may be written in from one-fourth to one-eighth of the time required for longhand, according to the skill of the writer, and his employment of the principles of abbreviation furnished in the system.

Explanation of terms. Phonetics (from φωνη, *phōnē*, voice), the things relating to the voice: the science which treats of the different sounds of the human voice, and their modifications. The style of spelling in accordance with this science is named Phonetic; the common style being called Romanic, because it is formed from an alphabet derived from that which was used by the Romans.

Phonography (from *phōnē*, voice, and γραφη, *graphē*, writing), the art of representing spoken sounds by written signs; also the style of writing in accordance with this art.

Phonotypy (from *phōnē*, voice, and τυπος, *tūpos*, type), the art of representing sounds by printed characters or types; also the style of printing in accordance with this art.

Phonogram (from γραμμα, *gramma*, letter), a written letter, or mark, indicating a certain sound, or modification of sound; as, — *k*, · *ah*.

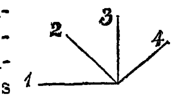
Logogram (from λογος, *logos*, word), a word-letter; a phonogram, that, for the sake of brevity, represents a word; as | *t*, which represents *it*.

Grammalogue, a letter-word; a word represented by a logogram; as *it*, represented by | *t*.

Phraseogram, a combination of shorthand letters representing a phrase or sentence.

Alphabet of nature. Phonography is based upon an analysis of the English spoken language. Its consonants and vowels are arranged so as to show, as far as possible, their mutual relations. In the consonants, *k* stands first, next *g*; the rest follow in perfectly natural order, first the mute or explosive letters, proceeding from the throat to the lips; then the semi-vocals, or continuants, in the same order; and lastly the liquids and nasals. Scarcely more than half the consonants are *essentially different*; the articulations in the pairs *k* and *g*, *t* and *d*, *f* and *v*, &c., are precisely the same, but the sound is, so to speak, light in the first, and heavy in the second letter of each pair. The consonants in each pair are represented by strokes in the same position, and of the same shape, but that chosen for the second is written *thick*, instead of *thin*. (See the shorthand signs for *k*, *g*; *t*, *d*; *f*, *v*, &c., in Plate XXXIX.) Thus, not only is the memory not burdened with a multitude of signs, but the mind perceives that a *thin stroke* corresponds with a *light articulation*, and a *thick stroke* with a *heavy articulation*. *K*, *t*, *p*, *sh*, *s*, *th*(*in*), *f*, are called light, or sharp consonants, and *sh*, *s*, *th*(*in*), *f*, are further denominated whispered, or breathed consonants; while *g*, *d*, *b*, *zh*, *z*, *th*(*en*), *v*, are heavy, flat, spoken, or murmured consonants. The distinction is, that in the flat letters (*g*, *d*, *b*, &c.) a vocal murmur is added to the action of the organs by which the sharp letters (*k*, *t*, *p*, &c.) are produced. The light sounds are also called *surds*, while all the other letters (including *ng*, *n*, *m*, *l*, *r*, *y*, *w*, and the vowels), are called *sonants*. *Ch* and *j* are double consonants, formed by the union of *t*, *sh*, and *d*, *zh*, as may be heard in fe*tch*, *ch*eap, e*dg*e, *j*em. They are placed next to the first elements *t*, *d*, which enter into their composition. The vowels are arranged naturally in two series, the first guttural and the second labial. Each series commences with the most open sound. The *short* vowels are represented by *light* dots and strokes, and their corresponding *long* sounds by *heavy* ones. After a few weeks' practice in writing phonography, the heavy strokes and dots are made without any perceptible effort; they are traced by the pen with as much facility as their corresponding heavy sounds are produced by the organs of speech.

Consonants. With one exception (*ch* and the upward *r*, as below), every right-line and curve employed in phonography is written in the direction of one of the lines in the annexed diagram, all straight lines and curves in direction 2 and the curves in direction 4 being inclined midway between a perpendicular and horizontal line. (For illustrations of single shorthand letters, see Plate XXXIX.; and for illustrations of joined characters, and the application of the various rules for writing, see Plate XL.)



Perpendicular and sloping letters are written from top to bottom, and horizontal letters from left to right. L, when standing alone, is written upward, and *sh* downward: *l* and *sh*, joined to other consonants, may be written either upward or downward, as may be convenient.

All the consonants in a word should be written without lifting the pen, the second letter beginning where the first ends, and so on. When a straight consonant is repeated, no break should be made between the two strokes; thus, —— *kk*. When a curved consonant is repeated, the curve should not be written larger, but doubled; thus, ⌣⌣ *nn*. Single consonants, and combinations of consonants that contain not more than one descending stroke, rest upon the line. When two descending letters are joined, the first should be made down to the line, and the second below.

As the straight line in direction 4, in the above diagram, may be written either up or down, it is made to represent two letters, namely, *ch* when written downward, and *r* when written upward; this additional sign being given to *r* for convenience and speed in writing. To diminish the risk of *ch* and *r* being mistaken for each other, / *ch* is made to slope 60 degrees from the horizontal, and ⁄ *r* when standing alone, 30. This line naturally takes these slopes when struck by the hand downward and upward respectively.

On account of their frequent occurrence, *s* and *z* are furnished with an additional character, particularly convenient for joining; thus o *s* or *z*. When the *s* circle is joined to straight letters, it is written on the upper side of *k*, and on the corresponding side of the other letters. When joined to curved letters, it is written inside the curve. When it occurs between two straight consonants, it is written on the outside angle. When it is joined to *l* only, the *l* is written upward; and when it is joined to *sh* only, the *sh* is written downward.

Vowels. There are six simple long vowels in the English language, namely,

	1.	2.	3.	4.	5.	6.
	ah,	*eh* (*a*),	*ee*;	*aw*,	*oh*,	*oo*;
as in	*a*lms,	*a*le,	*ee*l;	*a*ll,	*o*pe,	f*oo*d.

There are also six short vowels, of the same or similar quality, or tone, heard in the words

1.	2.	3.	4.	5.	6.
pat,	*pet*,	*pit*;	*not*,	*nut*,	*foot*.

The long and short sounds of Nos. 4 and 6 are identical in quality; Nos. 2 and 3 are nearly so; the long and short sounds of the pair No. 1 differ considerably in the south of Great Britain, but not much in Scotland: the greatest amount of difference exists in the pair No. 5.

The first three vowels are represented by a dot, and the last three by a short stroke or dash, written at a right angle with the consonant. The dot (for 1, 2, 3), and the dash

(for 4, 5, 6), are made heavy for the long vowels, and light for the short ones. When a vowel is placed on the left-hand side of a perpendicular or sloping consonant, it is read *before* the consonant; and when placed on the right-hand side, it is read *after* the consonant. A vowel placed above a horizontal letter, is read *before* the consonant, and when written under, is read *after* the consonant. This, it may be observed, is the way in which we read all European languages; namely, from left to right, and from top to bottom. The vowels are written at the side of the consonant, in three places,—at the beginning, middle, and end; the beginning of the consonant, whether written upward or downward, being the place of the first vowel-sign *ah*. The letter *l*, for instance, when written downward, has its vowels' places reckoned downward; and when written upward, the vowels are reckoned from the bottom upward.

Vowels placed at the beginning of a consonant (*ah* and *aw*, for example), are called *first-place vowels;* vowels written in the middle are called *second-place vowels;* and those written at the end are called *third-place vowels.*

The vowel points and strokes must be written at a little distance from the consonants to which they are placed. If allowed to touch, except in a few cases, they would occasion mistakes. The short vowels should not be called—No. 1, "short *eh;*" No. 2, "short *ee;*" No. 3, "short *i* (*eye*)," &c.; but—No. 1, "short *ah;*" No. 2, "short *eh;*" No. 3, "short *ee*," &c. It will be found more convenient when speaking of these short vowels to affix the letter *t* to each, and call them severally *at, et, it, ot, ut, ŏŏt.*

Diphthongs.

The double vowels heard in the words *ice, owl, ay, boy,* are represented by small angular marks.

I and *ow* are close diphthongs, accented on the second element; and *ai* (yes), *oi*, are open diphthongs, accented on the first element. Each is pronounced as one syllable. The shorthand signs for *i, ow, oi,* may be written in ANY place: *ai* is written in the FIRST place.

Letters Y and W.

The letters *y* and *w* are unlike any other consonants. They are, in fact, *consonants made from vowels; y* being a modification of *ee*, and *w* a modification of *oo;* as may be heard in pronouncing

yah, yeh, yih (or *yee*)*; yaw, yoh, yuh* (or *yoo*).
wah, weh, wih (or *wee*)*; waw, woh, wuh* (or *woo*).

It has been found expedient to represent these letters *in connection with the succeeding vowel,* by a *single sign,* having a vowel character; thus, ∪ ∩ ⊂ ⊃ These signs, like those for the simple vowels, are written by the side of consonants, in three places, heavy for long vowels, and light for short ones. When joined to consonants, they express *y* or *w* alone.

By prefixing *w* to the diphthong *ī*, the treble sound *wī* is heard, as in *twice.* It is represented by a small right angle, which may be written in ANY position.

The shorthand signs for the diphthongs, and double and treble letters of the *y* and *w* series, are always written in the same direction; that is, they do not accommodate themselves to the consonant to which they may be written, as do the signs for the simple vowels *aw, o, oo.*

Y and *w* are also furnished with full-sized consonantal forms, which are used like other consonants; thus,

yea, Yeo, use; way, away.

They give greater distinctness than the small curved double letters, in the writing of words which contain no other consonant than *y* or *w:* they are also serviceable when either of these letters is followed by *s.*

Letter H.

The aspirate occurs in English only when preceding a vowel, or *y, w,* which are modifications of vowels. It is expressed by a small dot prefixed to the vowel sign. When it is more convenient to use a consonantal form for this letter, it is written either downward, or upward, whichever may be most convenient for joining with the preceding or following letter. The names of the letters *y, w, h,* are *yay, way, aitch.*

General rules for writing.

In consequence of the deficiencies of the English alphabet, and the unphonetic character of our orthography, the spelling of a word can seldom be taken as a guide to its pronunciation. To write any given word, therefore, phonographically, its several *sounds* must first be ascertained: the student should then write the phonographic letters which represent them. The practice of phonography and the reading of phonotypy will improve the student's pronunciation, and train his ear to discriminate differences in orthoepy.

The circle *s* is generally used in preference to the stroke *s*. In any word that contains the circle *s*, the vowel is placed and read to the stroke-consonant, and not to the circle *s*, to which no vowel can be placed or read. The circle *s*, at the beginning of a word, is always read FIRST; and at the end of a word it is always read LAST. It may be made double-sized for *ss*. When a word begins with a vowel followed by *s* or *z*, or ends with a vowel preceded by *s* or *z*, the stroke form of the letter is used. The stroke *s* is used whenever it is necessary to place a vowel to this consonant. The stroke *z* is used in *all* words that begin with the sound of *z*.

When a vowel comes *between two consonants*, it is possible to write it either after the first, or before the second. Care must be taken not to write the vowel sign in an angle between two letters; as which might be read either *kee-p* or *k-ahp*. The three following rules are of general application.

FIRST-PLACE VOWELS are written after the *first* consonant. SECOND-PLACE VOWELS are written after the *first* consonant when LONG, and before the *second* when SHORT: it is thus known whether a second-place vowel sign is intended to express a long or a short vowel, independently of the heaviness or lightness of the vowel sign. THIRD-PLACE VOWELS are written before the *second* consonant. If the second consonant is the circle *s*, the vowel must necessarily be written after the first consonant.

When the diphthongs ∨ *ī* ∧ *ow*, are written by themselves for the words *I, how,* ∨ *I* is placed ABOVE the line, and ∧ *how* ON the line. When either of these diphthongs commences a word, the first place is the most convenient: in other cases they are both more easily written in the third place.

From the *kr* series of double consonants, a series of treble consonants is formed by making the hook into a circle; thus, *skr, str, spr.* They are used only initially. The same signs with a thick stem will represent *sgr, sdr, sbr.*

The *w* hook double letters (see Plate XXXIX., *wn, wm, wl, wr*), differ from those of the *kl, kr* series with respect to vocalization. The *kl, kr* double letters (or consonant diphthongs) are vocalized like the single consonants; that is, *a* (a dot in the first place), before *kl* is read *akl*, and *a* after *kl* is read *kla;* but with the *w* hook double letters (which are not consonant diphthongs), vowels can be written either before or after the *n, m, l, r,* represented by the stem of the letter, because *w* is represented by the hook.

N following a straight letter, is expressed by a final hook on the UNDER side of a horizontal stroke, and on the corresponding side of any other straight letter (see Plate XXXIX.); thus, *cane.* By making the hook into a circle, *s* or *z* is added; thus, *canes.* The *ns* circle is made double-sized for *nsez;* thus, *expenses.* After curves, the *n* hook is written inside the curve.

F or *v*, when following a *straight* letter, is expressed by a final hook on the UPPER side of a horizontal stroke, and on the corresponding side of any other straight letter; thus,

kf, tf, chf, pf, rf (upward);

as in *tough, cough.*

By halving any of the preceding letters, *t* or *d* is added, according as the letter is thin or thick; *t* being generally added when the letter is *thin*, and *d* when it is *thick;* thus, *bake,* *baked;* *rub,* *rubbed.* A vowel AFTER a half-sized consonant is read next to the primary single, double, or treble letter, and before the added *t* or *d;* thus, *point,* *bread.* *N, m, l,* and *r* are shortened for the addition of *t,* and these shortened strokes, when thickened, represent *nd, md, ld, rd.* *Lt,* when standing alone, is written upward; in other cases, either upward or downward: *ld* is always written downward. The practised phonographer may use a half-sized letter to represent either an added *t* or *d.* The only consonants that do not admit of being halved are *y, w, ng,* and the irregular *mp.* (All HOOKED letters are halved for the addition of *t* or *d.*)

A full-sized and a half-sized consonant, or two half-sized consonants, should not be joined unless they form an angle at the point of union; because it would sometimes be doubtful whether such combinations were meant for a single letter, or a full-sized and a half-sized letter, or two full-sized letters.

The termination *-tion* (*shon*), is expressed by a large final hook, twice as large as the *f* hook. After a curve it follows the direction of the curve. At the end of a straight letter beginning with a hook or circle, or springing from a curve, the *tion* hook, when final, is written on the OPPOSITE side, that the straightness of the letter may be preserved. In other cases, *-tion* when final, and following a straight letter, is written on the side opposite to that on which the preceding vowel is written, for convenience in vocalizing; thus, *caution,* *action.* After simple *t* or *d,* the *-tion* hook is always written on the right; thus, *addition.* The *n, f,* and *-tion* hooks may be used in the middle of a word, when it is convenient.

St is written by a small loop; as, *stock,* *fast.* This loop is used chiefly as initial or final, but it may be employed medially when the loop can be distinctly formed; as in *justify.* A loop half as long as a consonant, represents *str;* thus *strike,* *muster.* These loops may be combined with the initial *kr* and the final *kn* series of straight letters; thus, *against,* *striker.* *S* may be added to a final loop or to the large *ss* circle by continuing the stroke of the loop or circle; thus, *crusts,* *exercises.* A hook made by continuing the *s* circle to the other side of the consonant, adds *-tion (shn)* or *-sion (zhn);* thus, *possession.*

When a curved consonant is written twice its usual length, it expresses the addition of *thr* (in *father*), *tr,* or *dr;* thus, *neither.*

The prefixes in Plate XXXIX. are written near the following part of the word; but in reporting (except the dot *con*) they are joined, when it is convenient to do so, to save lifting the pen. When *con* or *com* is preceded by a consonant, either in the same word or the preceding word, *con* or *com* is understood by writing the syllable that follows, UNDER or CLOSE TO the consonant that precedes; thus, *inconstant,* *discompose,* *you will comply.* The preposition *in* may be expressed before the treble consonants, *skr, str, spr,* by a back hook; thus, *inscription,* *instruct.* Any consonant when disjoined from that which precedes it, expresses thereby the addition of *ality* or *arity,* or any other termination of similar sound; thus, *penalty,* *vulgarity.*

The learner should not attempt, at first, to bring into use all these abbreviating principles. He should be content to practise, for two or three weeks, a rather lengthened style of phonography, making much use of the simple consonants, until he feels confidence in the use of the phonographic characters, and in the principle of phonetic spelling. He may then gradually adopt the double and treble letters, and the prefixes and affixes, &c., *as he requires them;* that is, as he feels that the style he is employing is not brief enough for the manual dexterity he has acquired. In selecting one out of two or more possible forms for any word, the student must recollect that great ease in writing, and, consequently, the saving of time, is not secured by using hooked and grouped, and especially half-sized, letters, on all possible occasions; but he must learn to make a judicious selection, and employ those which are most easily written in any given case.

Grammalogues.

The single and compound letters are used in phonography to represent the most frequent words in the language. To write *the, and, that,* &c., in full, would be unnecessarily tedious; nor would these words, thus written, be more legible than when expressed by one simple and distinct character. Words so abbreviated are called *grammalogues,* or *sign-words,* and the shorthand letters that represent them are called *logograms,* or *word-signs.* The table in Plate XXXIX. is the result of numerous experiments in writing, continued through many years, for the purpose of ascertaining the most useful words to be abbreviated, and the shorthand letters by which they may be best represented. The stroke-vowels *aw, o, oo,* are used as logograms in each of these directions; thus,

all, too, two; oh, owe; awe, he; of, to; on, but; and, should.

And and *should* are written upward. *And* and *he* are represented by *dashes* instead of by their respective *dot* vowels, for the purpose of joining other words in reporting, and thus writing whole phrases without lifting the pen.

In the table of grammalogues (Plate XXXIX.), a word is occasionally printed with a hyphen; thus, *give-n;* or, with a double termination; thus, *importan$^{t}_{ce}$;* to intimate that the corresponding logograms represent both *give* and *given, important,* and *importance.* The context will show which is meant. *S* may be added to a logogram to mark the plural number or the possessive case of a noun, or the third person singular of a verb in the present tense.

In general, the positions of the grammalogues, ABOVE, ON, and THROUGH or UNDER the line, are determined by their vowels; and in the case of a word of more than one syllable, by its accented vowel. The positions of the vowels are:—1, *ah, aw, ī, oi, wī;* 2, *ā, ō;* 3, *ē, oo, ow, ū;* and the corresponding short vowels. The positions of the logograms are:—1, *above* the line; 2, *on* the line; 3, if down or up strokes, *through* the line; but if horizontal or half-length sloping, *below* it. Double-length curves take only the following positions:—PERPENDICULAR, *through* the line for ALL words; SLOPING, *on* the line for words containing first and second-place vowels, *through* the line for words containing third-place vowels; HORIZONTAL, 1, *above* the line, 2, *on* the line, 3, *under* the line.

The rules that determine the position of a grammalogue are, specifically, these four:—1. Common words are written, generally, on the line, because this position is most convenient: sometimes they are written in the first position, for the purpose of attaching other words in phraseography. 2. In the case of a word that contains several consonants, the letter chosen to represent it is written in the position which it occupies when the word is written in full. 3. In all other cases the logogram is written IN POSITION, in accordance with the vowel or accented vowel of the word which it represents. 4. But if that position is occupied by some other word, it is placed in the most convenient unoccupied position.

Stenography. In the following cases the name of the letter is the same as the sound of the word; the letter, therefore, represents the word: these may be called natural grammalogues;

\ *be*, ᵛ *I*, ˊ *awe*, ˡ *O! oh! owe*, ᵤ *ye*, ₙ *you*, ᶜ *we*.

These natural grammalogues it is not considered necessary to repeat in the list. Theoretically, *you, yōō*, or *ū*, is ₙ, but the light sign *yŏŏ* ₙ may be used in all cases. The double vowels ᶜ *wi*, ᶜ *wē*, when representing the words *with, we*, are written above the line, although they are third-place vowels, because this position is the best for attaching other words and forming phraseograms.

Outlines of words. As three letters in the phonographic alphabet (*y, s, r*) have duplicate forms, *w* three forms, *h* four forms, and two others (*sh, l*) are written either upward or downward; and as many groups of consonants may be expressed either by their alphabetical forms, or by abbreviations, it is evident that many words may be written in more than one way. For any given word the writer should choose that form which is most easily and rapidly written, and is at the same time capable of being clearly vocalized. The briefest outline to the eye is not always the most expeditious to the hand. The student will insensibly acquire a knowledge of the best forms by practice and observation.

Contractions. When *K* occurs between *ng* and *sh*, or *ng* and *t*, *P* between *m* and *t*, or *T* between *s* and another consonant, the *k, p*, or *t* may be omitted.

The downward *h*, when occurring before *m*, stroke *s, sh*, downward *r*, upward *l, nr*, &c., may be contracted to the simple tick ⁄; thus, *hm* (him).

The, the most frequent word in the English language, may be expressed by a short slanting stroke ⁄ joined to the preceding word, and generally written downward; thus, *in the*, but when more convenient, it is written upward. The first stroke of *on the* is made sloping to keep the sign distinct from ᵛ *I*. The tick *the* never BEGINS a phrase.

The connective phrase "of the," is *intimated* by writing the words between which it occurs *near to each other*, thus showing that the one is *of the* other.

A *or* AN.—*A* or *an* is joined to the preceding word by ı or -

The pupil is recommended to be sparing in his use of contractions in the first style of phonography. In the second, or reporting style, every legible contraction may be brought into use.

Phraseography. In longhand, swift writers join all the letters of a word together, and sometimes write several words without lifting the pen. So, in phonography several words may often be united. This practice, which is called phraseography, gives great assistance to the writer in following a rapid speaker. Some examples will be seen in Plate XL.

Punctuation, &c. Stops should be written in the usual way, except the period, for which a small cross is used; thus, , ; : × The hyphen is written thus, ⫽; the dash thus, ~~~; Interrogation (placed *before* the sentence); Exclamation; a smile. Accent may be shown by writing a small cross close to the vowel of the accented syllable. Emphasis is marked as in longhand, by drawing one, two, or more, lines underneath; a single line under a single word must be made wave-like, thus ~~, to distinguish it from ‿ *k*. In preparing manuscript for the press, a single line thus drawn underneath (wavy for a single word, and straight for more than one), signifies *italic;* two lines (which need not be waved) SMALL CAPITALS, and three lines LARGE CAPITALS. An initial capital is marked by two short lines under the word; thus, *The Times* newspaper, *Abel*. Figures are written as usual, or the words may be expressed in phonography. *One* and *two*, being grammalogues, are represented by their respective logograms. When the figures *one* and *six* are written by themselves, they should be formed thus, *1*, *6*, that they may not be mistaken for shorthand characters. (I. P.)

Stephanus, Byzantinus. STEPHANUS, BYZANTINUS, a learned grammarian, who flourished about the close of the fifth century. Nothing is known regarding him, even his very age has been questioned. He wrote a geographical lexicon, probably the first of its kind ever written, in which he made a great number of observations, borrowed from mythology and history, which showed the origin of cities and colonies, and of which we have little remaining but an abridgment by Hermolaus the grammarian. Even in this state, it has been found a work of no inconsiderable value. It is alphabetically arranged, and bears the inscription Περὶ Πόλεων, or *Concerning Cities*. The first edition was printed by Aldus, Venet., 1502, fol. This was followed by an edition printed by the heirs of P. Junta., Florent., 1521, fol. The text received many emendations in the edition of Xylander, Basil., 1568, fol. All these editions contain the Greek text, without any Latin version. An edition, with a translation and copious annotations, was published by Thomas de Pinedo, Amst., 1678, fol. Another edition, with a translation and a commentary, was prepared by Berkelius, and after his death was completed by J. Gronovius, Lugd. Bat., 1688, fol. Nor must we here omit the posthumous *Notæ et Castigationes* of Holstenius, Lugd. Bat., 1684, fol.

Stephanus, Robert. STEPHANUS (Fr. *Etienne* or *Estienne*, Eng. *Stephen*), *Henry*, the founder of a most remarkable and meritorious family of printers, was born at Paris in the year 1470. He began the business of a printer about the year 1503. This is the date of Boethius's treatise on arithmetic, the first book that is known to have issued from his press. A great proportion of the books which he published were Latin. They are printed in the Roman letter, and are not inelegant, though some of them abound rather too much in contractions. He died about the year 1520, and left behind him three sons, Francis, Robert, and Charles. His widow married Simeon de Colines (*Colinæus* in Latin), who thus got possession of Henry's printing-office, and continued the business till his death.

Of Francis, the eldest son, little more is known than that he carried on business along with Colinæus, and that he died at Paris in 1550.

STEPHANUS, *Robert*, the second son, was born at Paris in 1503. In his youth he made great proficiency in the Latin, Greek, and Hebrew languages, and at the age of nineteen had acquired so much knowledge that his stepfather intrusted him with the management of his press. He soon afterwards began business himself, and married Perrete, the daughter of Jodocus Badius, a printer and an author. She was a woman of learning, and understood Latin, which indeed was the necessary consequence of her situation. Her husband always entertained a number of learned men as correctors of the press. Being foreigners, and of different nations, they made use of no other language but Latin, which Perrete being accustomed to hear, was able in a short time not only to understand, but even to speak with tolerable ease.

In 1531 he published his *Thesaurus Linguæ Latinæ*, a work of great labour, and of great value. The device which he exhibited in all his books was a tree branched, with a man looking upon it, and these words *Noli altum sapere*, to which he sometimes added, *sed time*. In 1539, Francis I. made him his printer, and ordered a new set of elegant types to be founded for him. His frequent editions of the New Testament gave great offence to the doctors of the Sorbonne, who accused him of heresy for his annotations, and insisted upon the suppression of some of his books. Although Henry, the French king, in some measure protected him, the persecution of these divines ren-

dered him so unhappy, not to mention the expense and loss of time which an almost constant attendance at court unavoidably occasioned, that in 1552 he abandoned his country and settled at Geneva. Here he embraced the Protestant religion, and thus justified in some measure the suspicions of his theological enemies. It has been affirmed by several writers, that he carried along with him the royal types, and the moulds in which they were cast; but it is certain that he never afterwards made use of those types. Besides, is it possible that the author of so daring a theft could have been not only protected in Geneva, but even courted and honoured by the most eminent men of the age? Is it credible that such a crime could have been concealed for sixty years; or that Henry, the son and heir of the perpetrator, would have enjoyed the favour of the French king, if Robert Stephanus had acted such a shameful part? If he was burned in effigy at Paris, it was not for theft, but for having renounced the popish faith. After his arrival at Geneva, he published an account of the dispute between him and the Paris divines, which does as much honour to his abilities as his *Thesaurus* does to his learning. He died in 1559, after a life of the most extraordinary industry. The books of which he was the editor were not fewer that 360. Many of them were ancient classics in different languages. Several were accompanied with annotations which he collected, and all of them were corrected by the collation of manuscripts. He was so anxious to obtain perfect accuracy, that he used to expose his proofs in public, and reward those who discovered a mistake. His books consequently were very correct. It is said that his New Testament, called *O Mirificam* (because the preface begins with these words), has not a single fault. It was Robert Stephanus who first divided the New Testament into verses, during a journey between Paris and Lyon. The advantages of this improvement are fully counterbalanced by its defects. It has destroyed the unity of the books, and induced many commentators to consider every verse as a distinct and independent aphorism. By his last will his estate was left exclusively to such of his children as should settle at Geneva. He left behind him three sons, Henry, Robert, and Francis.

Stephanus, *Charles*, the third son of Henry, was, like the rest of his family, familiarly acquainted with the learned languages. This recommended him to Lazarus de Baif, who made him tutor to his son, and in 1540 carried him along with him to Germany. He studied medicine, and took his doctor's degree at Paris. He did not, however, forsake the profession of his family, but exercised it at Paris, where he became the editor of many books remarkable for neatness and elegance. He wrote above thirty treatises on different subjects, particularly on botany, anatomy, and history. Having been unsuccessful in business, he was imprisoned for debt in the Chatelet in 1561, and died there in 1564.

Stephanus, *Robert*, the son of Robert the first of that name, did not accompany his father to Geneva, but continued to profess the Romish religion, and to reside at Paris. His letter, as a printer, was remarkably beautiful. He was made king's printer, and died about 1589. His brother Francis, who was also a printer, embraced the Protestant religion, and resided at Geneva.

Stephanus, *Henry*, the eldest brother, was born at Paris in 1528. He became the most learned and most celebrated of all his family. From a very early age he gave proofs of uncommon abilities, and displayed an ardent passion for knowledge. The *Medea* of Euripides, which he saw acted while at school, first kindled his love for poetry, and inspired him with the desire of acquiring the language in which that tragedy is written. He entreated his father not to condemn him to study Latin, which he already understood from conversation, but to initiate him at once in the knowledge of Greek. His father willingly acceded to his request; and Henry applied with such vigour, that in a short time he could repeat the *Medea* by heart. He afterwards studied Greek under Danesius, who was tutor to the Dauphin, and finally heard the lectures of Tusanus and Turnebus. At an early age he became eager to understand astrology, and accordingly attended a professor of that mysterious art; but he was not long in discovering its absurdity. At the age of nineteen he began his travels, which he undertook in order to examine foreign libraries, and to become acquainted with learned men. He spent two years in Italy, and returned into France completely master of Italian, and bringing along with him copies of several scarce authors, particularly a part of Anacreon, which previously was supposed to be lost. He found his father publishing an edition of the New Testament, to which he prefixed some Greek verses. Soon after he visited England and the Netherlands, where he met with John Clement, an Englishman, to whom he was indebted for the remaining odes of *Anacreon*. During this journey he learned the Spanish language, which was very much spoken at that time in the Low Countries.

Whether Henry accompanied his father to Geneva, is uncertain: if he did, he must have returned immediately to France, for we find him soon after established at Paris, and publishing the odes of Anacreon. In 1554 he went to Rome, and thence to Naples. This journey was undertaken at the request, and in the service, of the French government. He was discovered, and would have been arrested as a spy, had he not by his address and skill in the language of the country been able to pass himself off for a native of Italy. On his return to France he assumed the title of printer to Ulric Fugger, a very rich and learned German merchant, who allowed him a considerable pension.

In 1560 he married a relation, as is generally supposed, of Henry Scrimger, a Scottish scholar and civilian, with whom he was intimately acquainted. His wife was a woman, as he himself informs us, endowed with the noblest spirit and the most amiable disposition. Her death, which happened in 1586, brought on a disease that had twice attacked him before. It was a disgust at all those pursuits which had formerly charmed him, an aversion to reading and the sight of books. It was probably occasioned by too constant and severe an application to literary pursuits. In 1572 he published, in four vols. folio, his *Thesaurus Linguæ Græcæ*, one of the greatest works, perhaps, that ever was executed by one man, if we consider the wretched materials which most ancient dictionaries could furnish, the size and perfection of the work, and the immense labour and learning which must have been employed in the compilation. In 1573, he added *Glossaria duo, e situ vetustatis eruta*. This work had been carried on at a greater expense than he could well bear. He expected to be reimbursed by the sale of the book, but he was unfortunately disappointed. Scapula, one of his own correctors, extracted from it whatever he thought would be most serviceable to students, and published it beforehand in quarto. By this act of treachery Henry was reduced to poverty.

About this time he was much beloved by Henry III. of France, who treated him so kindly, and made him such flattering promises, that he resided frequently at court. But these promises were never fulfilled, owing to the civil wars which soon after distracted France, and the unfortunate death of Henry himself. During the remainder of his life, his situation was very unsettled. We find him sometimes at Paris, sometimes at Geneva, in Germany, and even in Hungary. He died at Lyon in 1598, at the age of seventy. His temper during the latter part of his life is represented as haughty and severe, owing probably

to his disappointments. He was twice married, and by his first wife had a son and two daughters, one of whom was married to the learned Isaac Casaubon.

This most erudite printer was fond of poetry from his very infancy. It was his practice to compose verses on horseback, and even to write them, though he generally rode a very mettlesome steed. His *Thesaurus* was his great work, but he was also the author of many other treatises in the French and Latin languages. His poems are numerous. His *Apologie pour Heredote* is a very singular performance. It has been illustrated by the annotations of Duchat. The number of books which he published, though fewer than his father, was great, and they were superior in elegance to anything which the world had then seen. A great proportion of them were Greek. He was the editor, however, of many Latin and even of some oriental writings. His Greek classics are remarkably correct; and many of his editions are accompanied by most learned notes. His *Thesaurus* still maintains its reputation. An edition, with very ample editions, was recently published by Barker and Valpy; and another elaborate edition has been published at Paris.

STEPHANUS, *Paul*, the son of Henry, was born at Geneva in 1566, and continued his father's profession. He executed translations of several books, and published a considerable number of the ancient classics; but his editions possess little of his father's elegance. He died in 1627, at the age of sixty, after selling his types to one Chouet, a printer. His son Antony, the last printer of the family, abandoned the Protestant religion, and returned to France, the country of his ancestors. He received letters of naturalization in 1612, and was made printer to the king; but managing his affairs ill, he was reduced to poverty, and obliged to retire into an hospital, where he died in 1674, miserable and blind, at the age of eighty. Almeloveen *De Vitis Stephanorum*, Amst., 1683, 8vo; Maittaire, *Historia Stephanorum*, Lond., 1709, 8vo; *Biographie Universelle*, tom. xiii., p. 386; *Nouvelle Biographie Générale*, tom. xvi., 1856.

STEPHEN, SIR JAMES, long a faithful servant of the Colonial Department of the British Government, and a successful essayist, was born in London in 1789. He was educated at Trinity Hall, Cambridge, where he took his bachelor's degree in 1812. He subsequently adopted the legal profession, and was called to the bar at Lincoln's Inn. He had scarcely begun practice as a Chancery barrister when he received an appointment as counsel in the Colonial Department. He subsequently gave up his practice as a barrister, and became counsel to the Board of Trade, a situation which he soon after renounced for the assistant-under-secretaryship for the Colonies. Stephen afterwards became permanent under-secretary in the same office till 1847, when he resigned. During his long service he was, without question, one of the most efficient functionaries which the government possessed. In 1855 he published his views in a *Blue-book* regarding the reorganization of the civil service, when competitive examination was first broached as a means of determining the fitness of young men for public offices. On the whole, the opinion expressed by him of the public offices is not high. There are, however, he says, noble exceptions; and certainly the writer himself was one of the noblest. On his retiring he received the honour of knighthood, and he was appointed Regius-Professor of Modern History in the University of Cambridge in 1849. He was elevated to the latter post by reason of his extensive acquirements in history and in biography, prosecuted during the leisure hours of his official employment. He had contributed extensively to the *Edinburgh Review* on subjects pertaining to ecclesiastical history and general religious biography; and he issued in 1849 *Essays in Ecclesiastical Biography*, which have been well received by the public. He published likewise some very popular *Lectures on the History of France* in 1851; and, except an occasional lecture delivered before some popular institution, his publications close with this year. Sir James Stephen died at Coblentz on the 15th September 1859. His son, Fitzjames Stephen, who has likewise followed the law, is at present (March 1860) engaged on a Life of his father, which will appear prefixed to a new edition of his *Essays*.

STEPHEN, sovereigns of Rome, of Hungary, and of England; which see.

STEPHENSON, GEORGE, the founder of the railway system in Britain, and the principal improver, or (as some think) almost originator, of the present locomotive steam-engine. Some incidents in the life of this great mechanician having been mentioned in Professor James Forbes' *Dissertation* in vol. i., (pp. 883, &c.) of this work, and some observations having been there added on his part and share in the construction of the locomotive-engine, it will be unnecessary in this place to repeat what is previously recorded, and we shall therefore only cursorily notice the chief points in the life and mechanical triumphs of the subject of this biographical sketch.

In a poor cottage in the primitive, rough village of Wylam, eight miles west of Newcastle-on-Tyne, George Stephenson was born, on the 9th of June 1781. The various incidents connected with his humble origin and early occupations have the air of romance when contrasted with his ultimate attainments, fortune, and fame. Few tours in this country are more suggestive than one which the writer has undertaken to trace out the scenes and circumstances in which George Stephenson first lived and laboured; nor even yet has the most been made of the wonderful transition from obscurity to celebrity, from abject poverty to abundant wealth, from comparative ignorance to ample knowledge, fiom primitive simplicity to large experience, which has been exemplified in the life of the Wylam lad—the Killingworth breaksman; the bold projector and constructor of the Liverpool and Manchester Railway; and, finally, the owner and worker of Midland collieries, and the world-known engineer, the companion of men of science, and the father of a son who continued and augmented the glory that gathers round the name of Stephenson.

Taking up the biography of George Stephenson from the year 1804, he became a breaksman at Killingworth Colliery, seven miles north of Newcastle. The times were hard, taxes heavy, and his own prospects in particular rather gloomy. He was drawn for the militia, paid for a substitute, and contemplated emigration to the United States. Poverty prevented the step. He mended clocks and watches, repaired shoes, and cut out pitmen's clothes. Every spare minute was improved, and his observing eye was always vigilant. He improved the winding-engines of the colliery, and was fortunate in repairing and refitting a failing pumping-engine. His fame as an "engine-doctor" grew, and he was appointed colliery engine-wright at Killingsworth.

Railways were first employed in the northern collieries, the visitor to which may even now behold some remains of primitive attempts of this kind. The Wylam waggon-way is one of the oldest, and down to 1807 it was formed of wooden spars or rails, and passed close in front of the cottage where George Stephenson was born. In 1808 this wooden road was taken up, and supplanted by a "plateway" of cast-iron (a single line of rails), with sidings. In 1811 a locomotive-engine was ordered from Trevethick; and another in 1812, after the same pattern, was constructed at Gateshead. These ran upon the Wylam Railway, and are interesting though somewhat clumsy specimens of the earlier locomotives. It is remarkable that at this very time steam, in its other applications, had become a great industrial power,

Stephenson, George.

and was performing the work of thousands of horses. It had even then revolutionized the whole domain of human industry. It was driving mills and machinery, rolling iron, spinning cotton, grinding corn, and to some extent impelling ships over the waters; but the general adoption of the locomotive, which was to bring together towns and cities, almost to annihilate distance, and to confer upon man as much enjoyment and as many capabilities as if he had been endowed with wings, was not yet thought of, and could hardly have been conceived by the most sanguine spectator of the rude, unwieldy machines then creeping along the plateways of the northern collieries.

Stephenson made his first locomotive at Killingworth, and it was the first engine which had smooth wheels, the constructor being satisfied of sufficient adhesion between the toothless rim and an edge-rail. It was first placed upon the Killingworth Railway on July 25, 1814, but its performances were not remarkable. He constructed his second locomotive in the succeeding year, but its improvements were not great. In 1816 he constructed other engines, in which he further simplified the working parts, and amended the whole by resting the weight on four small cylinders, a plan which was afterwards abandoned for ordinary springs. These engines regularly dragged coals at Killingworth, and the writer has seen one of them at that colliery. Mr Stephenson became engineer of the Hetton Colliery Railway, which was opened in 1822, where five of his locomotives were soon at work. To meet the anticipated demand for these engines, he entered into arrangements with Mr Edward Pease in 1823, and soon afterwards erected the famous locomotive manufactory at Newcastle. The Stockton and Darlington Railway was opened for traffic in 1825, and the first engines employed on it were constructed after the Killingworth model, travelling at a speed of from six to eight miles an hour. Mr Stephenson was appointed in 1826 to survey the line for a railway between Liverpool and Manchester; and the history of this railway is to a great degree that of Mr Stephenson's advances; but when the line was completed the directors hesitated to adopt locomotives. A trial, however, was conceded, a prize of L.500 offered for the best engine, and on October 1, 1829, three engines appeared, and competed on the 6th. The Rocket was made by Stephenson. On the evening preceding the trial he added to it the blast-pipe, copied from the Sanspareil, a rival engine by Mr Hackworth. Up to that time the Rocket had only attained 15 miles an hour; but on the following day it ran at the amazing velocity (for that period) of 29 miles an hour, while the Sanspareil could only reach 22 miles. Controversy has settled that the merit of the blast-pipe is due to Mr Hackworth, whose engine, however, was disabled, and the Rocket obtained the prize.

It would be vain to attempt to condense into a few lines the several improvements which the locomotive experienced since that memorable trial, but their leading principles remain to this day, although numerous ingenious engineers have studied all its details, and have devised considerable improvements in its working parts, by which greater economy of fuel has been effected, and greater speed attained. The invention of the steam-blast has been attributed to Mr Stephenson, but those who are intimately acquainted with its history accord it to Mr Hackworth, and this has been contested against Dr Smiles, the biographer of Mr Stephenson. The summing up of those who hold this view is, that the speed of the locomotive-engine is mainly due to the application of Hackworth's blast-pipe, Booth's or Seguin's multitubular boiler, and Trevethick's high-pressure engine. It is therefore contended that George Stephenson did not contribute any very important *inventions* to the locomotive, but is entitled to a large share of the merit due to its ultimate success, inasmuch as he admirably simplified the machinery, and brought all possible mechanical skill to bear upon the accuracy and solidity of its workmanship, while as a private and public advocate of its powers and prospects (together with those of railways) he was second to none, manifesting and partly inspiring an almost unlimited faith in this great triumph of mechanical adaptation.

Mr Stephenson attained the culminating point of his fame upon the completion and success of the Liverpool and Manchester Railway. His subsequent life was one of activity as a railway engineer; but others now emerged from obscurity, and shared his triumphs, while they rather confirmed than lessened his celebrity. The article RAILWAYS details the various improvements in the system which were adopted at different times; while the history of railway progress, so far as it was contemporaneous with Mr Stephenson's life, displays not more his co-operation than his singleness of purpose and integrity of character. He discountenanced the lamentable railway mania, and stood, in the main, aloof from its trickeries and infatuations. He visited other countries as an engineer, and was greatly honoured in all such visits. Finally, he retired to Tapton, opened extensive collieries, and lived the life of a plain but wealthy country gentleman. In 1845 he took a warm interest in horticulture, built melon-houses, pineries, and vineries, and contended as eagerly with the cultivators of exotics as he formerly did with mechanicians, while his early affection for birds and animals revived. We have not referred to his improvements in the miner's lamp, mainly because they are noticed in the preliminary dissertation, already alluded to. He died 12th August 1848, aged 67. We should say his leading characteristics were sagacity, enterprise, and persistence.

Dr Smiles has written a popular life of this great man, replete with interesting details, but not, we think, always accurate in mechanical history. A "biography in brief" of Mr Stephenson may be found in the little work, *Our Coal and our Coal-pits, the People in them, and the Scenes around them* (pp. 228, &c.) Several points of interest in the history of the locomotive-engine have been discussed in technical periodicals, and might be advantageously collected into one publication. (J. R. L.)

Stephenson, Robert.

STEPHENSON, *Robert*, son of the preceding, was almost equally eminent as a mechanical engineer, and perhaps in some respects his father's superior. His father was married to his mother in 1802, and the Stephenson family then resided at Willington, near Newcastle-on-Tyne. Their son Robert was born there in 1803, in an humble cottage, where his father was often busy in making or mending shoes, cleaning clocks, or drawing rough sketches. Robert was christened in the school-house at Wallsend, and his earliest days were spent like those of the children of mechanics. His father's earnest wish was to give his son that education the want of which he himself so severely felt. When a widower, all his savings were accumulated with this object in view. He sent his child to school, and the boy picked up the elements of mechanics by frequenting, during long evenings, the library of the Literary and Philosophical Institute at Newcastle. Adding these acquirements to the lessons of the common workshop, he became expert in his department of knowledge. At Killingworth he made a sun-dial when he was thirteen years of age, and affixed it to his father's cottage-door, to the life-long gratification of the latter. This, however, was named to the writer as the father's work.

The son was apprenticed to the viewer of a colliery in the neighbourhood about 1819, and after spending two years in that occupation, he was in 1822 despatched to the University of Edinburgh for a session, during which he so far profited as to return with a prize for mathematics. He now spent a year or two in his father's locomotive manufactory at Newcastle, of which he was hereafter to become the principal. Having been sent out to report upon the gold

Stephenson, Robert.

and silver mines of Columbia and Venezuela, he passed two or three years in South America, and returned to England in 1827 or 1828, to find his father deeply engaged in preparing, and strenuously contending for, railways and locomotives. He devoted the ensuing four or five years to the improvement of locomotive-engines, which underwent great changes under his watchful superintendence. He made experiments upon the application of heat, the strength of cylindrical and other boilers, the best mode of riveting flat portions of the same, and established all his improvements upon the issue of such experiments. The Rocket and Planet engines were in a great measure the result of his researches, combined with those of his father, the Planet being the type of the present locomotive.

About this period (1830) he executed the Leicester and Swannington, Whitby and Pickering, and two other railways, and planned a large locomotive manufactory at Newton in Lancashire; but whilst these works were in progress, his father and others were engaged in the first survey of the great railway from London to Birmingham, and subsequently he himself was engaged upon it, and walked over the whole distance—it is said twenty times—in order to determine the best line. By the close of 1831 the requisite plans were deposited, preparatory to application for an act in the ensuing session of Parliament. The contest before committees was protracted and severe, and no less than L.72,868 were expended in carrying the bill from first to last through Parliament. The difficulties which the Messrs Stephenson encountered in the actual construction of this important railway are generally known. Extensive tunnellings and excavations, besides long embankments, had to be executed by the best contractors of that day, who, however, were mostly new to works of this nature, while specifications for various peculiar kinds of work had to be prepared by the engineers. Opposition from Northampton necessitated the Kilsby tunnel, which penetrated 160 feet below the surface for a length of 2400 yards. This tunnelling was let to a contractor for L.90,000, and appeared feasible, and free from great impediments; but it was found that at 200 yards from the south end a hidden water-bearing quicksand, overlaid by a thick bed of clay, extended 400 yards into the proposed tunnel. Eminent engineers despaired of success; but Mr R. Stephenson devised means by which the tunnel was ultimately completed in thirty months from the time of laying the first brick (of which 36,000,000 in all were used). During eight months no less than 1800 gallons of water per minute were raised and carried away by steam-engines from the quicksand; in all, 13 steam-engines, 1250 men, and 200 horses, were engaged in this task, and the total cost of the tunnel amounted to about L.350,000.

In the course of this line enormous sums were paid for land and compensation; in one instance, L.3000 was given for a piece of land, and L.10,000 for consequential damages, though in the end the land was greatly enhanced in value by the railway. From this and similar causes, the original estimates which Mr R. Stephenson had laid before Parliament, amounting to L.2,750,000, were so largely increased that the expenditure had equalled nearly L.5,000,000 before the railway was opened for traffic. During nearly five years had Mr Stephenson, as engineer-in-chief, borne the heavy responsibilities and anxieties of this great undertaking; and it was indeed a day on which he might well feel honourable pride, when, with a small party (of whom the writer was one), he travelled by the first locomotive that had traversed at one and the same time the entire line of 112 miles.

His fame as a railway engineer was now at its culminating point, and he was henceforward fully occupied for several years in devising and superintending the construction of other lines. Of these the principal were the Midland, Blackwall, Northern and Eastern, Norfolk and Chester, and Holyhead, not to name numerous branch lines. Abroad, too, his services were sought either as consulting or constructing engineer; and thus he took part in the system of Belgian and Italian railways, and was employed on some of the principal lines in France, Holland, Norway, Denmark, Canada, New Zealand, Egypt, and India. In connection with the English lines he gave much parliamentary evidence, and was concerned in several hotly-contested questions, such as the "battle of the gauges," as well as in numerous reports, arbitrations, and consultations.

As a railway engineer, his attention had been necessarily much directed to bridges, and several of those now standing on various lines attest the skill and taste of the engineer-in-chief and of his able assistants. He was thus led to consider the possibility of adapting malleable iron to a larger extent in bridges, and for far wider spans than had heretofore been attempted. His own article, IRON BRIDGES, contributed to this *Encyclopædia*, contains his mature views on this subject, as well as the details of the principal erections of this character, with illustrations. We shall, therefore, content ourselves here with saying, that his own skill in this department is exhibited in some of the greatest constructions in iron-bridge building now existing. Not to dwell upon the High-level Bridge at Newcastle and some others, we particularly refer to the Conway and Britannia Tubular-Bridges in North Wales. The latter is, indeed, celebrated through all countries, and is an object of wonder to foreigners. Its principle was a subject of profound study and frequent experiments by Mr Stephenson and his very able assistants. It must be mentioned that Mr Fairbairn claims the merit of being the originator of the tubular principle; but into the controversy on this question we are not called upon to enter, nor is this the place to pronounce upon the respective claims of either of these two eminent engineers. The bridge itself is a marvel of massiveness, design, and perseverance. Unsightly in some aspects, it is nevertheless grand as a whole. The weight of malleable-iron in it is no less than 9480 tons, and that of cast-iron 1988 tons. The length of the long tubes (in place) is 488 feet, 8 inches; their height above low-water (the Menai Straits) is 121 feet, 6 inches; above high-water, 100 feet; and the weight of each tube is 1803 tons. By this erection the value of the tubular principle is demonstrated, and the ability of all concerned established.

A bridge was commenced and built, under the direction of Mr Stephenson, across the St Lawrence, extending nearly two miles, and is now opened in connection with the Grand Trunk Canadian Railway. Unprecedented difficulties had to be overcome in founding the piers of this bridge in the rapid waters of the river, and it was necessary to sink the foundations below its bed, thereby reaching to a great depth, while operations could only be carried on during a period of the year. Grandeur of conception and successful execution are here combined in the most remarkable degree. In these respects, and in magnitude, it may be regarded as the engineer's greatest work in iron-bridge building.

It will be unnecessary to refer to minor labours and triumphs, but it should be recorded that in all his public works Mr Stephenson had the good fortune to be ably seconded by his subordinates, in selecting whom he displayed considerable judgment. Some of these may remain unknown, but others are in the front rank of the profession of their former chief.

In public life Mr Stephenson became further known (in 1814) as M.P. for Whitby, and as a respected speaker in the House of Commons upon his own subjects. In private life no man could be more honoured, loved, and happy. Great wealth, and numerous and attached friends, were his fortunate lot. He died 12th October 1859, aged 56 years. His remains were honoured with a public funeral and in-

Stepney || Stereoscope.

terment in Westminster Abbey, which was crowded on that occasion with a multitude of mourners distinguished by professional eminence and rank. Thus was he favoured in life and lamented in death. It is said that he once declined the honour of knighthood. No title would have added materially to his celebrity, and his fame will probably last as long as his great public works, which, after all, form his most appropriate and enduring memorials. To every railway traveller it may be said, with reference to the Stephensons, as once in relation to Wren and St Paul's Cathedral, *Si monumentum quæris circumspice.* (J. R. L.)

STEPNEY, a parish of England, and eastern suburb of London, in the borough of Tower Hamlets, lying to the east of the city, $2\frac{1}{2}$ miles E. of St Paul's. It contains numerous churches and dissenting places of worship, a grammar and other schools, a Baptist college, the London Hospital, and other charitable institutions. Many manufactures are carried on here to a considerable extent; among other establishments there are breweries, manufactories of sail-cloth, sails, tobacco-pipes, ropes, chain-cables, and steam-engines. Stepney contains the basin of the Regent's canal, which here joins the Thames. Area, 812 acres. Pop. 80,128.

STEREOSCOPE. The name *Stereoscope*, derived from the Greek words στερεός, *solid*, and σκοπεῖν, *to see*, has been given to a binocular optical instrument of modern invention, by which plane representations of figures or landscapes, or any objects whatever, as seen separately by each eye, are combined into one picture, which appear solid or in relief. Unlike other optical instruments, it cannot be used by persons who see only with one eye.

History.

As in all important inventions, the principle of the instrument, as well as its construction, has been claimed for different persons. The fundamental principle of the stereoscope is, that the pictures of any solid object, as seen by each eye, are different; that is, if an artist draws any solid object, as seen with each eye separately, the pictures will be different. Every body knows this that chooses to inquire into the matter; the right eye sees the right side of the nose only, as Gassendi said long ago, and the left eye the left side of the nose. The right eye sees only one glass of a pair of spectacles before the right eye, and the left eye sees only the other glass, which is before it; or, to state the fact more generally, the right eye sees more of the right side of all solid objects than the left eye does, and the left eye sees more of the left side of the same objects than the right eye. In vision these two pictures, the right and left eye pictures, are united into one. The second principle of the stereoscope is, that the pictures thus united, though flat or plane upon the retina, have the appearance of solidity or relief, and, therefore, two dissimilar pictures, like those on the retina, united by means of the two eyes, or by any method whatever, will also appear in relief.

The first of these principles was known to Euclid 2000 years ago, and is distinctly explained in his *Treatise on Optics*. Fifteen hundred years ago, Galen clearly proves that in viewing solid objects, with each eye and with both, we see *three different pictures*. "Standing near a column," he says, "and shutting each eye in succession, when the *right* eye is shut, some of those parts of the column which were previously seen by the *right* eye on the right side of the column, will not now be seen by the left eye; and when the *left* eye is shut, some of those parts which were formerly seen by the *left* eye on the *left* side of the column, will not now be seen by the right eye. But when we at the same time open both eyes, both these will be seen."

Baptista Porta.

Baptista Porta illustrates these views of Galen by the following figure, in which we see not only the principle of the stereoscope, but the binocular slide with the right and left eye picture united and producing solidity (fig. 1). Let A, he says, be the pupil of the right eye, B that of the left, and DC the body to be seen. When we look at the object with both eyes we see DC. But if it is seen with one eye it will be seen otherwise, for when the left eye B is shut, the body CD, on the left side, will be seen in HG; but, when the right eye is shut, the body CD will be seen in FE; whereas, when both eyes are opened at the same time, it will be seen in CD.[1]

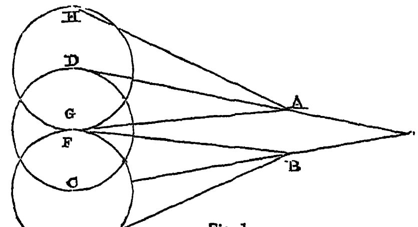


Fig. 1.

Jacopo Chimenti.

That we have here the representation of the right and left eye picture of the stereoscopic slide, and the true principle of the instrument is very obvious; but till now we had no evidence that such pictures were either executed or combined to produce relief. A gentleman who lately visited Lille, saw in the Museum Wicar two drawings by Jacopo Chimenti, placed together like AB, A being a picture of a youth sitting upon a bank and drawing with a compass, as seen by the right eye, and B, a similar drawing, as seen by the left eye. Upon looking at a point O, so as to join the drawings, the figure A rose into true relief.

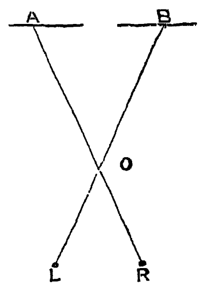


Fig. 2.

This, doubtless, is the invention of the ocular stereoscope, deduced from Baptista Porta's work. In the year 1593, when Porta's work was published in Naples, Jacopo Chimenti was in the 39th year of his age, and therefore very likely to have availed himself of the binocular theory of the Neapolitan philosopher.[2]

Leonardo da Vinci knew the same fact, and in 1613 Aguilonius, in his work on optics, wrote a whole book on the vision of solids (τά στερεά, *tu sterea*); and Dr Smith of Cambridge, Mr Harris of the Mint, and Dr Porterfield of Edinburgh, were all acquainted with the dissimilarity of the pictures as seen by each eye separately. Mr Harris, who wrote in 1775, tells us that we distinguish prominences of small parts "by the prospect we have round them;" and he adds, "By the parallax, on account of the distance betwixt our eyes, we can distinguish besides the front part of the two sides of a near object not thicker than the said distance, and this gives a visible relievo to such objects, which helps greatly to raise or detach them from the plane in which they lie. Thus, the nose on the face is the more remarkably raised by our seeing both sides of it at once." Hence it is obvious that optical writers in every age knew the two facts, that the pictures on the retina of the two eyes were dissimilar, and that by the union of these two flat dissimilar pictures we obtain the vision of solidity, the union of the two nearest similar points on the two pictures, placing that point at the shortest distance; and the union of the two most remote similar points, placing that point at the greatest distance from the eye.

In order to see objects in relief from plain representations of them, it was required only to obtain accurate

[1] *De Refractione Optices parte*, lib. v., p. 132; or lib. vi., pp. 143, 145; Neap. 1593.
[2] We have taken measures to obtain photographs of Chimenti's drawings.

Stereoscope.

pictures of them as seen by each eye, and a method of uniting these pictures. By means of photography and the binocular camera we obtain two dissimilar pictures, and by the method of Chimenti we can unite these pictures.

Elliott's ocular stereoscope.

So early as 1823 Professor Elliott of Liverpool, when a student at the logic-class in Edinburgh, was led to study the subject of binocular vision, and sometime afterwards he invented a method of uniting the two dissimilar pictures of objects as drawn by himself. He had resolved in 1834 to make the instrument, but delayed doing this till the year 1839, when he constructed an instrument for uniting two dissimilar pictures. This simple stereoscope had neither mirrors nor lenses, and consisted of a wooden box 6 inches long, at the end of which he placed two dissimilar pictures of a landscape (fig. 3) drawn by himself, as seen by each eye. These pictures were then united, and appeared in relief by converging the eyes to a point beyond the pictures. If he

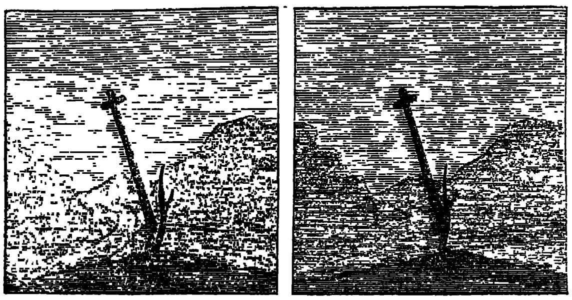


Fig. 3.

had reversed the pictures, as in fig. 3, he would have obtained the same effect by converging the optic axis to a point between the pictures and his eye. Owing to the

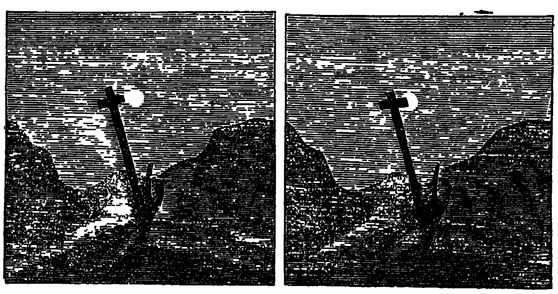


Fig. 4.

difficulty of obtaining right and left eye pictures of landscapes and figures, Professor Elliott proceeded no farther with his invention.

In 1836 Mr George Maynard, M.A., of Caius College, Cambridge, who had been previously studying the phenomena of binocular vision, published an article on the subject in a Toronto newspaper, in which he described the principles of the stereoscope, or the *Bathoscope* (from βαθος, depth, and σκοπειν, loses), as he called it.[1]

In June 1838 he communicated to the Royal Society of London an interesting paper on the physiology of vision, in which he described an instrument called a stereoscope for uniting the two dissimilar pictures of solid bodies as seen by each eye. This instrument, which is represented in fig. 5, he describes in the following manner:—

Wheatstone's reflecting stereoscope.

"AA′ are two plain mirrors about 4 inches square, inserted in frames, and so adjusted that their backs form an angle of 90° with each other; these mirrors are fixed by their common edge against an upright B or against the middle of a vertical board, cut away in such a manner as to allow the eyes to be placed before the two mirrors. C, C′, are two sliding boards, to which are attached the upright boards D, D′, which may thus be removed to different distances from the mirrors." In order to keep the two up-

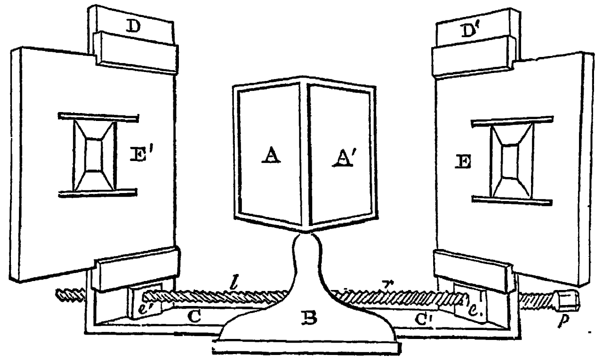


Fig. 5.

right boards at the same distance from its opposite mirror, Mr Wheatstone "employs a right and left-handed screw, *r*, *l*; the two ends of this compound screw pass through the nuts *e e′*, which are fixed to the lower parts of the upright boards D, D′, so that by turning the screw-pin *p* one way the two boards will approach, and by turning it the other, they will recede from one another; one always preserving the same distance as the other from the middle line *f*; E, E′, are pannels to which the pictures are fixed, so that their corresponding horizontal lines shall be on the same level; these pannels are capable of sliding backwards or forwards in grooves on the upright boards D, D′."

In using the apparatus "the observer must place his eyes as near as possible to the mirrors, the right eye before the right hand mirror, and the left eye before the left hand mirror, and he must move the sliding pannels E, E′, to or from him till the two reflected images coincide at the intersection of the optic axis, and form an image of the same apparent magnitude as each of the component pictures," . . . the entire effect of relief being produced by the simultaneous perception of the two monocular projections, one on each retina."

The figures to which Mr Wheatstone applied this apparatus were pairs of outline representations of objects of three dimensions, such as cubes, cones, and frustums of pyramids, like those shown at E, E′, in the figure; but though the effect produced by the apparatus was new and startling, it did not excite any general interest, and was known only to Mr Wheatstone's friends, or to one or two professors as a portion of their optical apparatus.

The lenticular stereoscope of Sir David Brewster.

Having had one of these stereoscopes constructed for him by the late celebrated optician, Andrew Ross, Sir David Brewster saw its imperfections, and its inapplicability as a general and popular instrument, and he was led to the construction of the *lenticular stereoscope*, now in universal use in every part of the world. The instrument was exhibited to the British Association at Birmingham in 1849, and a finely executed one by Mr Loudon of Dundee was exhibited by its inventor in Paris in 1850 to the Abbé Moigno. M. Duboscq devoted himself to the manufacture of the instrument, and executed for it the most beautiful daguerreotypes of living individuals, statues, and objects of all kinds. "The stereoscopes of M. Duboscq," says the Abbé Moigno, "are constructed with more elegance, and even with more perfection than the original English instrument; and while he is showing their wonderful effects to natural philosophers, and amateurs who have flocked to him in crowds, there is a spontaneous and unanimous cry of admiration."[2]

On the 30th December M. Duboscq exhibited the lenticular stereoscope to the Imperial Institute of France, and MM. Babinet, Pouillet, and Regnault were appointed a

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[1] *On the Bathoscopical Effects of Binocular Vision, and the Principles of the Stereoscope*, p. 4, Toronto, 1856.
[2] *La Presse*, Dec. 28, 1850.

Stereoscope.

committee to examine it.[1] Although Sir David Brewster had offered the free use of his invention to opticians in Birmingham and London in 1849, yet not a single instrument was made by English artists, and it was not till a year after its introduction into France that it was publicly exhibited in England.

In the beautiful collection of optical instruments which M. Duboscq contributed to the Great Exhibition in 1851, he placed a lenticular stereoscope, with a fine set of binocular daguerreotypes. The instrument attracted the particular attention of the Queen, and before the crystal palace was closed, M. Duboscq executed one of his finest stereoscopes, which was presented to her Majesty by Sir David Brewster in the artist's name. M. Duboscq having received many orders from England, sent over a number of stereoscopes; and in a short time they were manufactured in all parts of the world, and artists dispatched into every country to take binocular pictures of its buildings, monuments, and scenery.

The lenticular stereoscope consists of two convex lenses, or two semi-lenses, or two quarter-lenses, placed 2½ inches distant, through which the observer views what is called a binocular picture, held in the hand, or placed in a box at such a distance from the lenses that it may be seen distinctly, and magnified.

In the earliest instruments two whole lenses were used, in order to save the trouble of halving them, but in this case the two outermost halves were useless, as the eyes of the observer only looked through the inner halves. But in order to make the instruments cheaper, the lenses were cut into halves, or into quarters, and each half or quarter cut into a round disc, so that a single lens could make *one* semi-lens stereoscope, or *two* quarter-lens stereoscopes.[2] These different forms of the lenses are shown in the

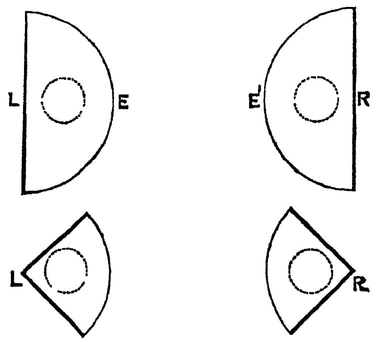

Fig. 6.

annexed diagram (fig. 6), where L is the lens opposite the left eye, and R the lens opposite the right eye, each eye looking through the part of the lens marked by a dotted circle the size of the pupil of the eye. If the eye is close to the lens it will see the object which it views as distinctly as if the lens were a foot in diameter; but as it cannot be advantageously placed close to it, the lenses are always made larger than is necessary. Beyond the size of lens which allows the pupil to see every part of the object, everything additional is superfluous. The two lenses L, R have been made so large as to meet, and sometimes the shape of a Gothic window has been given to them; but whatever be their size or shape, whether whole lenses, as they have been ignorantly made, or any other size, the eyes must look through two small circular portions equidistant from the centre, and placed at the distance of 2½ inches, as shown in the above figure.

It is hardly necessary to point out to the optical reader the peculiar advantages of semi or quarter lenses. It is impossible to give two separate lenses, L, R, the same focal length and magnifying power, however nearly we may approach to it; but two semi-lenses cut from the same lens, and the two quarter-lenses cut from the same semi-lens, have necessarily the same focal length and magnifying power.

The general form of the instrument in which these lenses are placed is shown in fig. 7. The instrument con-

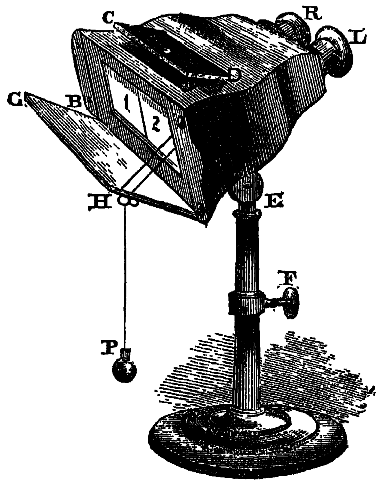

Fig. 7.

sists of a pyramidal box, or a box of any form, on the top of which are placed two eye-tubes containing the lenses R, L, which can be separated from one another in a variety of ways, to suit the distance between the eyes of the observer. They may also be drawn out so as to produce distinct vision of the picture, but they are prevented from turning round by a brass pin in the fixed tubes, which runs in a groove cut through the movable tubes. Immediately below the eye-tubes, at G, there should be a groove for the introduction of a pair of convex or concave spectacles, when necessary, or for coloured glasses, or other purposes.

If we now take a binocular slide containing two pictures of a person, or a landscape, as seen by each eye, or as drawn by the rules of perspective from two points 2½ inches distant, and put it into the horizontal opening at AB, and look into the instrument with the right eye at R and the left at L, we shall see the two pictures united into one, and having the same relief as the living person if it is a portrait, or as a scene in nature if it is a landscape; every part being no longer on a plane surface, but at its proper distance from the eye. If we shut the right eye R, and look only with the left eye L, we shall see only the picture 1, which will sink into a comparatively flat representation of the object, with only monocular relief. In like manner, by closing the left eye L, we shall see only the picture 2 comparatively flat; but when both eyes are opened the pictures 1 2, when combined, will start into all the roundness and solidity of life or nature.

The bottom of the stereoscope should be left open, so as to admit binocular pictures on glass, but in this case the open bottom must be covered either with ground glass or transparent paper, unless when the binocular slide has one of its surfaces made of ground glass. The lid CD, which is left open to throw light on opaque binocular slides like those on paper, card-board, or silver plate, must be shut when the pictures are either upon glass or transparent paper.

When the instrument is placed on a stand, as in the figure, it moves round a joint at E, and is raised or depressed by a stop-screw at F. A reflector GH is some-

[1] *Comptes Rendus*, &c., tom. xxxi., p. 897.

[2] See the article MICROSCOPE, vol. xiv., p. 770.

times added to the stereoscope for throwing different levels upon transparent pictures, and its position is regulated by a pulley P.

In order to explain why the stereoscope combines the two pictures, we shall do it most simply by desiring the reader to look at any object with his left eye through the

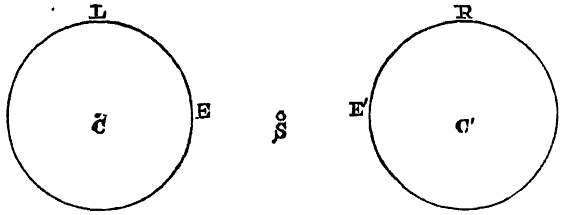

Fig. 8.

centre C of any convex lens such as L, fig. 8, so as to see it distinctly. The object will appear directly opposite C; but if, keeping the object and the eye stationary, he draws the lens gradually to the left, the object will advance towards S, just as the parts of the lens between C and E are opposite to the eye, the displacement of the object being greatest or equal to CS, when the eye looks at it through the part nearest the edge E. If the reader looks at a similar object with his right eye through the lens R, he will, in like manner, by moving it, displace the object from E′ to S. Hence it follows that if he looks with his left eye at one of the pictures of a binocular slide placed opposite the lens L, and with his right eye at the other picture placed opposite the lens R, he will see the two pictures combined in one when the left eye looks through the aperture close to E, and the right eye through the aperture close to E′. The lenses thus perform simultaneously two important functions: While they displace the pictures, they also magnify them. This is all that the stereoscope does. It simply magnifies and unites two pictures, but it does not give them binocular relief. This is done by a beautiful property of two eyes, as will be seen when we treat of the *Theory of the Stereoscope*. If the two eyes, however perfect be their vision, had not the power of converging their axes to any other distance but that of the surface of the pictures, no relief whatever would have been seen.

The lenses of stereoscopes cut out of semi-lenses, or quarter-lenses, and are placed in tubes so that the line LE or RE′ (fig. 6) is parallel to the line joining the two eyes, and they are prevented from turning round by a pin sliding in a groove, as already mentioned. Frequently, however, the pin gets out of the groove, and when the line LE or RE′, or CE, CE′, is not parallel to the line joining the eye, the picture viewed through the lenses rises above S (fig. 8), or falls below it, so that the instrument becomes useless. To prevent this the lenses have often been fixed, so that their distance cannot be altered to suit different distances in eyes, nor can they be adjusted to distinct vision by a motion of the tubes R L (fig. 7). The adjustment to distinct vision has in some instruments been obtained by making one half of the pyramidal box move within the other half; but, to avoid all these risks, whole lenses such as L, R′ (fig. 8), should be placed in tubes as at R, L (fig. 7), having neither pin nor groove, and they may be pulled out, or pushed in, or turned round without affecting the performance of the stereoscope, which is the only possible use of whole lenses. In a whole lens every radius CE (fig. 8), when it is brought opposite the eye-hole, has the same displacing power, and must always displace the picture in the same direction; that is, the two pictures must always be united at the middle point S, and will be equally magnified if the two lenses have the same focal length, which is never so certain as when semi-lenses are used.

Among the various forms which have been given to the lenticular stereoscope, those invented and manufactured by Messrs Smith, Beck, and Beck, 6 Coleman Street, London, hold a high place. These gentlemen received a medal of the first class from the jury of the Paris Universal Exhibition of 1855, for their unrivalled achromatic microscopes,[1] and if their stereoscopes had been exhibited on that occasion they would have been equally distinguished. The following is a brief description of their achromatic stereoscopes.

Smith and Beck's achromatic lenticular stereoscope

This instrument is shown in fig. 11, as taken out of its case A, and resting upon it as a stand, to which it is secured by the hooks C. It has a joint at B, and can be fixed in a vertical, horizontal, or any intermediate position by the

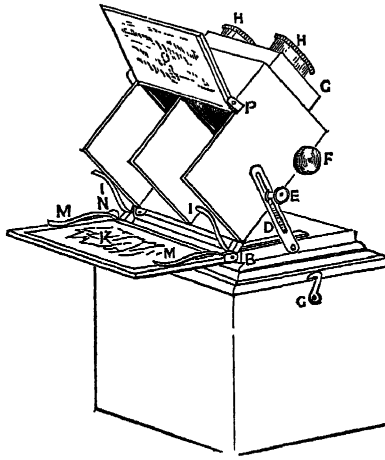

Fig. 9.

brass arm D, which is made tight by the milled head E. Two other positions, namely, when the instrument is horizontal and the person sitting, and when the person is in a standing position, may be obtained by an additional cabinet, which may be used for holding the slides.

The two semi-lenses, which, being rounded, have the appearance of whole lenses, nearly an inch in diameter, are shown at HH. They are placed in tubes, which turn round in their fittings at G, and are in their proper position when the two arrows on the brass arms HH point to one another. In order to adjust the instrument to different eyes, the part of it containing the semi-lenses is moved nearer to, or farther from the stereographs or binocular picture or slide by two milled heads F. The distance of the semi-lenses from the picture may also be increased for aged persons, by drawing them out from their fittings at G. The slides are placed outside and under the two springs I, I.

When opaque slides are used, such as daguerreotypes, or those made of card-board, light is thrown upon them by the mirror O on the inside of the door, which moves round a hinge at P.

When transparencies are used the door O is closed, and the picture illuminated by a removable reflector K, packed in the case, but which, when in use, is held by two brass arms and springs M, and is turned into different positions round the hinge B. "The silvered, or other side, is used according to circumstances; but occasionally some kind of tinted paper, or other reflecting substance, is preferable for giving a tone to the picture; but, whatever it may be, it has only to be placed above the reflector or under the springs, or in place of the reflector, if it is of a sufficiently stiff material."

In order to exhibit paper stereographs or slides, either when mounted in the ordinary way, or when they are given as illustrations in books—such as those in the *Stereoscopic*

[1] See art. MICROSCOPE, vol. xiv., pp. 779, 780

Magazine—Messrs Smith, Beck, and Beck have contrived the following ingenious form of the lenticular stereoscope.

Achromatic mirror lenticular stereoscope.

This instrument is intended to be held in the left hand by the handle A, as shown in fig. 10, the right hand being left at liberty either to shift the stereographs, or make the requisite adjustments. The semi-lenses are placed in the tubes C, C, and they are in their proper position when the arrow heads, or the brass rims D, D, point to each other. The adjustment to distinct vision is obtained by the milled head B, and a rack and pinion, and also by the motion of the tubes C, C.

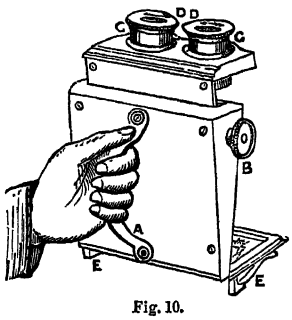

Fig. 10.

The principal feature in this form of the stereoscope is the application of a mirror EE in such a position that, when the instrument is held facing the light, the stereograph is illuminated by reflected as well as direct light, so as to obliterate the shadows of irregularities on the surface of the paper. This mirror is shown at FF, in fig. 11, which is a front view of the instrument when placed above the stereograph in a book, the springs E, E being turned up to allow the brass frame H to rest upon the back. When a separate stereograph is to be examined, the springs E, E are turned round, and the stereograph placed between them and the frame. The two pictures in the stereograph are separated by a division G, which is made of ground glass, to prevent any shadow from being formed on the picture.

In this stereoscope, as well as in the other, the tubes C, C can be turned round slightly from their proper position as determined by the arrows, in order to correct errors which occasionally exist in the stereographs, or in order to unite the pictures when seen by individuals whose eyes are imperfect.

Improvements on the reflecting stereoscope.

Various improvements have been made upon the reflecting stereoscope, for an account of some of which we must refer to Sir David Brewster's *Treatise on the Stereoscope.* The most ingenious and important of these, and one which is not described in that work, was invented by Mr Walter Hardie of Edinburgh, who has favoured us with the following description of it.

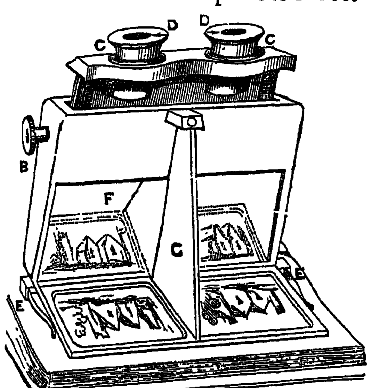

Fig. 11.

Mr Hardie's reflecting stereoscope.

In this instrument the planes of reflexion are *vertical* instead of horizontal, as in Mr Wheatstone's. The pictures are placed head to foot, and inverted towards the observer (see fig. 14). The reflectors (either silvered glass or reflecting prisms) are fixed side by side over them, and at such an inclination to each other and to the pictures that the reflected image of the upper picture in the right-hand mirror, and that of the lower picture in the left-hand mirror, are both visible in the same direction *ei*, and appear to coincide in position. When these images are viewed together, each by its appropriate eye looking into the mirror which reflects it, they are binocularly united; and if the pictures are stereoscopic, the stereoscopic illusion is produced.

The precise relative positions of the mirrors and pictures may be stated thus: the smaller angle of the *mirrors* must be equal to half the difference between that of the pictures and 180°; and the line of intersection of their surfaces must coincide with that of the two planes which are respectively perpendicular to the surfaces of the pictures at their horizons. The *pictures* being head to foot with their horizons parallel, their central perspective vanishing-points ought respectively to lie $1\frac{1}{4}$ inches (or half the width between the observer's eyes) on each side of the plane perpendicular to both picture-surfaces, and which passes through the point of contact of the inner edges of the mirrors. If the pictures are separate, by sliding one of them sideways, Mr Wheatstone's experiments in altering the inclination of the optic axes may be repeated. For ordinary use, however, it is more convenient to have both pictures on one piece of card-board, with a flexible fold or hinge between them, and with a thread stretched across from one to the other on each side, to hold them at

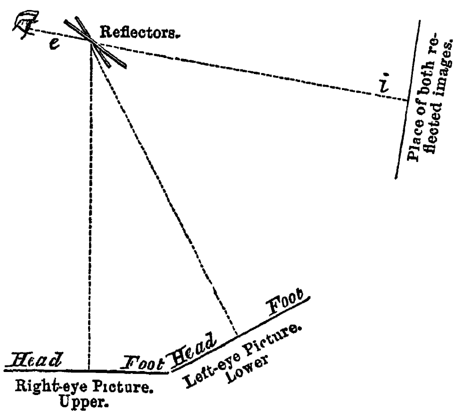

Fig. 12.
SIDE VIEW.

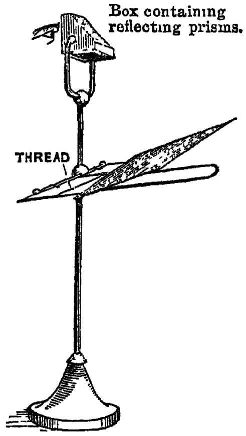

Fig. 13.

the proper angle when in use (see fig. 13, which shows the most convenient mode of constructing the instrument).

The stereoscope is adapted for pictures of any size, from that usually made for the lenticular stereoscope up to the largest that can be conveniently used in Mr Wheatstone's; and it has this advantage over the latter, that it easily allows of both pictures being equally illuminated. The distance of the pictures from the mirrors is adjusted to their size (height) by sliding the frame which carries them (upwards for the smaller pictures, or downwards for the larger ones) upon the vertical stem which supports the reflectors (see fig. 13). To facilitate this adjustment, a divided scale of inches may be marked on the upright stem; and the height on this scale, at which each particular picture requires to be placed, may be noted on the back of it. The breadth of the field of view may be further extended, so as to admit broader pictures by interposing refracting prisms (thin edges inwards) between the eyes and the reflectors. For small pictures requiring to be placed at short distances from the reflectors, lenses or lenticular prisms may be used in the same way with advantage.

Mr Claudet's stereomonoscope.

The stereomonoscope, invented by Mr Claudet, is an instrument which, as its name implies, exhibits an image *apparently* single, presenting the most complete stereoscopic illusion.

This instrument is founded on the principles of the phenomenon of relief of the image formed on the ground glass of the camera obscura, and which Mr Claudet seems to have been the first to notice and explain. Having tried to discover the cause of that phenomenon, he found that the image seen on the ground glass is not the same for both eyes; that when looking only with one eye it continually changes as we move the head, and, consequently, that the image visible for one eye is invisible for the other

Stereoscope.

The cause of this singular fact is, that the eye sees on the ground glass only the rays which are refracted by the lens in the direction of the optic axis, and that all the other rays are invisible.

This is owing to the perfect transparency of the ground glass, and to the arrangement of the molecules of its surface, by which the rays of light can—*nearly all*—pass through it without diverging from the surface, as it would be entirely the case if, instead of glass, the focussing screen was of paper or any other opaque substance, which, on account of this property of stopping the refracted rays on the surface, from which they diverge in all directions, present to both eyes at once all the different images produced by every part of the lens.

As regards the ground glass, it is evident that if each eye can see only the image produced by rays refracted in the direction of the optic axis, these rays must be those which, crossing each other on the ground glass, emerge from two opposite sides of the lens, consequently each eye having the perception of an image of different perspective, the result is perfectly stereoscopic. From the same cause, the effect is the converse of relief if we look with a pseudoscope.

The stereomonoscope is only an application of this property peculiar to the ground glass, to present to each eye only the image which is refracted in the oblique direction of the optic axis. If, instead of the natural objects, we place before the camera the two pictures of a stereoscopic slide, and have each of these images refracted by a separate lens, in such a manner that they coincide on the ground glass of the camera obscura, each eye seeing one of the two images and not the other, we have the same relief as when looking at the slide in a common stereoscope.

If, by inverting the position of the two images before the camera, we place the right picture on the left, and the left picture on the right, we have the converse of relief, or the pseudoscopic effect; but it becomes again stereoscopic by looking with a pseudoscope.

The slide must be cut in two parts, in order to be able to give them the separation by which each picture can be refracted in the oblique direction capable of bringing its image on the centre of the ground glass. The two lenses also must be able to slide in a groove, in order to adjust their position according to the separation of the two pictures, and according to the focal distance of the lenses, which of course varies as we wish to increase or diminish the size of the image on the ground glass, and it can be increased to a considerable dimension, which is one of the greatest advantages of the stereomonoscope. Nothing is more beautiful than the effect of one of these magnified pictures in perfect relief, and it can be examined by several persons at once.

The apparatus must be placed in a dark room, and the light of a window or lamp is admitted only through the openings of the pictures, if they are transparent views on glass, which are the best suited to the experiment. Views on paper, on silver plates, or positives on glass, requiring to be lighted by reflection, would necessitate a more complicated apparatus, and for this reason it is preferable to confine the stereomonoscope to the exhibition of transparent pictures, which can be easily lighted by transmitted light.

Fig. 14 represents the arrangement of the lenses A, A′, and pictures B, B′, by which the pictures coincide in one at C. Fig. 15 is a view of the whole apparatus. DD DD, is the camera, and EE EE, a sliding frame containing the pictures, by which they can be placed before the lenses at the distance required for the size of the compound image on the ground glass, which is fixed on a box sliding in the camera for the adjustment of the focal distance.

In order to understand the theory of the stereoscope, the reader must be acquainted with the phenomena and theory of binocular vision, in which we obtain single vision with two eyes, and see objects in relief, or differences in distance from flat pictures upon the retina.

Stereoscope.

Theory of the stereoscope.

1. In all stereoscopic slides or double pictures, viewed

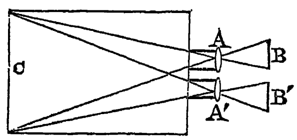

Fig. 14.

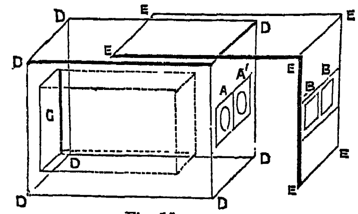

Fig. 15.

in the stereoscope, the left-hand picture, when rightly taken, which it seldom is, is a correct representation of an object as seen with the left eye, and the right-hand picture a correct representation of it as seen by the right eye; or they are correct drawings of the object as taken by the rules of perspective, from two points whose distance is 2½ inches, or that of the two eyes. These two pictures, though almost perfectly similar to one another, are essentially different; and if the one was laid upon the other, so that any one point of the one, the tip of the nose, for example, coincided with a similar point in the other, no other points in the two pictures would coincide.

2. When we look at a solid object—at a marble bust, for example—the tip of the nose, the eye, and the ear, are at different distances from the observer's eyes. When we see distinctly the tip of the nose, we see it single, and the eye and the ear are seen indistinctly and double. We see, in short, only one point of any object distinct and single, and when we thus see it, the optic axes, as they are called, or lines passing through the centre of the pupil and the centre of the crystalline lens, are converged upon or meet at that point, and the visible distance of the point thus viewed is the distance of the point of convergence of the optic axis from the eye. Although we cannot see distinctly and singly the nose, the eye, and the ear at the same moment, yet such is the rapidity with which the two eyes converge their optic axes upon each of these points in succession, and upon every other point in succession, that every point of the bust is seen distinctly and singly, and at the distance corresponding to the distance of the point of convergence. The bust is, therefore, seen in relief.

3. We have already seen that the stereoscope simply displaces each picture, carrying the left-eye one to the right, and the right-eye one to the left, and laying the one above the other at a point half-way between each. *It does nothing more*, the stereoscopic effect, or the relief, being produced solely by the movements of the two eyes.

If the refractive displacement of the two pictures has been such as to unite the two corresponding points at the tip of the nose, whose distance we call 2·4 inches, it will not have united the two corresponding points in the two eyes, the distance of which we may suppose to be 2·5 inches; and still less will it have united the two corresponding points at the tip of the ear, which we may suppose to be 2·6 inches, the eye and the ear points being respectively *one-tenth* and *two-tenths* of an inch distant.

When the two pictures thus combined by the lenses are viewed with both eyes, the tip of the nose will be seen distinctly at the distance of the point of convergence. The eyes will instantly, by means of their power of convergence, unite the separated points of the eyes, and then the still more separated points of the ears, running over every part of the bust with the rapidity of lightning, and uniting all the corresponding points in succession, precisely as it does in looking at the bust itself. The effect thus described may be represented as in fig. 16, where the points R, L

Stereoscope.

represent the two corresponding points in the *nose* united by the lenses; L′R′ the corresponding points of the *eye* not united, but distant $\frac{1}{10}$th of an inch; and L″R″ the corresponding points of the *ear* not united, but distant $\frac{2}{10}$ths of an inch.

When the corresponding points united by the lenses are those of the *eye*, 2·5 inches distant, the effect upon the other points of the bust will be as shown in fig. 17, where

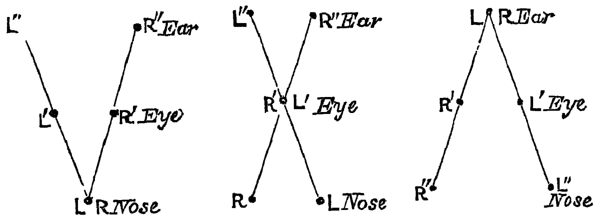

Fig. 16. Fig. 17. Fig. 18.

R′L′ are the *eye* points united; R″L″ the *ear* points brought nearer by $\frac{1}{10}$th of an inch, but still $\frac{1}{10}$th distant; and RL the *nose* points, the right-eye point having passed the left-eye point by $\frac{1}{10}$th of an inch.

When the corresponding points united by the lenses are those of the *ear*, the effect upon the other points of the bust will be as in fig. 18, where R″L″ are the *ear* points united; R′L′ the eye points, distant $\frac{1}{10}$th of an inch, the two having passed one another; and RL the nose points, distant $\frac{2}{10}$ths of an inch, having passed one another still farther.

Now, in all these cases the points L″R″, L′R′ (fig. 16), R″L″ (fig. 17), where L and R have not come up to one another, will be united by the eyes directing their axes to a point beyond the plane of the picture; while the points RL (fig. 17), and R′L′, R″L″ (fig. 18), which have passed one another, will be united by the eyes directing their axes to a point nearer the eye than the plane of the picture.

By whatever means the two pictures are laid upon one another,—whether by the straining of the eyes—directing their axes to points beyond the picture, or between the picture and the eye; by reflexion from mirrors or prisms, or by the refraction of prisms or lenses,—the relief, or stereoscopic effect, is produced in the manner we have now explained.

This theory of the stereoscope, or rather this explanation of the production of relief by the union of two dissimilar pictures, was first given by Sir David Brewster in the *Transactions of the Royal Society of Edinburgh*,[1] where he has pointed out the incorrectness of the explanation given by Mr Wheatstone.[2]

Method of taking stereoscopic pictures.

As no artist, however skilful, is capable of executing two pictures of any individual object, or group of objects, as they are seen by each eye separately, the stereoscope was of little value before the art of photography enabled us to take such pictures with the most perfect accuracy. If these pictures are not perfectly correct when taken upon a plane surface, their incorrectness, when combined so as to reproduce the object in relief, must be increased. In the exercise of the stereoscopic art, therefore, we must ascertain what is a true representation, of a statue for example, as seen with one eye through a pupil $\frac{1}{8}$th of an inch in diameter. It is doubtless a photograph taken with a lens $\frac{1}{8}$th of an inch in diameter. Every larger lens will give a photograph showing parts of the statue not visible to the eye, and consisting of a number of incoincident pictures as seen from every point of the lens.[3] But notwithstanding this defect, the artist is obliged to use a larger lens than this, in order to accelerate the process; but it is to be hoped that more sensitive materials may soon enable him to use a lens of the smallest size, and thus obtain perfectly correct right and left eye pictures. With the large lenses now in use, 2, 3, and even 4 inches in diameter, no correct stereoscopic pictures can be obtained.

But the right and left eye pictures must not only be taken with apertures as nearly as possible equal to that of the pupil, they must be taken by apertures placed at the same distance as that of the two pupils, that is, at the distance of $2\frac{1}{2}$ inches. All pictures taken otherwise are false, incorrect, and out of all accurate proportion. With this essential property, the stereoscopic camera cannot have lenses more than $2\frac{1}{2}$ inches in diameter, for they would just touch one another when of this size. With this information, we are now prepared to describe the binocular camera.

Binocular camera.

The camera must consist of two perfectly similar lenses, in order to give two pictures of the same size; but as it is difficult for the most skilful optician to make two lenses of the same focal length and magnifying power, Sir David Brewster, who was the first to describe a binocular camera, proposed to construct it of achromatic semi-lenses, that is, of an achromatic lens cut in two, and so placed that the distance of the centres of the apertures may be $2\frac{1}{2}$ inches.

Several of these cameras were made in London, and give the most perfect stereoscopic photographs; but professional artists have not found it their interest either to use small lenses, to make each single photograph as perfect as possible, or to place lenses at the distance of $2\frac{1}{2}$ inches, in order to combine these pictures into proper relief. Their object has been to use lenses of such a size as to make the time of taking the picture as short as possible, and produce a startling degree of relief by placing the lenses at great distances. Although these stereoscopic pictures may please persons of neither taste nor judgment, yet they are most incorrect representations of nature, which men of science instantly discover. In all stereoscopic pictures taken at angles above that which corresponds to a distance of $2\frac{1}{2}$ inches, the distances are all drawn out, as it were. A street is made twice as long; and all buildings or objects stretching from the eye are enormously increased in length. The head of a portrait is drawn forward from the neck, and the dress of a lady is made to project forward from her bust.

As every artist places his lenses at the distance he pleases, and as very few employ the proper distance, the thousands of stereoscopic photographs, nay, the millions now circulating in Europe, have no real artistic or geometrical value. If we knew for certain that the distance of the lenses employed were correctly $2\frac{1}{2}$ inches, or even if we knew that it was 4, 6, 8, or 10 inches, we could deduce from each pair of pictures, by nice micrometrical measures, the actual forms of the statue or person, or building or landscape, which it represents, as the actual distances of the corresponding points in the two pictures would thus give us a measure of the distances of these parts from the eye; the distance between the tips of the nose, for example, and the points of the ears, and the pupils of the eyes, being measures of the distances of these points from any plane perpendicular to the eye, provided the distance of the lenses was known. A sculptor could thus obtain, even from one stereoscopic photograph, assistance in modelling a bust, and a surveyor might make an approximate plan of a landscape from even one correct stereoscopic representation of it.[4]

A very great improvement in the art of taking single as well as binocular photographs has been made by Mr Thomas

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1 Vol. 15, p. 349, 1843, or *Phil. Magazine*, vol. xxv., pp. 356, 479, May and June 1844.

2 This is demonstrated in a more popular manner in Sir D. Brewster's *Treatise on the Stereoscope*, chap. v.

3 See our art. OPTICS, vol. xvi.

4 For further information on this subject, see Sir David Brewster's *Treatise on the Stereoscope*, chap. viii.

Skaife, Vanbrugh House, Blackheath, the only artist who has carried out the views of Sir David Brewster, as given in his address to the Photographic Society of Edinburgh.[1] In the instrument which he has invented for this purpose, and which he calls a *Pistolograph*, he uses lenses only an inch in diameter, the focal length of the combination being also an inch. The lens-tube, ABCD, of the pistolograph, as shown of its real size in the annexed figure, in which AB is the front and BC the back, LL a cemented achromatic lens of flint and crown glass, and *l l* an uncemented one, differing only from the ordinary portrait-back combination in being ground—that when the two lenses of which it is composed are together, they touch only at the margin of their inner surfaces. The solar focus of the combined lenses is $1\frac{1}{2}$ inches behind the right-hand surface of the lens *l l*.

Mr Skaife's pistolograph.

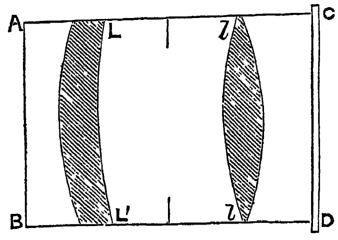

Fig. 19.

Owing to the small size of this instrument, and the small thickness of the glass through which the light passes, the actinic rays are so powerful that the photograph is taken almost instantaneously, and portraits are not deformed by the errors occasioned by the use of large lenses.[2] The small pictures, or pistolograms, as Mr Skaife calls them, when not used for rings, lockets, or bracelets, may be magnified by the enlarging camera without losing any of their sharpness.

The pictures thus obtained are enclosed between two plates of glass, "and when subjected for a definite time to a heat short of that which is required to melt glass, the three substances form but one, as hard and homogeneous as a single piece of crystal." To the picture thus enclosed and preserved from the air, Mr Skaife gives the name of Chromo-crystal. Some of those which we have seen are extremely beautiful.[3]

Mr Macraw's improvement.

A very ingenious improvement upon the binocular camera has been made by Mr Macraw, of Edinburgh, by which he can take two pairs of stereoscopic pictures upon a prepared plate, which of course must be double the length required for a single pair of pictures. For this purpose the prepared plate is inserted in an inner frame AB, which slips in a

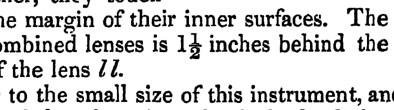

Fig. 20.

groove in the outer rim of the slide MN, with room at CD equal to one of the four spaces, 1, 2, 3, 4, of the plate. When the plate is placed as in the figure, the spaces 2, 4, are opposite the lenses, and receive the picture; and when AB is pushed up to N, the spaces 1, 3, will be opposite the lenses, and receive the second picture. (D. B.)

STEREOTYPE. See PRINTING.

STERLING, JOHN, a man whose reputation will rest henceforth much more on the fact of his having had Thomas Carlyle for his biographer than on any high merit of his own, was born at Kaimes Castle, Isle of Bute, Scotland, on the 20th July 1806. His father, Edward Sterling, originally from the county Waterford, in Ireland, but of Scottish descent, who had been educated for the Irish bar, but who had subsequently taken to soldiering, was now located among the shaggy mountains and sunny mists of Bute, as a sort of gentleman-farmer; and who became afterwards co-proprietor and chief editor of the *Times* newspaper. His mother, Hester Coningham, a native of Londonderry, and likewise of Scottish origin, was a beautiful, delicate, pious woman, from whom Sterling inherited the "delicate aroma" of his nature. He was the second child of seven, five of whom died while he was still a youth. In 1809, the Sterling family moved south to Llanblethian, in Wales. Here Edward Sterling began to write letters to the *Times*, when his interest in politics induced him to remove his family to Paris during the peace of 1814. Driven from the French capital next year by the return of Napoleon from Elba, he settled down with his family in London, and engaged in the profession of journalism. This brave, blustering, noisy individual, whom Carlyle was accustomed to call "Captain Whirlwind," has been thus graphically delineated by the same hand. "He was broad, well built, stout of stature; had a long, lowish head, sharp grey eyes, with large, strong aquiline face to match; and walked or sat in an erect decisive manner. A remarkable man." After having attended various schools in London or the neighbourhood, John Sterling was sent, when he was turned of sixteen, to the University of Glasgow, whence he was removed next year to Trinity College, Cambridge. He did not distinguish himself as a scholar in any particular branch while he resided at Cambridge, but under the tutorship of Julius C. Hare (subsequently Archdeacon of Lewes), he made very considerable progress, and displayed a quick, keen, piercing intellect, and great nobility of character. He particularly shone in connection with the Union Debating Club of Cambridge, of which Maurice, Trench, Spedding, J. M. Kemble, Venables, Charles Buller, and Monckton Milnes, were members. It is reported of Sterling, that he was the acknowledged chief of this club in all matters pertaining to speaking and arguing. Sterling left Cambridge without having taken his degree, and joined his friend Maurice in the intention of studying law. These two aspiring youths, in 1828, became possessors of the *Athenæum*, which they laboured hard to write into public favour, but the enterprise did not succeed, and the journal came into the hands of the present proprietor. Sterling about this period gained the friendship of Coleridge, whose influence over his mind was great and abiding, as Sterling's novel of *Arthur Coningsby* still testifies. Regarding this, his first regular contribution to literature, Carlyle remarks—

Sterling.

"It was in the sunny days, perhaps in May or June of this year, (1833), that *Arthur Coningsby* reached my own hand, far off amid the heathy wildernesses; sent by John Mill: and I can still recollect the pleasant little episode it made in my solitude there. The general impression it left on me, which has never since been renewed by a second reading in whole or in part, was the certain prefigurement to myself, more or less distinct, of an opulent, genial, and sunny mind, but misdirected, disappointed, experienced in misery;—nay crude and hasty; mistaking for a solid outcome from its woes what was only to me a gilded vacuity. The hero an ardent youth, representing Sterling himself, plunges into life such as we now have it in these anarchic times, with the radical, utilitarian, or mutinous heathen theory, which is the readiest for inquiring souls; finds, by various courses of adventure, utter shipwreck in this; lies broken, very wretched: that is the tragic nodus, or apogee of his life-course. In this mood of mind, he clutches desperately towards some new method (recognisable as Coleridge's) of laying hand again on the old Church, which has hitherto been extraneous and as if non-extant to his way of thought; makes out, by some Coleridgean legerdemain, that there actually is still a Church for him; that this extant Church, which he long took for an extinct shadow, is not such, but a substance; upon which he can anchor himself amid the storms of fate;—and he does so, even takingorders in it, I think. Such could by no means seem to me the true or tenable solution. Here clearly, struggling amid the tumults, was a loveable young fellow-soul; who had by no means yet got to land; but of whom much might be hoped, if he ever did. Some of the delineations are highly pictorial, flooded with a deep

[1] *Journal of the Photographic Society*, vol. iv., p. 83.

[2] We could recommend the use of smaller lenses of rock crystal. (See *Treatise on the Stereoscope*, pp. 138–140.)

[3] See *Instantaneous Photography, including Practical Instructions on the Manipulation of the Pistolograph*, by T. Skaife, Greenwich, 1860.

ruddy effulgence; betokening much wealth, in the crude or the ripe state."

Sterling's means did not compel him to adopt a profession, and from the nature of his talents, which were airy, graceful, and light-flowing; and from slight symptoms of pulmonary disease, he was withheld from binding himself down to any form of steady labour. He married in November 1830, and, taking suddenly ill shortly afterwards, he was forced to seek a more genial climate than England afforded. He accordingly started for the Island of St Vincent in the West Indies, where part of a valuable sugar estate had been bequeathed to him by a maternal uncle. Returning again to England in August 1832, he resolved to make a short tour in Germany. Chancing to meet his old tutor, the Rev. Julius C. Hare, at Bonn, he was persuaded to enter the English Church, and he was accordingly ordained deacon at Chichester in 1834, and immediately afterwards became curate of Herstmonceaux in Sussex, where his friend Hare was rector. Sterling remained in the Church for eight months, when, on the plea of ill health, he gave up his curacy, and possibly from some radical change in his opinions, real or imaginary, bade good-bye to the Church for ever.

Going to London in February 1835, he chanced to meet Thomas Carlyle for the first time, who had settled in London the previous summer. Carlyle describes Sterling as he then appeared, as follows: "A loose, careless-looking, thin figure, in careless dim costume, sat in a lounging posture, carelessly and copiously talking. I was struck with the kindly but restless, swift-glancing eyes, which looked as if the spirits were all out coursing like a pack of merry eager beagles, beating every bush. The brow rather sloping in form, was not of imposing character, though, again, the head was longish, which is always the best sign of intellect; the physiognomy in general indicated animation rather than strength." From this time Carlyle began to occupy the place of Mentor to Sterling, which had been so long held by Coleridge. Art, as Carlyle has remarked, was Sterling's *forte*, and not devotion in any form. Literature was henceforward his chief pursuit. His exceedingly precarious state of health caused him to lead a nomadic kind of life, which alternated between London and some warmer climate. In 1836 he went to the south of France; next year to Madeira, which he revisited again in 1840. Part of 1838 and 1839 he spent in Italy, and on his return to England he sought Clifton, and ultimately Falmouth. Carlyle, in his *Life of John Sterling*, says,—

"Sterling's bodily disease was the expression, under physical conditions, of the too vehement life which, under the moral, the intellectual, and other aspects, incessantly struggled within him. Too vehement;—which would have required a frame of oak and iron to contain it: in a thin though most wiry body of flesh and bone, it incessantly "wore holes," and so found outlet for itself. He could take no rest, he had never learned that art; he was, as we often reproached him, fatally incapable of sitting still. Rapidity, as of pulsing auroras, as of dancing lightnings; rapidity in all forms characterised him. This, which was his bane, in many senses, being the real origin of his disorder, and of such continual necessity to move and change,—was also his antidote, so far as antidote there might be; enabling him to love change, and to snatch, as few others could have done, from the waste chaotic years, all tumbled into ruin by incessant change, what hours and minutes of available turned up."

Sterling had meanwhile contributed to *Blackwood's Magazine* and to the *Westminster Review*, then under the charge of John Stuart Mill. "He had," says Carlyle, "an incredible facility of labour. He flashed with most piercing glance into a subject; gathered it up into organic utterability with truly wonderful despatch, considering the success and truth attained, and threw it on paper with a swift felicity, ingenuity, brilliancy, and general excellence, of which, under such conditions of swiftness, I have never seen a parallel." In order to meet a number of his literary friends on occasion of his hasty visits to London, the "Sterling Club" was formed, of which Carlyle, J. C. Hare, G. C. Lewis, John S. Mill, Tennyson, and others, were members. In 1839 he published a small volume of poems, which were almost ignored by the public, and in 1841 he again tried it with the *Election, a Poem in seven books.* In 1843 he published *Strafford, a Tragedy.* He had the great affliction during the same year to lose both his mother and his wife, who died within two hours of each other.

"If Sterling," says Carlyle, "has done little in literature, we may ask, What other man than he, in such circumstances, could have done anything? In virtue of these rapid faculties, which otherwise cost him so dear, he has built together, out of those wavering boiling quicksands of his few later years, a result which may justly surprise us. There is actually some result in those poor two volumes gathered from him, such as they are; he that reads there will not wholly lose his time, nor rise with a malison instead of a blessing on the writer. Here actually is a real seer-glance, of some compass, into the world of our day; blessed glance, once more, of an eye that is human; truer than one of a thousand, and beautifully capable of making others see with it. I have known considerable temporary reputations gained, considerable piles of temporary guineas, with loud reviewing and the like to match, on a far less basis than lies in those two volumes. Those also, I expect, will be held in memory by the world, one way or other, till the world has extracted all its benefit from them. Graceful, ingenious, and illuminative reading, of their sort, for all manner of inquiring souls. A little verdant flowery island of poetic intellect, of melodious human verity; sunlit island founded on the rocks;—which the enormous circumambient continents of mown reedgrass and floating lumber, with *their* mountain-ranges of ejected stable-litter however alpine, cannot by any means or chance submerge: nay, I expect, they will not even quite hide it, this modest little island, from the well-discerning; but will float past it towards the place appointed for them, and leave said island standing."

He was engaged during his last days on another poem, entitled *Cœur de Lion*, which he did not survive to complete. Sterling died at Ventnor, in the Isle of Wight, on the 18th September 1844, aged thirty-eight years.

Carlyle has the following remarks on Sterling's general appearance and manner:—

"Sterling was of rather slim but well-boned wiry figure, perhaps an inch or two from six feet in height; of blonde complexion, without colour, yet not pale or sickly; dark-blonde hair, copious enough, which he usually wore short. The general aspect of him indicated freedom, perfect spontaneity, with a certain careless natural grace. In his apparel, you could notice, he affected dim colours, easy shapes; cleanly always, yet even in this not fastidious or conspicuous: he sat or stood, oftenest, in loose sloping postures; walked with long strides, body carelessly bent, head flung eagerly forward, right hand perhaps grasping a cane, and rather by the middle to swing it, than by the end to use it otherwise. An attitude of frank, cheerful impetuosity, of hopeful speed, and alacrity; which indeed his physiognomy, on all sides of it, offered as the chief expression. Alacrity, velocity, joyous ardour, dwelt in the eyes too, which were of brownish gray, full of bright kindly life, rapid and frank rather than deep or strong. A smile, half of kindly impatience, half of real mirth, often sat on his face."

To Archdeacon Hare and Thomas Carlyle were committed the care of Sterling's literary character and printed writings. In 1848 appeared accordingly *Essays and Tales*, in two vols., by John Sterling, with a memoir prefixed by Archdeacon Hare. This biography had the misfortune to represent merely the character of Sterling as a clergyman; and Carlyle, who had loved the man with all the depth and fervour of no ordinary nature, resolved to re-write his biography, taking care to present Sterling in something like the human aspect which he wore among men. This work was published in one vol. in 1851. It is perhaps the greatest biographical achievement of this century.

STERNBERG, a town of the Austrian Empire, Moravia, in the circle and 10 miles N.N.E. of Olmütz. It is for the most part well built; and has an old castle of the princes of Liechtenstein, a church, Augustinian convent, military school, &c. Cotton and hosiery are manufactured here; and

as the town stands at the junction of several roads, there is a considerable trade, chiefly in linen. Pop. 12,400.

STERNE, LAURENCE, an eminent writer of fiction, has left behind him a sketch of the principal events of his life, and some particulars of his family history. From that outline it appears that he was born at Clonmel, in the south of Ireland, on the 24th November 1713. His father was a lieutenant in the army, and grandson of Dr Richard Sterne, archbishop of York. When his son was about eight years of age, Lieutenant Sterne placed him at a school in Halifax, to which town he had been conducted by his professional duties. That officer died in 1731, and in the following year, young Sterne, by the bounty of a relation and namesake of his own, was transferred from the school of Halifax to Jesus College, Cambridge. Having completed his studies at the university, he proceeded to York; and his uncle, Dr Jacques Sterne, prebendary of Durham, and canon residentiary and precentor of York, procured him the living of Sutton, and afterwards a prebend at York. At York he formed an acquaintance with the lady who afterwards became his wife, under circumstances sufficiently romantic. From a friend of hers he obtained the living of Stillington, but continued for twenty years to reside at Sutton, relieving the burden of his double charge, as he informs us, "by books, painting, fiddling, and shooting." In the library of Shelton Castle, the residence of his friend and relation, John Hall Stevenson, author of a licentious production, entitled *Crazy Tales*, Sterne found among the dross of antiquity many a brilliant gem, which he transferred without scruple to his own pages. In this stolen garb he cut a most imposing figure, until Dr Ferriar of Manchester, twenty years after the death of the celebrated plagiary, restored the pilfered trappings to the rightful owners. (See Dr Ferriar's *Illustrations of Sterne*, Lond., 1790, 8vo.)

In 1759, Sterne produced the first two volumes of *Tristram Shandy*, which procured him both money and reputation. In these volumes there was abundance of matter which every one could relish; and what was unintelligible was thought profound. Much ingenious speculation was squandered upon the black leaves and marbled pages, which were long contemplated with wonder, before they were discovered to mean nothing. "The republic of dark authors," says Swift, "have been peculiarly happy in the variety, as well as extent, of their reputation." Before this period Sterne had only printed two sermons. The two volumes of *Tristram Shandy* were succeeded by two volumes of *Sermons*. In 1761 appeared the third and fourth volumes of the novel, and the fifth and sixth in the year following. The seventh and eighth volumes were published in 1765; but these monstrous births had by that time ceased to please. Four volumes of *Sermons* were produced in 1766; and in 1767 these were followed by the ninth and last volume of *Tristram Shandy*. In 1768 Sterne returned from Italy, whither he had repaired in the hopes of finding relief for a consumptive complaint with which he had long been afflicted. He only survived to prepare for the press the first part of his *Sentimental Journey*, which was published in 1768. In the month of March of that year he expired at his lodgings in Bond Street, surrounded by strangers, a mode of death which he considered as most desirable.

The English writer to whom the author of *Tristram Shandy* is most indebted for his matter is Burton; and his manner bears some resemblance to the capricious, whimsical, and digressive *Tale of a Tub*. He even mimics Swift in sneering at "the great Dryden;" but in the writings of his prototype he might have found many things infinitely more worthy of imitation. In order to make room for his pathos, however, he eschewed the misanthropy of the dean of St Patrick's, and set up for a lover of his species, to which character his claims were less than equivocal, for his philanthropy did not extend so far as to his own mother. That sensibility is worthy only of ridicule that bestows a tear with greater promptitude than a shilling.

The humour of Swift and Rabelais, whom Sterne pretended to succeed, came from them as naturally as song from a bird; they lose nothing of their manly dignity in laughing their great laugh as nature bade them. But Sterne, who can make you laugh and cry by turns, who will not permit you any repose, he is but a great jester rather than a great humourist. Yet, nevertheless, a critic who refuses to see in many charming descriptions of Sterne's, wit, humour, pathos, and sometimes even real sentiment, must be hard to please. If the last words the famous author wrote were bad and wicked, the last words written by the stricken man were for pity and pardon.

STERNHOLD, THOMAS, was born in Hampshire towards the latter half of the fifteenth century. He had his education at Oxford, was chosen groom of the robes to Henry VIII. and retained the same office under his successor, and died in August 1549.

Sternhold's only claim to distinction is his having executed part of an English metrical version of the Psalms usually attached to the Book of Common Prayer, and characterized by all the bad taste and vulgar bathos of a street-ballad. His version of fifty-one of the Psalms was published after his death in 1549, and bore the title of, *All such Psalm of David as Thomas Sternholde did in his Lyfe drawe into English Metre*, 8vo, London. Sternhold was likewise the author of *Certain Chapters of the Proverbs of Solomon* drawen into metre, 8vo, London, 1549. Sternhold found even a ruder hand than his own to continue the metrical labour which he had begun. The edition of Sternhold and Hopkins appeared in 1562 with the title of *The whole Booke of Psalmes, collected into English metre*. As Campbell observes, in his *Specimens of English Poetry*, these men, "with the best intentions and the worst taste, degraded the spirit of Hebrew Psalmody by flat and homely phraseology, and, mistaking vulgarity for simplicity, turned into bathos what they found sublime." (See also Warton's *History of English Poetry*, vol. iii., edition of 1840.)

STESICHORUS (Στησίχορος), a famous Greek poet, said to have been born in Himera in Sicily B.C. 632. He was accordingly a contemporary of Sappho, Alcæus, Pittacus, and Phalaris. His father was probably a native of Mataurus, which would go far to explain the tradition of his being sprung from Hesiod, for it is well known that in that district there lived a race of epic poets who claimed kindred with the most ancient singer of Greece. The name which this poet is said first to have received was Tisias, and afterwards it was converted into Stesichorus, from his first having established a chorus for singing to the harp. Like all great poets his birth is said to have been accompanied by an omen. A nightingale is said to have sat upon the babe's lips and sung. Little is known regarding his life with certainty. The myths of Suidas unfortunately render the authentic portion of his narrative quite untrustworthy. Stesichorus probably died at Catanna sometime between 560 B.C. and 552 B.C., at the age of eighty, or, probably, eighty-five. He was one of the nine great lyric poets recognised by the ancients. His choral odes contained all the essential elements of perfect choral poetry. He was the first to break the monotony of the strophe and antistrophe, by the introduction of the epode. Kleine, who has furnished by far the most useful edition of the fragments of Stesichorus (Berolini, 1828), has classified his extant poems into mythical poems, hymns, erotic poems, pastoral poems, fables, and elegies. The fragments of Stesichorus were first printed together with the works of Pindar in 1560. Among recent editions are those of Suchfort, Schneidewin, Bergk, Blomfield, and Gaisford.

STETHOSCOPE, a wooden cylinder about eighteen inches long, invented by M. Laennec of Paris in 1823, and used by modern medical practitioners to ascertain the healthy or morbid condition of the organs within the chest. It is well known that wood is an excellent conductor of the vibrations that give the sensation of sound, and that, if a person scratch one end of a log of wood many yards in length, another person, by putting his ear to the other extremity, will distinctly hear every sound emitted. On this principle, the stethoscope has been invented. It is now frequently made of gutta-percha. The heart, by its violent and incessant action, imparts a motion and thrilling to the walls of the chest, which an observer can loudly hear by applying the ear to the left side; and the Stethoscope enables him to obtain the same information, with less trouble to the patient, and without anything disagreeable to the most delicate feelings. Hence, those who are well practised in the use of the stethoscope, and who have compared their observations on the living body with the appearances found in the dead bodies of those who have died of diseases of the heart, are enabled to detect enlargement of that organ, ossification of its valves, or aneurism of the great vessels. In diseases of the lungs, likewise, and even of the abdominal viscera, the stethoscope is a most valuable means of diagnosis.

STETTIN, a fortified town of the Prussian dominions, capital of the province of Pomerania, on the left bank of the Oder, which is here crossed by two bridges, leading to the suburb of Lastadie on the other side, 78 miles N.E. of Berlin. Immediately below the town the Oder expands into the wide lake of Stettin, through which it falls into the Baltic. The fortifications of the town are strong, and include part of the suburbs across the river. They are entered by five principal and several smaller gates; two of the former, the King's Gate and the Berlin Gate, are richly adorned with emblematical figures, and are among the finest structures of the kind in Germany. The town is old, and in general well built, containing several large and handsome squares. The public buildings, however, are not very conspicuous or remarkable. Among these, the most important is the ancient castle, which was the residence of the Dukes of Pomerania from 1575 till the line became extinct in 1637. In the chapel of the castle is the ducal vault. The castle contains a collection of northern antiquities, now in course of formation, and has a lofty tower which commands a fine prospect over the town and neighbourhood. In one of the public squares of Stettin stands a fine marble statue of Frederick the Great, and another of Frederick William III. of the same material. The town-hall, exchange, and theatre are among the chief edifices of the town. Its churches are not very noteworthy, if we except the massive and venerable St James', which occupies a conspicuous position on a hill near the centre of the town. The oldest part of this building goes back as far as the 13th century. The other Protestant churches are four in number, and there is one belonging to the Roman Catholics. Stettin is the see of a bishop, and has a court of law and public offices. There is a gymnasium, with a library, museum, and observatory attached to it, several other schools of various kinds, a workhouse, hospitals, and other benevolent institutions. The manufactures of the town are very extensive, including linen, woollen, and cotton cloth, canvas, leather, hosiery, hats, soap, tobacco, beer, and sugar. Ships and boats are also built here, and ship's anchors are forged for all the vessels of the Prussian states. The trade of Stettin is great and rapidly increasing. It is not only one of the chief ports of Prussia, but at the same time the most important commercial town on the shores of the Baltic. The following table exhibits the quantities and values of the principal articles exported and imported at Stettin in the year 1854:—

Articles.	Imports.		Exports.	
	Quantity	Value.	Quantity.	Value.
		L.		L.
Bones.....................(cwt.)	...	...	60,871	136,809
Coffee.................... „	56,942	290,404	...	...
Grain, of diff. kinds (bushels)	503,590	101,074	1,854,340	554,201
Herrings..............(barrels)	140,740	188,999	...	...
Iron of all kinds.........(cwt.)	451,896	184,051	797	703
Oil of different kinds and oil-cakes............(cwt.)	232,258	689,480	45,629	28,171
Rice.................... „	151,815	158,105	...	...
Wine.................... „	104,584	251,001	...	...
Wood.................... „	2,738	2,053	...	306,653

And the total value of the exports and imports for each year from 1850 to 1854 was as follows:—

	1850.	1851.	1852.	1853.	1854.
	L.	L.	L.	L.	L.
Imports	2,070,123	1,724,487	1,956,946	2,697,143	2,459,160
Exports	1,023,980	1,205,895	1,324,522	1,872,403	1,314,310

The total number of vessels, exclusive of those in the coasting trade, that entered at the port in 1852 was 720, tonnage, 150,404; and of those that cleared in the same year the number was 723, and the tonnage 160,148. Stettin is a place of great antiquity. It owes its origin to a Wendish castle, and as early as 830 there was a considerable village on the spot. In those early ages a temple of the Wendish idol Trigloff, which stood here, was several times destroyed and rebuilt again, while Christianity and Paganism by turns got the upper hand in their struggle for the country, and when Christianity was finally introduced, about the beginning of the 13th century, immense treasures of gold, silver, and precious stones were found stored up in it. The town shared in the vicissitudes of this part of Pomerania, which are narrated in the article POMERANIA, belonging at one time to Denmark, at another to Sweden, and finally to Prussia. Two Russian empresses, Catherine the Great, and Maria Feoderowna, wife of Paul the successor of Catherine, were born here. Pop. (1858) 53,103.

STEUBENVILLE, a town of the United States of North America, capital of Jefferson county, in the state of Ohio, on the Ohio, 35 miles W. by S. of Pittsburg. It occupies an elevated position, in the midst of a beautiful country, and contains county buildings, numerous churches, an academy and a school, two banks, and several newspaper offices. The manufactures of the town are extensive, including woollen and cotton fabrics, paper, glass, machinery, &c. There are also several iron-foundries and flour-mills. The whole manufactories employ more than 1000 hands. Pop. (1850) 6139.

STEVENSON, ROBERT, an eminent civil engineer, was born at Glasgow in 1772, and died at Edinburgh in 1850. The death of his father, a West India merchant, left him while yet an infant in very disadvantageous circumstances; but, by the energy and self-denial of his mother, who had designed her only child for the church, he obtained a good education, and acquired some tincture of classical learning. The bent of his mind, however, was decidedly towards the physical sciences; and having early imbibed an enthusiastic admiration of Smeaton, which he retained through life, he resolved to follow the profession of a *civil engineer*. In spite of many discouragements, which he bore with hopefulness and patience, he succeeded in prosecuting his studies, first in the Andersonian Institution, then recently opened at Glasgow, and afterwards at the University of Edinburgh, under Robison, Dugald Stewart, and Playfair. In 1797 he became engineer to the Board of Northern Lighthouses, an office which he

held for nearly half a century; and during his incumbency, he erected no fewer than *twenty-three* lighthouses, including that of the Bell Rock, which alone is sufficient to stamp his reputation as an engineer. Some description of this remarkable rock will be found under the head LIGHTHOUSES, and it is not needful, in this place, to do more than say that Mr Stevenson displayed, in its design and execution, great mechanical skill and practical sagacity, as well as untiring perseverance and indomitable courage. Following the model of the Eddystone, which he greatly revered, he yet made some important improvements in framing his own design, and in particular he succeeded in converting the floors of the apartments, whose outward disruptive thrust, Smeaton had contrived to counteract by an ingenious expedient, into really conservative bonds or ties for the whole edifice. He also greatly improved the optical and mechanical arrangements of the lighthouses, and added some valuable distinctions, especially the *flashing* and *intermittent* lights, for enabling the mariner to identify the lights on a coast.

In the course of his general practice as a civil engineer, he designed and executed many important works in various parts of the United Kingdom, and among others bridges at Glasgow and Stirling. The fine approach to the city of Edinburgh by the Calton Hill was also designed by him and formed under his eye. He traced and designed the lines of many canals and railways, which have since been executed much in accordance with the recommendations in his numerous printed reports. There is scarcely a harbour or navigable river in Britain about which his advice, which was often also called for in Ireland, was not at some time given. His printed reports and other contributions to the knowledge of engineering extend, when collected, to five thick quarto volumes.

He was not naturally of a scheming turn of mind, yet he occasionally assumed the character of an inventor, as in the case of his ingenious suggestion of a new form of suspension-bridge for small spans, in which, by passing the chains *under* the roadway, the necessity for tall piers is avoided. Several bridges have been executed on this plan. For timber bridges, also, he proposed a simple and beautiful construction of arch, in which the *ring course* consists of layers of thin planks bent to the circular form, and stiffened by means of the vertical frame-work supporting the horizontal beams on which the level roadway rests. This kind of bridge has come into very general use on railways. He is, moreover, entitled to the merit of first having pointed out the advantage of using malleable iron for the rails of our *iron ways*. He also first called attention to the interesting fact which he first detected at the mouth of the Dee, in Aberdeenshire, that even in the case of our small rivers the fresh water they bring down floats for some distance on the surface of the sea before mingling with the salt water. This fact he demonstrated by the use of an instrument which enabled him to take water from any depth and draw it to the surface, unmixed with any of the intermediate fluid.

Robert Stevenson possessed great sagacity, buoyant fortitude, and untiring perseverance; and he was early remarkable for scrupulous punctuality in all his engagements. In private life he was a man of sterling worth, and full, even in his last years, of that genial unselfishness and generosity which in so many men do not outlive their boyhood. His whole mind was elevated by habitual and unobtrusive piety. The remembrance of his early struggles never left him, but seemed to influence him much in his unwearied efforts to forward the progress of young men through life, a duty which he considered as sacred and in which he greatly delighted, and from the prosecution of which no personal inconvenience ever made him swerve. Towards himself he practised something like the old Roman self-denial; and up to the close of his long and laborious life, he would never permit his age to be pleaded as a reason for shrinking from the calls of duty. (A. S.)

STEWARD, an officer appointed in another's stead or place, and always taken for a principal officer within his jurisdiction. Of these there are various kinds. The greatest officer under the crown is the lord high steward of England, whose office was anciently the inheritance of the earls of Leicester, till forfeited by Simon de Montfort to King Henry III. But the power of this officer is so very great, that it has not been judged safe to trust it any longer in the hands of a subject, excepting only for a particular occasion, as to officiate at a coronation, or at the arraignment of a nobleman for high treason or felony. During his office the steward bears a white staff in his hand, and when the trial is ended he breaks the staff, and with it his commission expires. There is likewise a lord-steward of the king's household, who is the chief officer of the king's court, has the care of the king's house, and authority over all the officers and servants of the household except such as belong to the chapel, chamber, and stable. The court of the lord high steward of Great Britain is a court instituted for the trial of peers indicted for treason or felony, or for misprision of either.

STEWART, DUGALD, was born in Edinburgh, 22d November 1753. He was the son of Dr Matthew Stewart, at that time the eminent Professor of Mathematics in the University, and of Marjory, only child of Archibald Stewart of Catrine, writer to the signet in Edinburgh. Mr Stewart's father and grandfather were both clergymen of the Church of Scotland,—the former having been minister of Rothesay for upwards of fifty years, and the latter having held the charge of Roseneath, before his appointment, as the successor of Colin Maclaurin, to the chair of mathematics in the University of Edinburgh.

Mr Stewart received the principal part of his early education at the High School of his native city, where, under the instruction of the celebrated Dr Alexander Adam, he laid the foundation of those classical tastes and accomplishments which he cherished through life, and the influence of which was so strongly marked in the course of his subsequent career as thinker, professor, and author. From the High School, Mr Stewart passed to the University of Edinburgh, where he studied for four sessions, from 1765-66 to 1768-69. The two names which the young student of arts in the metropolitan university of last century heard mentioned with the greatest reverence, and was taught to honour above all others, were Bacon and Newton. The assiduous pursuit of physical and mathematical science, after the manner of the great Restorer of learning and his disciple, was the most notable feature of university life in Edinburgh during the first half of the eighteenth century. This change in the character of the university studies, from the more abstract and technical culture of the preceding century, was chiefly due to the energy and enthusiasm of the three Gregorys and of Colin Maclaurin. The general method of scientific research, by which results so splendid as those of Newton had been achieved, naturally attracted a large share of attention. Accordingly we find that at the period of Mr Stewart's attendance at the university, the character of the Inductive Method formed a special topic in the prelections of the Professor of Natural Philosophy (James Russell), while, in the lectures of the Professors of Logic and Moral Philosophy, the importance of the application of the same method to the Science of Mind was impressively inculcated. By those influences was the youthful mind of Stewart powerfully moulded. He thus naturally imbibed that admiration of the spirit, method, and aims of Bacon, which so strongly predominated through his entire life, intellectual and moral, and at the same time acquired that taste for physical and mathematical science

which he conjoined with his distinctive attachment to reflective studies.

It was, however, in the Logic and Moral Philosophy class-rooms that Mr Stewart found objects of study more immediately congenial to his taste and capacities. John Stevenson, the Professor of Logic, though not an original thinker, was nevertheless a careful and efficient instructor, as has been gratefully commemorated by more than one pupil, who afterwards rose to eminence in life. Stevenson, during Stewart's attendance on his course of lectures, showed the greatness of his mind by candidly giving up, as insufficient and in part erroneous, doctrines which he had inculcated during the greater portion of a long life, when, in his later years, he became convinced, on grounds adduced by another, of their inadequacy,—an exemplification of the philosophical spirit which gained the admiration and lived in the memory of his youthful auditors. The preceptor by whom Mr Stewart was most strongly influenced at this period was doubtless Adam Ferguson, the accomplished Professor of Moral Philosophy. With Ferguson Stewart had much in common. The pupil naturally and cordially sympathised with the admiration of classical antiquity, the fervid eloquence, the liberal political doctrines, and, above all, the lofty and ennobling ethical views, which characterised his instructor. Dr Ferguson, moreover, very early discovered and appreciated the peculiar capacity of his pupil for reflective studies. About this period Mr Stewart appears to have entertained the design of studying for the Church of England. The University of Glasgow then, as at present, afforded facilities to young men of talent and application for pursuing a course of study at Oxford. Stewart accordingly entered that university in 1771-72, partly with a view to the Snell Exhibition, but also, influenced by the recommendation of Ferguson, that he might enjoy the privilege of the prelections of Dr Thomas Reid, whose *Inquiry into the Human Mind* (1764) was already regarded by thinking men as the inauguration of a new epoch in Speculative Philosophy. Reid occupied a chair which had been rendered celebrated by his predecessors, Hutcheson and Adam Smith. Its influence and lustre were destined even more greatly to increase during Reid's professoriate. While powerfully combating the fundamental doctrines of Locke, Berkeley, and Hume, the prelections of Reid were admirably fitted to evoke and regulate the philosophical capacity of his pupils. In a style lucid, simple, and devoid of technicality or much speculative refinement, he inculcated a philosophy of the nature, origin, and bounds of human knowledge, at once independent and restrained, and bearing in all its parts strong traces of that fresh and vigorous reflection, manliness, earnestness, and lofty aim by which he was so eminently characterised. Stewart caught the spirit of his instructor, and intelligently appreciated his philosophical method and purpose. During a long lifetime, consecrated to Philosophy, Stewart nourished that spirit in Scotland, and continued and extended the application of the method with a freshness, power, delicacy, amplitude of learning and illustration, all his own,—evincing that he was no mere inheritor of a dead tradition, but a true disciple, in whose mind principles quickened and grew, until they effloresced in all the fulness and variety of life and beauty.

In 1772, Mr Stewart, at the early age of nineteen, undertook the charge of the mathematical classes in the University of Edinburgh, in room of his father, whose health was beginning to decline. These classes he conducted with marked ability and success. After acting for three years as his father's substitute, he was formally elected conjoint Professor of Mathematics, June 14th 1775. During session 1778-79, Mr Stewart conducted the class of Moral Philosophy, at the urgent request of Professor Ferguson, who had engaged to accompany the American Commissioners as their secretary on their mission to the colonies. Mr Stewart commenced an original course of lectures on Morals after only a week's notice. He was at the same time engaged for three hours daily as Professor of Mathematics, giving during the session a course of lectures on Astronomy for the first time. His brilliant appearances in this new and congenial sphere as a lecturer in Philosophy were long remembered by his auditors. In 1783 he visited Paris for the first time along with his friend, Lord Ancrum, afterwards Marquis of Lothian. On his return to Scotland in the autumn of the same year, he married Helen, daughter of Mr Neil Bannatyne, Glasgow. Mrs Stewart died in 1787, leaving an only child, afterwards Lieutenant-Colonel Matthew Stewart. Mr Stewart again married in 1790 Helen D'Arcy Cranstoun, daughter of the Hon. George Cranstoun, and sister of the Countess Purgstall and of Lord Corehouse. On the resignation of the professorship by Dr Ferguson in 1785, Mr Stewart was transferred from the Chair of Mathematics to that of Moral Philosophy. From his appointment to this chair until his retirement from active academical duty in 1810, Mr Stewart exercised by his teaching alone, without taking into account the concurrent and more general impression made by his published writings, a wide, powerful, and peculiarly elevating and refining influence. Among his students were to be found not only the youth of Scotland, but many, and these of the highest rank, from England. The continent of Europe and America likewise furnished a number of pupils.

The sphere of investigation which Mr Stewart proposed to himself in the Chair of Moral Philosophy was far from being limited by the science of Ethics proper. The ground-plan of his course was a study of the human mind in the totality of its phenomena; or, to use more recent phraseology, the science of General Psychology. With this as a basis, or root, he connected Metaphysics proper, or the science of First Principles; the application of these principles in Natural Theology; Ethics proper; the theory of Taste; Politics, including the theory of Government and Political Economy. As a philosophical lecturer, Stewart must be allowed to have held a high place, though the character of his mind was not severely analytic or abstract. Without habitually offering a definite determination of the questions which he discussed, he had the faculty of unfolding comprehensive fields of thought, and thus of exciting, in a high degree, the intellectual activity of his students. He possessed, moreover, and wielded with the ease of a master, the power of sketching ideals of human life and action, which inspired in many of his youthful hearers an enthusiasm at once so intense and continuous as to influence and mould their whole future character. His mode of lecturing, that of speaking from notes, was well suited to the character of his mind, and to his treatment of philosophical themes. It allowed full scope for the imagination and feelings, and left unimpeded the flow of a versatile and abundant eloquence, which, as occasion required, was graceful, tender, and sublime. "Dugald Stewart," says Lord Cockburn, himself a pupil, "was one of the greatest of didactic orators. Had he lived in ancient times, his memory would have descended to us as that of one of the finest of the old eloquent sages. But his lot was better cast. Flourishing in an age which required all the dignity of morals to counteract the tendencies of physical pursuits and political convulsions, he has exalted the character of his country and generation. No intelligent pupil of his ever ceased to respect philosophy, or was ever false to his principles, without feeling the crime aggravated by the recollection of the morality which Stewart had taught him."

Mr Stewart gave from the beginning of his career as professor lectures on Politics proper, or the Theory of Government, in connection with his course of Moral Philosophy. In the winter of 1800, he commenced a separate

course of lectures on Political Philosophy, which, in addition to Politics proper, embraced also the recent science of Political Economy. In his lectures on Political Economy, Mr Stewart accepts in general the results of the speculations of the French economists and of Adam Smith. He concurs with the economists and Smith in advocating the propriety of allowing the freest scope for individual interest and effort in the matter of trade, and the unrestricted exchange between nations of the varied products of their industry. On this point, indeed, Stewart sought to give to the principles of the *Wealth of Nations* a wider application than their author had allowed; for he maintained against Smith the impolicy of those restrictions known as the navigation laws, which were only finally abolished in 1850. To the political teachings of Stewart, the present generation owes more than it can well appreciate. At a time when the mere discussion of the fundamental principles of Politics and Political Economy was sufficient to excite suspicion of disaffectedness to the interests of the country, and of sympathy with revolutionary tendencies, Stewart had the courage, in his place as a university professor, to canvass those questions, and to seek to inculcate on the intelligent youth of the land opinions of so advanced a character, that they did not meet with general appreciation and acceptance until long after the period of their promulgation.

In March 1792, Mr Stewart gave to the world the first volume of *Elements of the Philosophy of the Human Mind.* This volume was his earliest contribution towards that scheme of a comprehensive delineation of the human mind, which he had proposed to himself as the grand aim of his life. The volume is chiefly psychological; and, after preliminary remarks on the nature, ends, and utility of philosophy, deals with the powers of Knowledge, embracing External Perception, Attention, Conception, the Laws of Association, Memory, and Imagination. At the period of the publication of the first volume of the *Elements*, philosophical speculation, at least in England, was of the lowest sensational school. The theorists in philosophy of that time sought to explain the mental phenomena by the material hypothesis of vibrations and vibratiuncles, and by an exaggerated application of the principle of Association. Nothing, accordingly, could be more opportune than the appearance of the first volume of Mr Stewart's writings at the period in question. In spirit and matter, the kind of thinking which these writings successively exemplified, was fitted to impart an elevated tone to the current speculation and feeling of the age, alike in Psychology, Metaphysics, and Morals.

In 1793 Mr Stewart read before the Royal Society his *Account of the Life and Writings of Adam Smith.* His Memoir of Principal Robertson, and that of Dr Reid, were read before the same body,—the former in 1796, the latter in 1802. In 1805 appeared his first pamphlet on what was known as the Leslie case, entitled, *A Statement of Facts, &c.;* and, in December of the same year, he added a second pamphlet, entitled, *Postscript to Statement of Facts.* The *Statement of Facts*, though hastily written, is remarkable for the clearness and ability with which it disentangles the real point at issue from the mass of irrelevant matter which, as usually happens, was raised in the popular discussion of a purely philosophical question. On general and historical grounds Mr Stewart seeks to vindicate, within certain limits, the doctrine of Causation, the approval of which by Mr Leslie was made the ground of objection to his appointment to the Chair of Natural Philosophy. Mr Stewart especially endeavours to show that the doctrine which teaches that the utmost we can observe in physical sequences is simply invariable antecedence and consequence, is both theologically innocuous, and the only safe opinion. The controversy was finally decided in favour of Mr Leslie.

In 1806, Mr Stewart received the appointment of the writership of the *Edinburgh Gazette*, as a recognition of the services which he had rendered to education and philosophy. The salary attached to the office was L.300 per annum. In the summer of this year, he accompanied Lord Lauderdale on his mission to Paris, which he had previously visited before and at the commencement of the Revolution, and where he had acquired a large circle of friends, distinguished in philosophy, literature, and politics, among whom may be mentioned the Abbé Morellet, the Baron de Gerando, &c. Mr Stewart's health, which had been delicate for some years, received a severe blow from the death of his second son, George, in 1809. He was unable to lecture during a great part of session 1809-10. Dr Thomas Brown, at his request, acted as his substitute. Mr Stewart finally withdrew from active professorial duty at the end of that session. Dr Brown was appointed conjoint-professor of Moral Philosophy, Mr Stewart's name still remaining in the commission. Shortly after the death of Dr Brown, in 1820, Mr Stewart formally resigned the professorship, which was conferred upon Mr John Wilson. From the year 1809 until the close of his life, Mr Stewart lived in comparative retirement at Kinneil House, Linlithgowshire, which was kindly placed at his disposal by his friend the Duke of Hamilton. His retirement was almost exclusively devoted to maturing and arranging the philosophical labours of his previous life; his reflective activity being interrupted only by friendly intercourse, and the calls of those strangers whom the lustre of his name led to pay a passing visit at Kinneil. From Kinneil were dated, in 1810, the *Philosophical Essays;* in 1813 (but only published in 1814), the second volume of the *Elements;* in 1815, the first, and, in 1821, the second part of the *Dissertation;* in 1826 (but only published in 1827), the third volume of the *Elements;* and, in 1828, a few weeks before his death, the *Philosophy of the Active and Moral Powers.* The last mentioned work, with the relative part of the *Outlines*, embody the results of his ethical speculations. His *Lectures on Political Economy* were first published in his *Collected Works*, edited by the late Sir W. Hamilton. In January 1822, Mr Stewart was struck with paralysis. "The malady," says his son, "which broke his health and constitution for the rest of his existence, happily impaired neither any of the faculties of his mind nor the characteristic vigour of his understanding. As soon as his health was sufficiently re-established, he continued to pursue his studies with his wonted assiduity; exhibiting, among some of the heaviest infirmities incident to age, an admirable example of the serene sunset of a well-spent life of classical elegance and refinement, so beautifully imagined by Cicero: 'Quiete, et pure, et eleganter actæ ætatis, placida ac lenis senectus.'" Mr Stewart died in Edinburgh on the 11th June 1828, after a brief illness, and fresh shock of paralysis. His remains were interred in the family vault on the west side of the churchyard of Canongate, not far from the grave of Adam Smith.

Among Scottish philosophers Mr Stewart stands prominently out as a psychological observer. On questions properly metaphysical he has left little which can be regarded as essentially his own. The field within which he chiefly laboured was that of the phenomena of the mind, intellectual, moral, and æsthetical, as these appear under the modifications imposed on them by the general circumstances of human life, — education and society. In careful, delicate, and original observation, within this sphere, he has seldom been equalled; and though led into diffuse composition both by the character of his mind and the habits of the academical teacher, there are few writers in the English language whose beauties of style, and living sympathy with what is best in human life and in its aspirations, are more fitted to refine the taste and quicken the moral sensibilities. (J. V.)

STEWART, *Matthew*, an eminent mathematician, and father of Dugald Stewart, the eminent Scottish philosopher, noticed above, was born in 1717 at Rothesay in the Isle of Bute, of which parish his father was minister. Being intended for the church, he passed through the usual course of a grammar-school education, and was in 1734 received as a student into the University of Glasgow. There he had for his preceptors in moral science and mathematics the celebrated professors Hutcheson and Simson, by the latter of whom he was instructed in what may be called the *arcana* of the ancient geometry.

His views making it necessary for him to remove to Edinburgh, he was introduced by Dr Simson to Maclaurin, and he attended his lectures with such advantage as might be expected from eminent abilities, directed by the judgment of him who made the geometry of Newton intelligible to ordinary capacities. From his intimacy with Simson he had, however, acquired such a predilection for the ancient geometry, as the modern analysis, however powerfully recommended, could not lessen; and he kept up a regular correspondence with his old master, giving him an account of his progress and his discoveries in geometry, and receiving in return many curious communications respecting the *Loci Plani*, and the porisms of Euclid.

While the second invention of porisms, to which more genius was perhaps required than to the first discovery of them, employed Dr Simson, his pupil pursued the same subject in a different and new direction. In doing so, he was led to the discovery of those curious and interesting propositions, which were published under the title of *General Theorems* in 1746. They were given without the demonstrations, but did not fail to place their discoverer at once among the geometers of the first rank. They are for the most part porisms, though Stewart, careful not to anticipate the discoveries of his friend, gave them no other name than that of theorems.

Before this period he had entered the church, and through the patronage of the Duke of Argyle and the Earl of Bute, he obtained the living of Roseneath, a retired country parish in the west of Scotland; but in 1747 he was elected to the mathematical chair in the University of Edinburgh, which had become vacant the year before by the death of Maclaurin. The duties of this office gave a turn somewhat different to his pursuits, and led him to think of the most simple and elegant means of explaining those difficult propositions which were hitherto only accessible to men deeply versed in the modern analysis. In doing this, he was pursuing the object which of all others he most ardently wished to attain, namely, the application of geometry to such problems as the algebraic calculus alone had been thought able to resolve. His solution of Kepler's problem was the first specimen of this kind which he gave to the world; and it was impossible to have produced one more to the credit of the method which he followed, or of the abilities with which he applied it. On this problem the utmost resources of the integral calculus had been employed. But though many excellent solutions had been given, there was none of them at once direct in its method and simple in its principles. Stewart was so happy as to attain both these objects; and his solution appeared in the second volume of the *Essays of the Philosophical Society of Edinburgh* for the year 1756. In the first volume of the same collection there are some other propositions of Stewart's, which are an extension of a curious theorem in the fourth book of Pappus. They have a relation to the subject of porisms, and one of them forms the ninety-first of Dr Simson's restorations. They are besides very beautiful propositions, and are demonstrated with all the elegance and simplicity of the ancient analysis.

The prosecution of the plan which he had formed of introducing into the higher parts of mixed mathematics the strict and simple form of ancient demonstration, produced the *Tracts, Physical and Mathematical*, which were published in 1761, and the *Essay on the Sun's Distance*, which was published in 1763. In this last work it is acknowledged that he employed geometry on a task which geometry cannot perform; but while it is granted that this determination of the sun's distance is by no means free from error, we may venture to affirm that it contains a great deal which will always interest geometers, and will always be admired by them. Few errors in science are redeemed by the display of so much ingenuity, and what is more singular, of so much sound reasoning. The investigation is everywhere elegant, and will probably be long regarded as a specimen of the most arduous inquiry which has been attempted by mere geometry. The *Sun's Distance* was the last work which Dr Stewart published; and though he lived to see several animadversions on it made public, he declined entering into any controversy. His disposition was far from polemical; and he knew the value of that quiet which a literary man should rarely suffer his antagonists to interrupt. He used to say, that the decision of the point in question was now before the public; that if his investigation was right it would never be overturned, and that if it was wrong it ought not to be defended. A few months before he published the essay just mentioned, he gave to the world another work, entitled *Propositiones Geometricæ more Veterum demonstratæ*. This title, it is said, was given to it by Dr Simson, who rejoiced in the publication of a work so well calculated to promote the study of the ancient geometry. It consists of a series of geometrical theorems, for the most part new; investigated first by an analysis, and afterwards synthetically demonstrated by the inversion of the same analysis. Dr Stewart's constant use of the geometrical analysis had put him in possession of many valuable propositions which did not enter into the plan of any of the works that have been enumerated. Of these not a few have found a place in the writings of Dr Simson, where they will for ever remain to mark the friendship of these two mathematicians, and to evince the esteem which Simson entertained for the abilities of his pupil.

Soon after the publication of the *Sun's Distance*, Dr Stewart's health began to decline, and the duties of his office became burdensome to him. In the year 1772, he retired to a small demesne which he possessed in Ayrshire, where he afterwards spent the greater part of his life, and never resumed his labours in the university. But though mathematics had now ceased to be his business, they continued to be his amusement till a very few years before his death, which happened on the 23d of January 1785, at the age of sixty-eight.

The habits of study, in a man of original genius, are objects of curiosity, and deserve to be remembered. Concerning those of Dr Stewart, his writings have made it necessary to remark, that from his youth he had been accustomed to the most intense and continued application. In consequence of this application, added to the natural vigour of his mind, he retained the memory of his discoveries in a manner that will hardly be believed. He rarely wrote down any of his investigations till it became necessary to do so for the purpose of publication. When he discovered any proposition, he would put down the enunciation with great accuracy, and on the same piece of paper would construct very neatly the figure to which it referred. To these he trusted for recalling to his mind at any future period the demonstration or the analysis, however complicated it might be. Experience had taught him that he might place this confidence in himself without any danger of disappointment; and for this singular power he was probably more indebted to the activity of his invention than the mere tenaciousness of his memory. Though he was extremely studious, he read few books, and verified the observations of M. d'Alembert, that of all men of letters, mathematicians read least of

the writings of one another. His own investigations occupied him sufficiently; and indeed the world would have had reason to regret the misapplication of his talents had he employed in the mere acquisition of knowledge that time which he could dedicate to works of invention.

STEWARTON, a town of Scotland, Ayrshire, on the right bank of the Annock, 6 miles N. by W. of Kilmarnock, and 18 S.S.W. of Glasgow. It is generally well built, consisting of one main street about a mile long, with several smaller streets. There is a town-hall, a jail, places of worship belonging to the Established Church, the Free Church, and the United Presbyterians, and schools with libraries connected with each of the churches. Extensive and flourishing manufactures are carried on here, especially of Highland bonnets, carpets, linen, damask, and spindles for cotton and worsted. There are also mills for carding and spinning wool; and considerable quantities of steel clock-work are made and exported from Stewarton. Pop. of the town, 3164.

STEYER, or STEYR, a town of the Austrian empire, Upper Austria, at the confluence of the Steyer and the Enns, 19 miles S.E. of Linz. It stands between the two rivers, and is connected by bridges with the suburbs Ennsdorf and Steyerdorf on either side. On a hill above the town stands the castle, belonging to Prince Lamberg, and on another hill near the suburb Steyerdorf is a Jesuits' college, now suppressed. In the cathedral, which was built in 1443 on the model of St Stephen's in Vienna, there are some beautiful specimens of painted glass, and a fine old bronze font. Steyer is celebrated for its manufactures, especially of hardware; which are so extensive as to have procured for the town the name of the Austrian Sheffield. There are also paper-mills, cotton-factories, manufactories of woollen cloth, &c. A considerable trade is carried on in the exportation of these articles. Steyer was the birthplace of the satiric poet Blumaner. It was at one time the capital of Styria. Pop. 10,414.

STICCATO (*Ital.*), a rude musical instrument, formed of a number of sticks of hard wood of different lengths, generally attached to each other by strings at the ends, but so as to hang separate from one another when suspended by the top. It is played upon by striking the sticks with rods of cane or whalebone tipped with ivory balls. Mersenne, in his *Harmonia Universalis*, calls this instrument *ligneum psalterium*.

STIEGLITZ, CHRISTIAN LUDWIG, an eminent architectural writer of Germany, was born at Leipzig on the 12th of December 1756. In his youth he had his mind familiarized with pictures, cabinets of medals and minerals, in his father's collection, which was the means of forming the lad's taste for those ultimate walks which he found so congenial. When pursuing his studies at the university he directed his attention mainly to jurisprudence. He likewise wrote poems, tales, and romances. In 1784 he took the degree of Doctor of Laws, and in 1786 appeared his first architectural work entitled *Versuch über die Baukunst.* In 1792, the same year in which he was made a member of the council of Leipzig, he brought out his *Geschichte der Baukunst der Alten*, and shortly after appeared his *Encyclopadie der bürgerl. Baukunst*, in 5 vols., 1792–98. Passing over his specimens of modern architecture as feeble and generally insipid, we come to a really excellent work published in 1820, called *Altdeutsche Baukunst*, which contributed in a large degree to the diffusion of that taste for mediæval art which is so general in Germany at the present day. His *Geschichte der Baukunst* appeared in 1827. After having contributed various articles to different journals and to Ersch and Gruber's *Encyclopädie*, and having produced other works of more or less merit, Stieglitz died in his native town on the 17th of July 1836.

STIFEL. See ALGEBRA.

STIGLIANO, a town of Naples, in the province of Baslicata, 29 miles S.W. of Matera. It contains several churches and convents, and has some trade in cattle, wine, and oil. Pop. 4200.

STIGLMAYER, JOHANN BAPTIST, an eminent metal-founder of Munich, was the son of a poor blacksmith, and was born at Fürstenfeldbrück, near Munich, on the 18th October 1791. The boy originally acquired the art of drawing by copying some illustrative wood-cuts of an old convent in possession of his father. Having been placed with a goldsmith of Munich, he by his industry and good conduct recommended himself to the director of the Bavarian mint, who procured him admission into the academy in 1810. This was the means of introducing him to the notice of the king, who in 1819 sent him to Italy to complete his studies. While in Rome Stiglmayer's attention was drawn to the art of metal-founding by Ludwig, then crown-prince of Bavaria. After spending a year or two in the study of metal castings he returned to Munich in 1822, and set to work in 1826 at the royal bronze-foundry, and turned out more extensive castings than any other man of modern times. He executed numerous monuments of his own planning, but generally he preferred following the designs of Schwanthaler, Thorwaldsen, and Rauch. He died on the 2d of March 1844, the day on which his nephew, assistant and successor, Ferdinand Miller, cast the colossal statue of Goethe, designed by Schwanthaler, for the city of Frankfort.

STILL, JOHN, said to be the author of *Gammer Gurton's Needle*, was a native of Grantham in Lincolnshire, and was born in 1543. He became a student of Christ's College, Cambridge, where he duly graduated and took orders. He was appointed in 1570 Lady Margaret's professor in his university, subsequently held livings in Suffolk and Yorkshire, and was master successively of St John's College and of Trinity College. Still was elevated to the bishopric of Bath and Wells in 1592, and after enjoying considerable fame as a preacher and disputant, he died, leaving a large fortune from lead-mines discovered in the Mendip Hills.

To Bishop Still is ascribed the authorship, on somewhat slight grounds, of the earliest comedy but one in the English language. This is *Gammer Gurton's Needle*, which bears on the title-page, "Made by Mr S., Master of Arts," which was first published in 1575. Perhaps the introduction to the second act of that coarse play, which consists of the oldest drinking-song in the English language, has made the jolly bishop more widely known than his loudest disputations would ever have rendered him. This exquisite old song, commencing,

> "I cannot eat but little meat
> My stomach is not good,"

has been found, on more recent research, to belong to an earlier date than the era of Bishop Still. (See Dyce's *Life of Skelton*, vol. i., pp. 7–9.)

STILLING, JOHANN HEINRICH JUNG commonly called, a famous German Pietist, was the son of a poor charcoal-burner, and was born at Gründ in Westphalia in 1740. He originally worked at his father's occupation, but afterwards selected the trade of a tailor. He soon afterwards relinquished this business in favour of a teacher's situation. He alternated between the ferula and the needle for some time, until some rich persons, attracted by his simplicity and his modest devoutness, made him tutor to their children. Having saved a little money, he now went to the university of Strasburg, where he studied medicine, and subsequently became a physician at Elberfeld. Jung became famous as an oculist, and is said by the poet Matthisson to have restored upwards of 2000 poor blind people to their sight. He was as liberal as he was skilful, and hundreds of the

German poor knew the hand of the generous philanthropist who had heard nothing of his skill as a physician. In 1778 he was chosen professor at Lautern, in 1787 at Marburg, and in 1803 at Heidelberg. He died at Carlsruhe in 1817.

When a student at Strasburg, Stilling had accidentally taken the attention of Goethe by his simplicity, his earnestness, and the humble devoutness with which he entered into everything which he undertook. Goethe remained his warm friend throughout life, and has sketched his character with much fondness in various passages of his *Dichtung und Wahrheit*, books ix. and x. (See also Lewes's *Life of Goethe*, vol. i., p. 105.) Stilling was a voluminous writer. The most popular of his works are his autobiography (*Lebensgeschichte*) and his *Theorie der Geisterkunde*, which have both been rendered into English by Jackson. But he has attained his greatest fame as a mystical writer and thinker. His works have been published by Grollman at Leipzig, 13 vols., 1835.

STILLINGFLEET, Edward, Bishop of Worcester, and "renowned," according to Lord Macaulay, "as a consummate master of all the weapons of controversy," was born at Cranborne, in Dorsetshire, in 1635. He was educated at St John's College, Cambridge; and having received holy orders, was, in 1657, presented to the rectory of Sutton in Nottinghamshire. In 1659 appeared his first work, entitled, *Irenicum, or the Divine Right of particular Forms of Church Government Examined*. By publishing his *Origines Sacræ*, one of the ablest defences of revealed religion that has ever been written, he soon acquired such reputation, that he was appointed preacher of the Rolls Chapel; and in January 1665 was presented to the rectory of St Andrews, Holborn. He was afterwards chosen lecturer at the Temple, and appointed chaplain in ordinary to King Charles II. In 1668 he took the degree of D.D.; and was soon after engaged in a dispute with those of the Romish religion, by publishing his discourse concerning the idolatry and fanaticism of the Church of Rome, which discourse he afterwards defended against several antagonists. In 1680 he preached at Guildhall Chapel a sermon on Phil. iii. 26, which he published under the title of *The Mischief of Separation;* and this being immediately attacked by several writers, he, in 1683, published his *Unreasonableness of Separation*. In 1685 appeared his *Origines Britannicæ, or the Antiquities of the British Churches*, in folio. During the reign of King James II., he wrote several tracts against popery, and was prolocutor of the convocation, as he had likewise been under Charles II. After the Revolution he was advanced to the bishopric of Worcester, and was engaged in a dispute with the Socinians, and also with Mr Locke; in which last contest he is generally thought to have been unsuccessful. He died at Westminster in 1699, and was interred in the cathedral of Worcester, where a monument was erected to his memory by his son, bearing a highly eulogistic Latin epitaph from the pen of Bentley, who had been his chaplain. Dr Stillingfleet wrote other works besides those here mentioned, which, with the above, have been reprinted in six volumes, folio, 1710.

STILLINGFLEET, *Benjamin*, an ingenious naturalist, born in 1702, was the grandson of Dr Stillingfleet, Bishop of Worcester. His father, Edward Stillingfleet, M.D., was fellow of St John's College, Cambridge, and Gresham professor of physic; but marrying in 1692, he lost his lucrative offices and his father's favour; a misfortune that affected both himself and his posterity. Benjamin, his only son, was educated at Norwich school, which he left in 1720, with the character of an excellent scholar. He went to Trinity College, Cambridge, at the request of Dr Bentley, the master, who had been private tutor to his father, domestic chaplain to his grandfather, and much indebted to his family. Here he was a candidate for a fellowship, but was rejected, as he believed, by Bentley's influence. Perhaps, however, this seeming ingratitude was not of any real disservice to Stillingfleet. By being thrown into the world, he formed many honourable and valuable connections. He dedicated some translations of Linnæus to the late Lord Lyttelton, partly, he says, from motives of private respect and honour. Lord Barrington gave him, in a very polite manner, the place of master of the barracks at Kensington; a favour to which Stillingfleet, in the dedication of his *Calendar of Flora* to that nobleman, alludes with the warmest gratitude. His *Calendar of Flora* was formed at Stratton in Norfolk in the year 1755, at the seat of his friend Marsham, who had made several observations of that kind, and had communicated to the public his curious observations on the growth of trees. But it was to Wyndham of Felbrig in Norfolk that he appears to have had the greatest obligation; he travelled abroad with him, spent much of his time at his house, and was appointed one of his executors (Mr Garrick being another), with a considerable addition to an annuity which that gentleman had settled upon him in his lifetime.

Stillingfleet's genius seems, if we may judge from his works, to have led him principally to the study of natural history. In his walk of learning he mentions as his friends, Dr Watson, Dr Solander, Mr Hudson, Mr Price of Foxley, and some others; to whom may be added the ingenious Mr Pennant.

Stillingfleet published a volume of *Miscellaneous Tracts* in 1759. They are chiefly translations of some essays in the *Amœnitates Academicæ*, published by Linnæus, interspersed with some observations and additions of his own. His *Essay on Conversation*, a poem, was published in the first volume of Dodsley's *Collection*. His London residence was in lodgings in Piccadilly, where he died in 1771, at the age of sixty-nine, leaving several valuable papers behind him. Coxe has written a notice of his life and works, 1811.

STILPO, a celebrated philosopher of Megara, who flourished during the second century B.C. In his youth he had been addicted to licentious pleasures, from which he religiously refrained from the moment when he ranked himself among philosophers. When Ptolemy Soter, at the taking of Megara, offered him a large sum of money, and requested that he would accompany him into Egypt, he accepted but a small part of the offer, and retired to the Island of Ægina, whence, on Ptolemy's departure, he returned to Megara. That city being again taken by Demetrius the son of Antigonus, and the philosopher required to give an account of any effects which he had lost during the hurry of the plunder, he replied that he had lost nothing; for no one could take from him his learning and eloquence. So great was the fame of Stilpo, that the most eminent philosophers of Athens took pleasure in attending upon his discourses. His peculiar doctrines were, that species or universals have no real existence, and that one thing cannot be predicated of another. With respect to the former of these opinions, he seems to have taught the same doctrine as the Nominalists of more modern times. In ethics he seems to have been a Stoic, and in religion he had a public and a private doctrine, the former for the multitude, and the latter for his friends. He admitted the existence of a Supreme Divinity, but had no reverence for the Grecian superstitions. (See *Diog. Laërt.*, ii., c. 12.)

STIRLING, one of the most ancient towns in Scotland and capital of the county of the same name, is built on the slope and around the base of a ridge of rock situated in the carse or plain watered by the river Forth; Long. 5° 45′ west, Lat. 56° 6′ north. It is chiefly interesting for its antiquities, its historical associations, and its singularly beautiful, picturesque, and central situation. The town is, from the nature of the ground, very irregular, and the houses in one part, or what may be called the old town, are antiquated and

Stirling. destitute of all architectural beauty, with narrow and confined streets; while in the other, or new town, quite the reverse is the case. Towards the south and south-west, extensive suburbs are springing up containing many large and handsome villas. Numbers of new streets and terraces have been projected, and some promise to be speedily completed. Great improvements have and still are taking place, and the streets are now well paved and kept in good order. The old rickety and unsightly houses are being demolished one by one, and new and substantial ones built in their stead. A plentiful supply of pure water was a few years ago led in from the Touch Hills, about 4 miles distant, by means of cast-metal pipes.

The Castle. The Castle, the most prominent place of interest in Stirling, is built on the western extremity of the ridge on which the town is situated, and is of much greater antiquity than the town itself. It is defended on three sides by the precipitous rocks on which it is built, and on the fourth, or town side, by a deep broad fosse, crossed by a drawbridge, and two strong walls, the approach being commanded by flanking batteries. In the centre of the castle stands the old Parliament-House, now used as barracks; on the left is the palace of James V., a magnificent structure, the hall of which is now also converted into barracks, but still known as the "King's room," the remainder being used as officers' rooms, canteen, sutlery, &c. The building to the west of the palace is of much older date, and contains the well-known "Douglas room," (so called from James II. having killed William earl of Douglas in it). This room, along with other portions of the building, was burned down in 1857, but has been rebuilt in its original form in every respect, except that the ornaments are iron instead of wood, in case of further accidents. Adjoining this building is the Chapel-Royal of James VI., now used as an armoury.

Monuments. Near the castle is the Lady's Hill and Valley, where in olden time the joists and tournaments were held. They have now, in the course of improvement, been inclosed in the new cemetery, but have not lost their distinctive features. In this cemetery is a most beautiful and chaste group of statuary, erected by William Drummond of Rockdale Lodge to the memory of the martyred Margaret Wilson and her sister Agnes. At the head of King Street is a monument, by Mr Handyside Ritchie of Edinburgh, to Wallace, and presented to the town by Mr Drummond. In front of the First U.P. Church is a beautiful Corinthian monument to Ebenezer Erskine, the founder of the Secession body in Scotland, and the first minister of that congregation.

Public buildings. The public buildings are the East and West Churches, both in the Gothic style (the upper windows, however, of the latter have Saxon arches), with a modern erection between, which adds nothing to their beauty, and which it is contemplated to remove. The West Church was erected in 1494 by James IV.; the East at a later period by Cardinal Beaton. Close beside these churches is a ruin called "Mar's Work." It was a mansion-house commenced by the Earl of Mar out of the stones of Cambuskenneth Abbey, but was never completed. Near it is the ancient palace of the Argyle family, and now converted into a military hospital under the name of "Argyle-House." In Broad Street stands the ancient town-house, with its spire and old jail attached. In the town-house are still kept the pint jug, the ancient standard for liquid measure in Scotland; and in the court-room are about a dozen fine ancient carvings on oak, known as the Stirling heads which formerly adorned the hall of the palace of James V., and are believed to represent the king's family and courtiers. The county sheriff-court and also the justice of peace court are held here, and the circuit court meets here twice every year. The new jail is a strong handsome building, lately erected in room of the old one, which was too small and insecure. It is one of the finest buildings in Stirling. The Athenæum is a good building in King Street, with a spire 120 feet high; and in it is a public reading-room and a library of about 7000 volumes. The North Church is decidedly the most elaborate building in town. The Free North Church and the Second U.P. Church are both handsome buildings, and the National Bank is also a fine building.

Parks. To the south of the Castle was the Royal Gardens, of which nothing now remains except the trace of the terraces rising the one above the other, in the centre of which is an octagonal mound called the "King's Knote." To the south of the gardens is the "King's Park," where the kings of Scotland used to keep their deer. It is now given over by government to the town as a public park. The Gowlan Hills to the north of the Castle was the place where, in very early times, justice was administered, where at a later period executions took place, and where, later still, James V. used to slide or "hurle" down its steep sides on a cow's-head, hence called "Hurly Hawkie," another name for the same hill. Between this hill and the castle is a pass called Ballengeich or "windy-gowl," from which James V. took the cognomen of "The gudeman of Ballengeich." The public walks about Stirling are unrivalled in Scotland. The oldest and best of them runs along the top of the rock on which the town is built, and is known as the Back Walk.

Stirling Bridge. Stirling Bridge is the most noted structure of the kind in Scotland for its antiquity and the historical events connected with it. It was till within about 30 years the only access for wheeled carriages into the north of Scotland. Its age is unknown, but it was in existence in 1571. It is of very antique structure, being narrow, high in the centre, and is composed of 4 arches. Formerly it had two gates, one at each end, each gate being flanked by two small towers. The gates are now removed, though the towers still remain. This bridge, though once very strong, is now beginning to show signs of decay, and large rents are appearing in it.

Manufactures and commerce. Stirling has, since the introduction of railways, become a place of great importance. The Scottish Central Railway runs past it, and it is the terminus of other three lines: the Stirling and Dunfermline, the Forth and Clyde, and the Dunblane, Doune, and Callender, the two latter being single lines. Though a place of no great commercial importance in itself, it has, through its central situation, both in regard to Scotland and the rich agricultural, mining, and manufacturing districts around, become one of the most important towns in Scotland. There are three considerable wool-mills and one carpet and shawl manufactory connected with the town; also two extensive coach factories, a number of timber-yards, and two tanneries. Drummond's Agricultural Museum holds a prominent place in the town as a seed and implement warehouse, exporting to all parts of the globe. Though the Forth flows past the town, shipping is necessarily very limited on account of the shallowness of the water, it being confined to a few small sloops and an occasional vessel of between one or two hundred tons. A line of passenger-steamers runs between Stirling and Granton, but the business has since the railway opened greatly fallen off. There are two weekly newspapers, the *Stirling Journal* and *Stirling Observer*. There are seven banks, all of them doing a large business, and a very prosperous savings-bank.

Religion and education. There are in the town 3 Established churches, 2 Free churches, 2 United Presbyterian, 1 Reformed Presbyterian, 1 Episcopalian, 1 Congregational, 1 Baptist, 1 Methodist, and a Roman Catholic—in all, 13 places of worship. Connected with the religious element is the Stirling Tract Enterprise, instituted by Mr Peter Drummond in 1848, and which alone increases the revenue of the Stirling Post Office by upwards of L.2000 annually. In education the town stands high. A new academy was built in 1854, having a classical master, a master of modern languages, an English master, a mathematical master, a drawing master, a gymna-

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sium, and between 300 or 400 pupils. There is also a school, known as Allan's School, for the education of the poorer classes, besides several other private educational establishments, all of which are well attended. There is a Ragged School sustained by public liberality, which contains between 60 and 70 outcast children.

Hospitals.

Among the charitable endowments are Spittal's Hospital, with an income of nearly L.1000 derived from land, which is expended on the aged poor belonging to the seven incorporated trades; and Cowan's Hospital, which has an income of about L.4000, also derived from land, and which is expended on the decayed members of the Incorporation of Guildry. The finest hall in the town is the Guild Hall, belonging to the latter of these institutions, and was originally built for the accommodation of twelve decayed guild brethren; but as no one would inhabit it, the funds accumulated till they now produce the above sum. The house has now been turned into a hall for the meetings of guildry. Allan's and Cunningham's mortifications have incomes of L.600 and L.200 respectively, wholly devoted for the education of youth.

History.

Stirling as a town, or rather a place of defence, is of unknown antiquity. It is even believed that it was used as a place of defence at a time when all the Low Country was under water. It first emerges into history as one of the four burghs forming what is now called the Convention of Royal Burghs. Its history since then has been so intimately connected with the history of Scotland, that it is unnecessary to give a sketch of it here.

Government.

The town is governed by a provost, 4 magistrates, and 16 councillors, 21 in all, a third retiring every year.

Population, &c.

The population is 12,837; inhabited houses, 1270; annual value of real property in 1859–60, L.36,791 (exclusive of railways); parliamentary constituency, 592; municipal constituency, 475. Stirling is united with the burghs of Dunfermline, Culross, Queensferry, and Inverkeithing in returning a member to Parliament.

STIRLINGSHIRE, one of the most beautiful counties in Scotland, situated on the isthmus between the Firths of Forth and Clyde, is bounded on the north by the counties of Perth and Clackmannan, east by the Firth of Forth and Linlithgowshire, south by Lanarkshire and Dumbartonshire, and west by Dumbartonshire. Its greatest length from Linlithgow Bridge to Loch Lomond is 45 miles, and its greatest breadth 18 miles, though in many places it is not above 1 to 3 or 4 miles broad. Its area is 462 square miles, or 295,875 acres, divided into 21 entire parishes, and portions of 4 others which partly belong to other counties. It lies on both sides of the boundary line between the Highlands and the Lowlands, but in its general features is mountainous, although there are two extensive carses or plains in it, called the carses of Stirling and Falkirk. About two-thirds of Stirlingshire is unfit for cultivation, owing to its hilly nature, but affords excellent pasturage for sheep. The remainder is among the most fertile portions of Scotland.

Hills.

The principal chain of hills is the Lennox Hills, otherwise called the Campsie Fells, and Fintry Hills; and, in the neighbourhood of Stirling, the Touch Hills. This range runs across the county from Dumbartonshire to nearly Stirling, but never attains a higher elevation than about 1500 feet. Ben Lomond on the north-west, on the banks of Loch Lomond, is 3191 feet high, and Ben Cleuch, in the parish of Alva, 2400 feet high. To the north and east of the Lennox Hills the country is low, and much of the land along the Forth is only a few feet above the level of the river. Towards the western and southern extremities the surface is more varied, presenting tracts of heath, moss, and green pastures, intermixed with cultivated land, the latter confined for the most part to the banks of the streams.

Rivers.

The streams of Stirlingshire are the Forth, Avon, Allander, Kelvin, Endrick, Carron, Allan, Devon, and Bannock. Of these the principal is the Forth, which rises from a spring on the northern side and near the summit of Ben Lomond, and pursues a course of 8 or 10 miles under the name of the Water of Duchray. It then passes into Perthshire under the name of *Avendhu*, or Black River, and soon after returns to the county, and thenceforward obtains the name of the Forth. Pursuing its way through what is called the Vale of the Forth in a slow and sluggish manner, after winding round the base of Craigforth, it receives the clear waters of the Teith, which forms a fine contrast to the dark muddy waters of the Forth. Further on it is joined by the Allan, a brawling, brattling stream, which is only in the county a mile or two of its course, and shortly afterwards passes Stirling, forming from that place to Alloa what is known as the Links of the Forth, so called from the extraordinary number of windings it makes. These links are one of the finest and most picturesque sails in Scotland. At one time the Castle of Stirling appears right in front, and in a few minutes it is away behind, then at one side, then at the other, and in fact the traveller, until he becomes familiar with it, is quite bewildered. After passing Alloa, the river becomes an estuary, and is known as the Firth of Forth. The Carron, the next in importance, rises in the interior, pursues an easterly course, and joins the Firth of Forth at Grangemouth. It is navigable for vessels of 200 tons up to the village of Carronshore, the shipping place of the Carron Company, about 2 miles above its confluence with the Forth. The Avon makes two separate stretches on the boundary. The Endrick is principally a county stream, and pursues a very sweet and romantic course in the western district. The Allander and Devon are only for a very short distance within the county. The Bannock, famous for its battle of the same name, which gave liberty to Scotland, is wholly a county stream, and joins the Forth a little below Stirling.

Lakes.

The lakes of Stirlingshire, with the exception of Loch Lomond, are neither large nor of much importance. The one-half, and the most picturesque half of this, the queen of Scottish lakes, belongs to the county, and contributes to it the islands Inchcailloch, Inchfad, Inchcruin, and several others of lesser importance. Loch Coulter, in the parish of St Ninians; Loch Elrigg, Black Loch, and Little Black Loch, in Slamannan, are all small. Loch Katrine touches the county for a distance of two miles.

Geology.

Stirlingshire is one of the richest counties in Scotland for minerals. The north-west boundary of the great coal-field which extends from Kintyre to Fifeshire, runs along the base of the Lennox Hills, and is extensively worked at Plean, Bannockburn, Greenyards, Denny, Carron, Slamannan, and, in fact, the whole of the south-east corner of the county, but is nowhere found in the north and west. Ironstone is found in almost inexhaustible quantities, a fact which influenced Dr Roebuck, after he had examined the whole of Scotland, to fix on the neighbourhood of Falkirk as the site for the now magnificent Carron Iron-works. The richest variety is found at Kilsyth, and owing to its occurring in rounded masses in the form of a flat-topped loaf, varying in size from a quarter of an inch to a foot in diameter, is called fall ironstone. The hill of Craigforth, near Stirling, is almost one mass of pure ironstone. Limestone, in many instances, accompanies the coal in two strata, the one above and the other below the coal, the former being always the best quality. Copper is found, but not in sufficient quantities to be workable, although mines were opened at Kilsyth and Logie, which however were soon abandoned. Veins of silver were discovered nearly 100 years ago at Logie and Alva, and were worked for some time, but were soon given up. Cobalt, arsenic, and lead are also found in very small quantities. Sandstone abounds in the south and east districts, and is

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extensively quarried. Trap-rocks, particularly basalt, are found north-west of the coals, and rise up in nodulated hills through various parts of the coal-fields. The rock on which the town and castle of Stirling are built, and the neighbouring well-known hill, the Abbey Craig, which, though not in Stirlingshire, touches it, are examples of this volcanic action. Precipitous columnar cliffs and extensive ranges of basaltic colonnade exist in solitary protrusions, as in the broad mass of the Lennox Hills. The rocks of the north or Highland district are principally schistose. One remarkable feature traceable in all the hills lying in or near the carse of Stirling is, that the rocks on the west and south-west sides are bare and precipitous, while the eastern and northern sides have a gentle slope, and are covered with herbage. The reason assigned is, that at one time the waves of the Atlantic Ocean rolled through the Low Country into the German Ocean, and washed the soil from the exposed sides of these rocks and deposited it on the protected sides.

Climate.

The climate of the eastern division of the county is milder than that of the west, partly owing to the inferior elevation, and partly because of the superior shelter afforded it by the trees and hedges, but principally because in summer the German Ocean is 5° warmer than the Atlantic. The west, however, escapes those fogs which infest the east during the prevalence of the east winds.

Soil.

Stirlingshire has every variety of soil common to Scotland, and may be classified into carse, dryfield, hill, moor, and moss. The carse extends along the line of the Forth, from half-a-mile to 5 miles in width, making altogether 56 square miles, or nearly 36,000 imperial acres of the very best grain-producing land in the kingdom. It consists of the finest argillaceous earth, perfectly free of stones, and originally of a bluish colour, and of a soapy or mucilaginous consistency; but after cultivation becomes of a hazel colour, and of a loamy friability. It is of the depth of between 20 and 30 feet, and is seldom more than 25 feet above the level of the sea. It contains beds of shells, moss, and clay marl. In it, in a stratum of moss, have been found at various times the entire skeletons of two whales and the part of another, deers'-horns, bones, &c., some of which had evidently been used as instruments of the chase. One of the skeletons is now in the Zoological Gardens of Edinburgh. The dryfield is a darker and more sandy earth, in some places of some depth, and in others only a few feet. The hilly and moorish lands are of considerable extent and unfit for cultivation, both from elevation and from want of a regular sufficient depth of soil. The moss-lands were at one time of some extent, but they were let out in small portions at little or no rent to cottars, who got the produce of the ground for the clearing away of the moss, and were generally known by the name of moss lairds. These moss-lairds are fast dying out, the grounds thus cleared being let out as regular farms.

Agriculture.

Agriculture is in a very high state; but owing to the varieties of the land, it is various in its modes. The Carse farmers produce a great quantity of wheat and beans, for the growing of which their soil is peculiarly adapted, as it is strong and heavy. The dryfield farmers, on the contrary, on account of their land being lighter, and not so well adapted for the growth of strong-strawed serials, never thought of sowing either wheat or beans till the potato disease made its appearance, when they introduced them as fills-up, but are quite unable to obtain the heavy crops Carse farmers do. On the other hand, the dryfield farmers have the advantage over their Carse brethren in the production of potatoes and turnips, which, before the disease, were cultivated in immense quantities and with great success. The other grains grown are oats and barley, and mangel-wurzel is being introduced for the feeding of cattle. Stirlingshire takes the lead of all Scotch counties for its agricultural improvements. The arable farms range in extent from 40 to 100 or 150 acres; while the hill-farms, where sheep and cattle are kept, are sometimes 4000 acres. Almost all the Highland district, or the mountains of Buchanan and Drymen, the Lennox Hills, &c., are disposed as sheep-walks, and produce excellent pasturage. The cattle are mostly Highland and country cattle, and the sheep blackfaced, a breed of the Cheviot's called the Linton breed, and Leicesters. Few horses are reared. There are several agricultural societies for the promotion of agriculture in the county, the principal of which is the Stirling Central Union, a very extensive society, numbering about 300 members. It has a cattle show in June which is one of the finest in Scotland, both for quantity and quality, and it has a seed-grain competition both in the spring and autumn of the year. The Falkirk Trysts, the largest cattle and sheep markets in the kingdom, are held on Stenhouse Muir, near Falkirk, on the second Tuesday and Wednesday of August, September, and October, for cattle and horses; and the previous Monday for sheep, in September and October.

Woodlands.

There is a good deal of the less valuable ground covered with oak coppice, which yields a regular income every 21 years for bark. These coppices are in some cases divided into 21 hags or portions, one of them being cut down every year, leaving only a few reserves for standard timber. These hags yield on an average 2½ tons of bark per acre, which, selling at L.8 per ton, yields an income of L.20 per acre every 21 years, or 19s. a year, instead of from a shilling or two up to ten, if they were used for any other purpose. About 30,000 or 40,000 acres are thus occupied.

Manufactures.

The manufactures are carpets, tartans, plaidings, shawls, and other woollen goods, which have obtained a world-wide celebrity, and which are chiefly made in Stirling, Bannockburn, St Ninians, and the neighbouring villages. Blankets and serges are manufactured at Alva. Large cotton-mills occur at Fintry, Balfron, and Milngavie. Printfields exist at Denny, Kincaid, Milngavie, Lennoxtown, and Strathblane. Several paper-mills are situated at Denny and Bridge of Allan. There are several chemical works at Stirling and Falkirk. Tanning is carried on extensively in Stirling, St Ninians, and Falkirk. Distilleries are large and extensive. Nail-making is a considerable trade in St Ninians and the surrounding villages; but the grand staple manufacture is that of iron goods, cast and malleable, at the stupendous works of Carron, the largest iron-foundry in the world. It is situated on the River Carron, about 3 miles above Grangemouth, and was established by royal charter in 1760, under the management of Gascoigne, Caddell, and Company, and has passed through several managements, and is now principally in the hands of the Messrs Dawson and Stainton. The property is divided into 600 shares of L.250 each. The ironworks cover an extent of 40 acres, and contain four large furnaces for smelting the ore—three by hot blast and one by cold blast, perhaps the only one now in Scotland. These furnaces were at one time blown by water-blast, but steam is now used instead; and we believe that the first steam-engine of any size ever made is still to be seen at these works. There are five cupolas and about forty air-furnaces for smelting the pig-iron, also two large forges for tilting scrap iron, for making axle-blocks, &c. This company employ 1200 men at their works, and about 1000 more in pits and mines at Carronhall, Quarrole, Kinnaird, and Netherwood, in the county, besides large fields in other parts of the country. They have now a world-wide connection, and have obtained their position by the manufacture of ordnance for the various European governments, but especially of the once celebrated carronades, which were invented there. They have

Stjernstolpe || Stobæus.

large warehouses in London, Liverpool, Glasgow, and Leith; have five large and powerful steamers plying between Grangemouth and London; seven trading sloops; and about thirty lighters on the Forth and Clyde Canal, which is in connection with the works by means of a railway. They have also railway connection with the Edinburgh and Glasgow line. Owing to its magnitude, Carron has always such a supply of coal and iron as to be quite independent of the fluctuation of these articles in price, and of strikes. The Falkirk Ironworks may be considered an offshoot of the Carron Works. It was established in 1825, employs about 400 men, and covers 10 acres of ground, but has no blast furnaces to manufacture its own iron. There are other two foundries of lesser importance near Camelon.

Roads and railways. The Scottish Central Railway enters the county near Bridge of Allan, and joins the Edinburgh and Glasgow at Greenhill, passing in its route Bridge of Allan, Stirling, Bannockburn, and Larbert. The Edinburgh and Glasgow Railway traverses the county from Linlithgow Bridge to Castlecary, and passes Polmont and Falkirk. The Forth and Clyde Railway, starting from Stirling, runs along the Vale of the Forth, and passes out of the county beyond Kilmaronock. This railway, though by no means a paying one, is eminently useful, as it opens up an extensive tract of county hitherto almost inaccessible except by county roads. The Stirling and Dunfermline Railway is only for 2 or 3 miles within the county. The Stirlingshire Midland Junction was made for the purpose of uniting the Edinburgh and Glasgow at Polmont with the Scottish Central at Larbert, thus shortening the way to Edinburgh. The Denny Junction, a branch of the Scottish Central, runs from Larbert to Denny. The Edinburgh and Glasgow are making a branch line to Grangemouth. The great northern highway runs through the county from a little to the north of Stirling Bridge to Linlithgow Bridge, through Bannockburn, Larbert, Camelon, Falkirk, &c., but is now little used. The Glasgow Road runs through St Ninians and Denny, and the Dumbarton Road through Kippen, Bucklyvie, &c.

Canals. The Forth and Clyde Canal, from Grangemouth to Glasgow, traverses the county a great portion of its length, and is joined near Lock 16 by the Union Canal from Edinburgh, which is also in the county for a number of miles.

Government. Stirlingshire is governed by a lord-lieutenant, a vice-lieutenant, and a court of lieutenancy, a sheriff, two sheriffs-substitute, and two procurators-fiscal.

Population, &c. The principal towns in Stirlingshire are—Stirling, Falkirk, Denny, Grangemouth, Kilsyth, Campsie, and Balfron. The village of Bridge of Allan has obtained great celebrity within the last twenty years for the medical properties of its mineral-waters, which are drunk in great quantities by an immense number of visitors who frequent it. It is unquestionably the greatest watering-place in Scotland. The population of the county, in 1851, was 86,237; the inhabited houses, 11,312; and the valuation for 1859-60, L.276,060. The county returns a member to Parliament, and has a constituency of 1670.

The religion of the county is principally Presbyterian, and is represented by 37 parish and quoad sacra churches, 21 Free Churches, 24 United Presbyterian, 3 Independent, 3 Baptist, 2 Reformed Presbyterian, 5 Scottish Episcopalian, and 4 Roman Catholic. In education the county is well supplied, there being parochial schools in every parish, besides many others belonging to the various denominations and to private individuals. (G. J.)

STJERNSTOLPE. See Scandinavian Literature.

STOBÆUS, Joannes, whose compilations have been found so highly valuable, is supposed to have been born at Stobi, a city of Macedonia. Heeren has endeavoured to render it probable that he must have lived between the years 450 and 500. He does not appear to have been a Christian. From about 500 writers, in verse as well as prose, he extracted and digested an immense collection of passages, which has most commonly been considered as one work divided into four books, the two first being described as *Eclogæ Physicæ et Ethicæ*, and the other two as *Sermones;* but, according to Heeren, they constitute two distinct compilations. As many of the books quoted by Stobæus have scarcely left any other vestiges behind them, his merit in preserving these numerous and variegated reliques of antiquity cannot well be too highly estimated. Of the third and fourth books, otherwise called the *Florilegium*, the Greek text was published by Victor Trincavellus, Venet., 1536, 4to. An edition, accompanied with a Latin version, was published by Conrad Gesner, Tiguri, 1543, fol. It was reprinted at Basel in 1549, and at Zurich in 1559. Of the *Eclogarum Libri Duo*, the Greek text was first published, together with a Latin version by Canter, Antverp, 1575, fol. The editor made use of two manuscripts belonging to Sambucus and Sirlet; and hence a certain bibliographer has described this as Sirlet's edition. A valuable edition of the *Eclogæ* was long afterwards published by Heeren, Gotting., 1792-4, 2 tom., 8vo. The *Florilegium* and the *Eclogæ* had been published in the same volume, under the title of *Stobæi Sententiæ, ex Thesauris Græcorum Delectæ*, Lugduni, 1608, fol. Some copies have a new title, with the date of 1609. We must not overlook the elegant labours of Grotius, *Dicta Poetarum quæ apud Stobæum Exstant, Emendata, et Latino Carmine Reddita*, Paris, 1623, 4to. The editions have all been nearly superseded by that of Gaisford, Oxon., 1822, 4 tom., 8vo. The text, which has been adjusted with great industry and skill, is not accompanied with a Latin translation.

Stockholm.

STOCKHOLM, an important city in the north of Europe, the capital of Sweden, occupying a fine position on the strait that connects Lake Mälar with the Baltic, about 36 miles from the sea by water, 380 miles N.E. of Copenhagen, and 440 W.S.W. of St Petersburg, N. Lat. 59. 20; E. Lon. 18. 3. It has been called the Venice of the north; and there is some reason for the appellation from the similarity of its situation, partly on the mainland and partly on several small islands. Though inferior in general effect to that beautiful Italian city, Stockholm presents from some points a very imposing aspect; and the natural beauties of its environs far surpass those of Venice. It consists of three parts; the city proper, occupying three islands, which are so united as to form to all appearance but one; the northern suburb, *Norrmalm*, and the southern suburb, *Södermalm*, which stand on the mainland on either side of the strait. The islands are known by the name of Holms, those on which the city proper is built are Stockholm (the Castle Island), or Staden (the City), which is the largest of the three; Riddarholm (Knight's Island), to the west; and Helgeandsholm (Holy Ghost Island), to the north. There are also several other islands, covered in whole or in part with buildings; such as Kungsholm (King's Island), to the west of the northern suburb; Blasiiholm, which has been converted into a peninsula; Skeppsholm, (Ship Island), and Kastellholm (Castle island), all lying to the east of the city proper. All of these subdivisions of the city are connected with the mainland, and with one another by numerous bridges, the finest of which is the new bridge of granite, from the city proper to the northern suburb. On the mainland to the north the ground rises gradually as it recedes from the water, while to the south the cliffs are more bold and abrupt, and many of the houses nestle amid overshadowing trees in the various ledges of the rocks. Although the ground on which a great part of Stockholm is built is hard and rocky, yet all the lower portions of the city are founded on piles. The streets, espe-

Stockholm. cially in the city proper, which is the oldest portion, are very narrow and irregular; though in the other parts of the town and suburbs, more attention is paid to straightness and uniformity, yet even there they are of no great width. The houses in the city are in general built of stone; those in the suburbs of brick, and in the more remote portions sometimes only of wood. There are several public squares and market-places; some of them of considerable size. The public buildings are numerous, but most of them are not very remarkable. By far the largest and finest of these is the palace, which occupies the northern part of the Staden Island, and is conspicuous for its immense size and slightly elevated position. It was begun in 1697 and completed in 1753, after the designs of Count Tessin; and from whatever point it is viewed it presents an aspect imposing from its simple and massive grandeur. The lowest story is of granite, the rest of brick covered with stucco. Its form is quadrangular, with two projecting wings towards the north-east. The finest front is that facing south-east, which has a portico of six Corinthian columns. On the north-west it is approached by the new bridge leading from the northern suburb; and on the north-east, where it faces a spacious quay, there is between the two wings a terrace beautifully laid out as a flower-garden. The palace contains a picture gallery, sculpture gallery, royal museum, royal library of about 70,000 volumes, cabinets of antiquities, &c. The chapel is profusely decorated, but not in very good taste. The royal apartments occupy the north-east side of the quadrangle, and are approached by a fine staircase. The royal wardrobe and armoury, containing many suits of armour and of clothes which belonged to former monarchs and famous men, has been removed to a large building in the Gustavus Adolphus market, in the northern suburb; and the royal stables, which can accommodate 146 horses, stand on the Helgeandsholm. South of the palace is an esplanade, called the Slottsbacken, in which stand a tall granite obelisk, and a bronze statue of Gustavus III. Here also is the Cathedral of St Nicholas, the most ancient church in Stockholm, whose lofty tower has a very picturesque effect. In the interior there are two large pictures, and an altar-piece richly carved in ebony, and adorned with ivory, gold, and silver. Much more interesting is the Riddarholms Church, on the island of that name. It is an old Gothic building, but has been considerably altered by various additions and restorations, and it is now only used as a royal mausoleum. The aspect of the interior is very impressive, but quite different at first sight from that of a church. All round the walls there are equestrian figures, clothed in complete suits of armour, worn by the several sovereigns of Sweden. The figures are eleven in all: one is clothed in the heavy armour of Birger Jarl, the founder of Stockholm; another wears the helmet of Charles VIII., with a vizor in the form of a man's face; and a third, a richly wrought suit of armour, said to have been made by Benevenuto Cellini for Charles IX. In a side chapel of this church is the tomb of Gustavus Adolphus, surrounded by a multitude of flags and other trophies of his victories. Here are also preserved the clothes that he wore when killed on the field of Lützen. Opposite to this is another chapel, containing the remains of Charles XII., in a marble tomb; and here also are to be seen the cloak and hat worn by the hero in the trench before Fredrickshald, the latter pierced by the bullet that terminated his existence. Many other Swedish monarchs lie in the vaults of this church, and among their tombs not the least interesting is that of Bernadotte or Charles XIV. Many noble and distinguished Swedes, not of royal lineage, are interred in this church; and the shields of the knights of the seraphim are hung round the choir. Of the other churches in Stockholm, of which there are 20, none are very remarkable; in one of them, that of Adolphus Frederick, there is a monument to Descartes, who died at the Swedish court. The Riddarhus, or house of assembly for the nobles, is a plain and not very elegant structure, with many interesting historical associations. The hall of the assembly is hung round with the escutcheons of the nobility, and contains a president's chair, of fine Dutch workmanship in ebony and ivory. Stockholm has two theatres, one of which is a large and handsome building in the northern suburb, opposite the palace. Beside this building is the square of Gustavus Adolphus, containing a fine bronze statue of that monarch. The principal other public buildings are the governor's house, the town-hall, exchange, post-office, arsenal, and barracks. On the Skeppsholm stand most of the buildings connected with the admiralty. The educational institutions of the city are numerous, including a medical college, technological institution, naval and military schools, and several others. There are numerous scientific, literary, and artistic societies; and many hospitals, infirmaries, and other charitable establishments. Stockholm is the chief seat of the manufacturiug industry of Sweden; it produces metal fabrics, silk, woollen cloth, hosiery, cotton, linen, sugar, tobacco, &c. There are here, too, a porcelain manufactory and numerous printing-presses, and many mathematical and optical instruments are prepared. The southern suburb, which is occupied chiefly by tradespeople, contains an immense iron magazine, and a large dock. The trade of the city is very considerable. The chief articles of export are—iron of various kinds, steel, copper, lead, grain, timber, leather, oil-cakes, and butter. Among the imported goods are—coals, cotton, wool, raw silk, coffee, sugar, spices, tea, wine, and spirits, &c. The following table exhibits the total declared value of the exports and imports of Stockholm for several years from 1851 to 1857:—

	Imports.	Exports.
1851	L.948,844	L.533,508
1853	831,432	548,092
1855	1,412,518	709,575
1856	1,829,380	629,466
1857	1,295,568	615,502

In 1857 the exports and imports were distributed among different nations, as follows:—

	Imports.	Exports.
Great Britain and colonies	L.269,846	L.175,026
Hanse Towns	306,034	92,732
Russia	225,472	8337
Prussia	100,322	72,354
Brazil	137,886	12,627
France and Algiers	41,072	53,722
Denmark	37,088	46,957
Other countries	177,848	153,747
Total	L.1,295,568	L.615,502

There are more than 200 vessels belonging to the port of Stockholm. In 1856 the number that entered was 1711, with an aggregate tonnage of 196,350; the number that cleared, 1662; tonnage, 171,740. The harbour is somewhat difficult of entrance, but very large and excellent; the quays are spacious, and the largest vessels can lie close to them. Numerous steamers ply between Stockholm and Lubeck, Stettin, St Petersburg, and other places. In the environs of the city there are many beautiful and much frequented parks and promenades. One of the finest of these is the *Djurgård*, or deer-park, which occupies an island to the east of the city, and is easily accessible by ferry-boats. In this park stands the palace of Rosendal, built by Bernadotte; and there are here also many theatres, ball-rooms, and coffee-houses. The *Ladugardsgård*, or review-ground, lies to the north of this, across a narrow arm of the sea; the Haga Park, to the north-west of the city, is another favourite resort; as also is the park of Carlsberg, which contains a favourite palace of Charles XII., now occupied by the military academy. At a somewhat

Stocking. greater distance from Stockholm there are several other royal and baronial residences, occupying beautiful situations on the islands or shores of Lake Mälar. Stockholm was founded about the year 1260, by Birger Jarl, who made it his residence. But even before this time the site had been occupied; Odin had built here the city Sigtuna, which flourished for several centuries before the introduction of Christianity; but is now entirely perished, save a few scattered ruins. It was near this site, also, that the first Christian colony was settled in Sweden; but their abodes also have almost entirely perished. Stockholm was strongly fortified, and sustained several sieges. One of the most memorable of these took place in 1501 and 1502, when it was held for nearly six months by Queen Christina of Denmark against the Swedish insurgents, but was at last surrendered after the garrison had been reduced from about 1000 to 80 in number. A still more noble defence of the city was made in 1520, by Christina Gyllenstierna against Christian II. of Denmark. It was surrendered after a siege of four months; but the terms of the surrender were violated soon after by the conqueror ordering the execution of all the most distinguished Swedes in the town. This and similar acts of treachery and cruelty led to the final expulsion of the Danes by Gustavus Vasa. It was not till the seventeenth century that Stockholm became the capital of Sweden, Upsala having previously to that time enjoyed that distinguished honour. Pop. (1859) 101,502.

STOCKING, that part of the clothing of the leg and foot which immediately covers them from the cold. Anciently, the only stockings in use were made of cloth, or of milled stuffs sewed together; but since the invention of knitting and weaving stockings of silk, wool, cotton, thread, &c., the use of cloth stockings is quite discontinued. Dr Howell, in his *History of the World*, vol. ii., p. 222, relates, that Queen Elizabeth, in 1501, was presented with a pair of black knit silk stockings by her silk-woman, and thenceforth she never wore cloth ones any more. The same author adds, that King Henry VIII. ordinarily wore cloth hose, except there came from Spain, by great chance, a pair of silk stockings. His son, King Edward VI., was presented with a pair of long Spanish silk stockings by Sir Thomas Gresham, and the present was then much taken notice of. Hence it should seem that the invention of silk knit stockings originally came from Spain. Others relate, that one William Rider, an apprentice on London Bridge, seeing at the house of an Italian merchant a pair of knit worsted stockings from Mantua, took the hint, and made a pair exactly like them, which he presented to William earl of Pembroke, and that they were the first of that kind worn in England, anno 1564. The modern stockings, whether woven or knit, are formed of an infinite number of little knots, called stitches, loops, or meshes, intermingled in one another. Knit stockings are wrought with needles made of polished iron or brass wire, which interweave the threads, and form the meshes of which the stocking consists. At what time the art of knitting was invented, it is perhaps impossible to determine, though it has been usually attributed to the Scots, as it is said that the first works of this kind came from Scotland. It is added, that it was on this account that the company of stocking-knitters established at Paris in 1527 took for their patron St Fiacre, who is said to have been the son of a king of Scotland. But it is most probable that the method of knitting stockings by wires or needles was first brought from Spain.

Woven stockings are generally very fine. They are manufactured on a frame or machine made of polished iron, the structure of which it is needless to describe, as it may be seen in almost every considerable town in Great Britain. The invention of this machine is, by Mr Anderson, attributed to William Lee, M.A. of St John's College, Cambridge, at a period so early as 1589. Others have given the credit of the invention to a student of Oxford at a much later period, who, it is said by Aaron Hill,[1] was driven to it by dire necessity. This young man falling in love with an innkeeper's daughter, married her though she had not a penny, and he by his marriage lost a fellowship. They soon fell into extreme poverty; and their marriage producing the consequences naturally to be expected from it, they became miserable, not so much on account of their sufferings, as from the melancholy dread of what would become of their yet unborn infant. Their only means of support was the knitting of stockings, at which the woman was very expert. "But sitting constantly together from morning to night, and the scholar often fixing his eyes, with steadfast observation, on the motion of his wife's fingers in the dexterous management of her needles, he took it into his imagination that it was not impossible to contrive a little loom which might do the work with much more expedition. This thought he communicated to his wife, and joining his head to her hands, the endeavour succeeded to their wish. Thus the ingenious stocking-loom, which is so common now, was first invented; by which he did not only make himself and his family happy, but has left his nation indebted to him for a benefit which enables us to export silk stockings in great quantities, and to a vast advantage, to those very countries from whence before we used to bring them, at considerable loss in the balance of our traffic."

Stockport. STOCKPORT, a market-town, parliamentary and municipal borough of England, in Cheshire, on the borders of Lancashire, at the confluence of the Mersey and the Tame, 5 miles S.E. of Manchester. It occupies a pretty steep hill, washed on two sides by the Mersey; and the houses rise in irregular tiers from the base to the summit, so as to present, especially by night, when the factories and other buildings are lighted up, a very picturesque appearance. The older part of the town occupies the central and most elevated position, where there is a spacious market-place on a pretty, flat piece of ground. From this the various streets, which are for the most part steep and narrow, diverge in different directions. The Mersey is crossed by four bridges, and the Tame by one, which connect the town proper with several extensive suburbs on their other sides. Heaton-Norris, Edgeley, and Portwood are the names of the largest of these. The old bridge over the Mersey consists of one lofty arch. Below this is another, recently built, with 11 arches, crossing not merely the river, but many of the streets, at an elevation of 40 feet above the water. Much loftier is the viaduct of the London and North-Western Railway, which is supported by 26 arches, the central one 110 feet above the river. The principal building in Stockport is the parish church, which stands near the market-place. It was originally built in the fourteenth century, but has been almost entirely rebuilt in modern times, in the perpendicular style. The chancel retains the original decorated architecture, and was restored in 1848; it contains fine stone stalls and some interesting tombs. This church has also a lofty pinnacled tower, with a peal of eight bells. St Thomas's church is a fine Grecian building, with a tower and cupola. The other churches belonging to the Establishment are 6 in number within the limits of the borough; besides which, there are numerous dissenting places of worship, 15 belonging to different sects of Methodists, 5 to Independents, 3 to Baptists, and 1 each to Roman Catholics, Unitarians, and Mormonites. Another conspicuous edifice in the town is the new market-house, which has a handsome front, and contains a spacious hall, roofed with

[1] See an *Account of the Rise and Progress of the Beech Oil Invention*, &c., 8vo, 1715.

iron and lighted from above. Other public buildings are the court-house, barracks, theatre, and news-room. Some of the schools also occupy large and handsome edifices. Chief among these is the free grammar-school, founded in 1487, and under the patronage of the Goldsmith's Company of London. The school-house was rebuilt in a handsome style in 1832. A national school, which was founded here in 1805, has a large and fine building. There are, besides these, British and infant schools, and Sunday schools belonging to the different denominations. One of the last-mentioned occupies an enormous building, containing 84 class-rooms, and attended by about 4000 children. Stockport has a mechanics' institute; an infirmary, with a Grecian front, occupying a prominent position in the town; a dispensary; almshouses; poorhouse; and other charitable institutions. The cotton manufacture has one of its chief seats in this town; where it has supplanted the silk trade that formerly used to flourish here, but has very much declined. For spinning and weaving cotton there are in the town and suburbs about 100 houses, employing in all more than 3800 horse-power. One of the factories is an immense building, 300 feet by 200, having six storeys and about 600 windows. In addition to these there are three houses for printing cotton, two for bleaching, and several for dyeing. Silk goods, thread, hats, brushes, spindles, &c., are also manufactured here: the casting of brass and iron, the making of machinery, and brewing are carried on, and there are several brick-fields in the vicinity. Manufacturing industry is greatly favoured by the abundance of coal found in the neighbourhood. Markets are held weekly, and fairs four times a year. The town stands on a branch of the Manchester and Ashton Canal, and is the place of junction of several important lines of railway. The borough is governed by a mayor, 13 aldermen, and 42 councillors; and returns two members to Parliament. Stockport is believed to occupy the site of an old Roman station, which stood at the junction of several roads, and was thus a place of considerable importance. A Roman fort probably stood on the place afterwards occupied by a castle, which has now entirely disappeared. It was held in 1173, by Geoffrey de Constantin against Henry II. During the civil war of the seventeenth century, Stockport was the scene of some fighting: it was taken from the Parliamentarians by Rupert in 1644, but retaken by Lesley in the following year. In 1745, the town was occupied by Prince Charles Edward. It was first made a municipal and parliamentary borough by the Reform Act of 1832. Pop. of the borough (1851) 53,835.

STOCKS, or PUBLIC FUNDS *in England*. See FUNDING SYSTEM.

STOCKTON-UPON-TEES, a market-town and municipal borough of England, in the county of Durham, on the left bank of the Tees, about 4 miles from its mouth, and 18 miles S.E. of Durham. It is for the most part substantially built of brick, and regularly laid out, having one main street nearly a mile in length, running from north to south. At the south end of this street a handsome stone-bridge of five arches crosses the river into Yorkshire. A short distance below this bridge the river bends towards the north, where it is lined by a wharf running parallel to the main street, and connected with it by numerous smaller streets. West of the principal street there are many handsome new streets and buildings, and in the north-east of the town is a large square, planted with trees, and lined with good houses. The parish church is a large edifice of brick, erected in 1710 on the site of one as old as 1234. It has a tower 80 feet high, and contains a theological library. Trinity Church is a neat Gothic building, with a square tower and octagonal spire. Stockton also contains places of worship for Independents, Methodists, Presbyterians, Quakers, Baptists, Roman Catholics, and Unitarians. Several of these have Sunday schools attached to them; and there are, besides, National, British, and infant schools; a bluecoat charity school, school of industry for girls, a library, newsroom, and mechanics' institute. Among the charitable institutions there are several almshouses and a dispensary. The town-hall, a square building with a clock-tower, stands in the market-place, and near it is a handsome Doric column, 33 feet high, which occupies the site of the old market-cross. Stockton has also a custom-house, theatre, assembly-rooms, and billiard-rooms. The manufactures and trade of the town are both very extensive. Among the former, the most important are those of linen and sailcloth, ropes, and worsted, along with the building of ships and boats, the casting of brass and iron, brewing, &c. The town imports from foreign countries masts, spars, and timber, iron, hemp, flax, tallow, and hides; from British ports, groceries, wine, spirits, and colonial wares. The chief article exported to foreign lands is lead; to London and other ports in this country are sent flour, butter, cheese, linen, yarn, timber, and coal. In 1857, there were registered as belonging the port, 137 sailing-vessels, tonnage 28,261; and 30 steamers, tonnage 2986. In the same year there entered the port 1180 sailing-vessels, tonnage 122,411; and 129 steamers, tonnage 28,680: and there cleared 2683 sailing-vessels, tonnage 259,560; and 180 steamers, tonnage 45,191. The river is navigable for some distance above the town, and its navigation has been improved by a cut made just below, which avoids a considerable bend in the river, and facilitates the access of vessels to the town. Ships of 300 tons burden can come up to the quays of Stockton. The town is connected by railway with all the lines in Great Britain; and the line from this to Darlington was the first that was constructed, having been opened for goods in 1825, and at a later period also for passengers. Stockton is an ancient place; it was at one time the residence of the bishops of Durham, who had a castle here, of which, since its demolition in 1652, only a few traces remain. The town was plundered by the Scotch in 1325; and in the civil war of Charles I. it adhered to that monarch, but was taken by the Scotch in 1644. The borough is governed by a mayor, 5 aldermen, and 18 councillors. Pop. of the borough, 10,459; of the town, 9808.

STODDART, SIR JOHN, was born in 1773, and was educated at the grammar-school of Salisbury, under Dr Skinner. Having made considerable proficiency at that institution, he entered Christ Church, Oxford, in 1790, where he studied divinity; but subsequently preferring the law, he commenced the study of it, and took the degree of D.C.L. in 1801. In 1796 and 1798 he had engaged in a joint translation of the *Fiesco* and *Don Carlos* of Schiller with Dr Noehden. Taking, at the outset, a favourable view of the French Revolution, he had published in 1797 a translation of a French work on the Executive Directory of France. In 1801 he wrote *Remarks on Local Scenery and Manners in Scotland, during the years* 1799 *and* 1800, 2 vols. 4to. Stoddart having entered the College of Advocates, was appointed in 1803 King's Advocate and Admiralty Advocate in Malta, where he remained for the next four years. In 1810 he commenced writing on politics in *The Times* newspaper, which in 1812 led to his appointment as political editor of the same journal. With much energy, great knowledge, a clear style, and a great deal of bluster, he wrote such vigorous and often absurd articles in "the great Thunderer," as led to his being burlesqued and caricatured by the wits of London as the great Dr Slop of Printing-House Square. The proprietors of *The Times* disapproving, it is said, of the rancour of his fulminations against the exiled Emperor N. Buonaparte, dissolved his connection with that newspaper in 1816. In 1817 he made an attempt to revive his decadent political glory by the publication of the *New Times*. The English people did

not regard his fire and fury, and allowed it quietly to burn itself out. In 1826 he was made a knight, and was appointed Chief-Justice and Judge of the Vice-Admiralty Court of Malta, where he remained during the next thirteen years. On his return to England he went into retirement, where he is said to have been much and widely esteemed. He wrote *An Introduction to General History*, and a *Universal Grammar* for the *Encyclopædia Metropolitana*, which have also appeared as separate works. Besides writing political pamphlets on various subjects of popular note, he took a lively interest in the amendment of law; and at the first meeting of the Law Amendment Society after his death, which occurred on February 16, 1856, Lord Brougham pronounced a eulogium on his memory.

STOICS, the name given to that sect of Grecian philosophers founded by Zeno of Citium, from Στοα, the porch in Athens where he taught.

STOKE-UPON-TRENT, a market-town and parliamentary borough of England, in the county and 16 miles N. by W. of Stafford, 148 miles N.W. of London, on the Trent. The borough is much more extensive than the town, and includes a large portion of the district known by the name of the Potteries, comprising several distinct parishes and townships. The town of Stoke has been of late much improved, and is now very well built: the town-hall is an elegant edifice, and the parish church is a fine specimen of the later English architecture, with a beautiful painted window and several monuments, including that of the celebrated Wedgwood. The Baptists, Quakers, and several sects of Methodists, have also places of worship in the town. Education is provided for by National and Diocesan schools. The principal manufactures of the place are those of china and earthenware, in which a very large proportion of the people is employed. There are also extensive coal-works in the vicinity. Markets are held weekly, and are well supplied with all kinds of provisions. The borough has been represented in Parliament by two members since the Reform Act of 1832. Dr Lightfoot, the celebrated and learned divine, was born at the rectory of Stoke-upon-Trent in 1602. Pop. of the borough, 84,027; of the parish, 57,942.

STOLBERG, THE BROTHERS. COUNT CHRISTIAN STOLBERG, who was the eldest of the two celebrated men who bore this name, was born of an ancient family in Germany on the 15th October 1748. LEOPOLD FRIEDRICH STOLBERG, who was the younger brother, was born on the 7th November 1750. They prosecuted their studies together at the University of Göttingen, where they cultivated literature and allied themselves with that band of poets who were then rising into fame, of whom the chief were Bürger, Voss, and Holty. They became distinguished for their classical taste; were enormous admirers of Klopstock, and judged Ossian divine. The younger brother executed a very tolerable translation of Homer's *Iliad*, and subsequently published a translation of a portion of Æschylus. The two brothers made a tour with Goethe through Switzerland and part of Italy, and returned by way of Copenhagen. Christian having now married, the two brothers had to separate. After composing some dramas on the classical models, and serving under the prince-bishop of Lubeck, Friedrich likewise married in 1782. In 1785 he was intrusted by the Danish court with a mission of importance to the court of Russia. On his return he retired to Neuenburg in Prussia, where he wrote *Der Island*, a sort of novel, containing dialogue, reflection, description, and recommendation. In 1789 he was again invited by the Danish court to act as its minister to the court of Prussia. He continued to reside in Berlin after his embassy was at an end, and made another tour through Germany, Switzerland, Italy, and Sicily, of which he published an account in four discursive volumes in 1794. He was subsequently employed on various embassies between the courts of Denmark and Russia. Friedrich had hitherto been a zealous Protestant, but the aspects of the French Revolution seemed to have awakened alarm within his breast. The Protestants of Germany for the most part eyed favourably that baptism of blood and fire which the French nation was undergoing, and from this, or perhaps from some deeper cause, he went over with his whole family to the Church of Rome. After his conversion he wrote his *Geschichte der Religion Jesu Christ*, which was published in 15 volumes in 1806. His works, which are very varied, consist of odes, satires, hymns, elegies, translations, dramas, histories, and novels. He died on the 5th September 1819. His brother Christian wrote poems, dramas, translations, and biographies, and died on the 18th of January 1821. The younger brother had the most ability, but both, in many of their writings, display noble sentiment, kindly feeling, and lofty aspiration.

STOLPE, a town of the Prussian monarchy, Pomerania, in the government and 38 miles N.E. of Cöslin, on the river Stolpe, about nine miles above its mouth. It has a castle, built in 1507, and is surrounded by walls and entered by four gates. Here are four churches, a nunnery, several hospitals, a court of law, and public offices. One of the churches is remarkable for its antiquity, and another for a very lofty tower. Stolpe is the chief seat in Pomerania of the manufacture of amber articles, and carries on a considerable trade in these, as well as in linen, timber, and fish. At the mouth of the river stands its port, Stolpemünde, which has a considerable navigation and fishery. The river abounds in salmon. Pop. 11,340.

STONE, EDMUND, a distinguished self-taught mathematician, was born in Scotland, but neither the place nor the time of his birth is well known; nor have we any memoirs of his early life, except in a letter from the Chevalier Ramsay to Father Castel, a Jesuit of Paris, and published in the *Mémoires de Trevoux*. Born the son of a gardener of the Duke of Argyle, he was eight years of age before he learned to read. By chance a servant having taught him the letters of the alphabet, there needed nothing more to expand his abilities. He applied himself to study, and arrived at the knowledge of the most sublime geometry and analysis, without a master, without a conductor, without any other guide but the light of his own mind. He was author and translator of several useful works, viz., *A New Mathematical Dictionary*, in 8vo, first printed in 1726; *Fluxions*, in 8vo, 1730; the Direct Method is a translation from the French of De l'Hospital's *Analyse des infiniment Petits*, and the Inverse Method was supplied by Stone himself; *The Elements of Euclid*, in 2 vols. 8vo, 1731. Stone was a fellow of the Royal Society, and had inserted in the *Philosophical Transactions* (vol. xli., p. 218) an "Account of two species of lines of the 3d order, not mentioned by Sir Isaac Newton or Mr Stirling." In 1758 he published "The Construction and principal Uses of Mathematical Instruments;" translated from the French of M. Bion. In 1742 or 1743 his name was withdrawn from the list of the Royal Society; and in his old age he appears to have been left to poverty and neglect. He survived till March or April 1768.

STONEHAVEN, a burgh of barony and market-town of Scotland, in the county of Kincardine, at the mouth of the rivers Carron and Cowie, in a small bay on the German Ocean, 15 miles S. by W. of Aberdeen. It consists of an old and a new town, the former on the right and the latter on the left bank of the Carron, which is here crossed by a bridge connecting them. The old town has one principal street, broad but irregular, and is in general but ill built; the new town, on the contrary, has a spacious square and several streets running in straight lines parallel or at right angles to each other. In the square stands a fine market-house, and the houses in this part of the town are for the

most part superior to those in the older portion. In the vicinity of Stonehaven stand the parish churches of Dunottar and Fetteresso, and there are also others belonging to the Free Church, the United Presbyterians, and the Scottish Episcopal Church. The town has several schools, a literary institution, library, court-house, and jail. Cotton and linen fabrics are manufactured here, and there are also a distillery and a brewery. Haddock and herring fishing give employment to many of the people. The harbour is a natural basin, but has been improved by the erection of piers; it is, however, only accessible to small vessels. Two miles further south, on a rock overhanging the sea, and separated from the mainland by a deep chasm, stand the ruins of Dunottar Castle, once the seat of the Earls Marischal. Pop. 3240.

STONEHENGE, a singular and gigantic remnant of antiquity, consisting of enormous stones, in an upright or horizontal position, in Salisbury Plain, Wiltshire, about 2 miles W. of Amesbury, and 9 N. of Salisbury. When seen from a distance its appearance is somewhat insignificant, on account of its position on a wide, unbroken plain; and even when close at hand, it requires some careful examination before its magnitude can be fully appreciated. It is the prevailing opinion among antiquarians that Stonehenge owes its origin to the Druids, and it has attracted much attention, as it is of great extent, and in some respects very different from other remains of the same general character. The plain in which it stands is covered with a great number of mounds or barrows, many of them containing ancient British remains. Stonehenge itself is enclosed by a double mound or ditch, circular in form; and there is an avenue or approach leading from the north-east, and bounded on each side by a similar mound and ditch. The outer mound is 15 feet high, the ditch nearly 30 feet broad, the whole 1009 feet in circumference, and the avenue 594 yards long. The whole fabric consists of 2000 circles and two ovals. The outer circle is about 108 feet in diameter, consisting, when entire, of 60 stones, 30 uprights and 30 imposts, of which remain only 24 uprights, 17 standing and 7 down, 3½ feet asunder, and 8 imposts. Eleven uprights have 5 imposts on them by the grand entrance. These stones are from 13 to 20 feet high. The smaller circle is somewhat more than 8 feet from the inside of the outer one, and consisted of about 30 smaller stones (the highest 6 feet), of which only 19 remain, and only 11 standing: the walk between these two circles is 300 feet in circumference. The central portion is an oval formed of 10 stones (from 16 to 22 feet high), in pairs, with imposts, which Dr Stukeley calls *trilithons*, and each pair separate, and not connected as the stones in the outer circle are. Within these were a number of smaller single stones, of which only 6 are standing. At the upper end of the adytum is the altar, a large slab of blue coarse marble, 20 inches thick, 16 feet long, and 4 broad; pressed down by the weight of the vast stones that have fallen upon it. The whole number of stones, when the structure was complete, is calculated to have been about 140. Many of the stones have been more or less hewn, and they appear to have been brought from Marlborough Downs, 15 or 16 miles off, as they appear to be of the same hardness, grain, and colour, generally reddish, with the Gray Weathers still found there. The heads of oxen, deer, and other beasts, have been found on digging in and about Stonehenge, and human bodies have also been discovered in the circumjacent barrows. There are three entrances from the plain to this structure, the most considerable of which is from the north-east, and at each of them were raised on the outside of the trench two huge stones, with two smaller within, parallel to them.

It has been long a dispute among the learned, by what people and for what purpose these enormous stones were collected and arranged. The first account of the structure we meet with is in Geoffrey of Monmouth, who, in the reign of King Stephen, wrote the history of the Britons in Latin. He tells us that it was erected by the counsel of Merlin, the British enchanter, at the command of Aurelius Ambrosius, the last British king, in memory of 460 Britons who were murdered by Hengist the Saxon. The next account is that of Polydore Vergil, who says that the Britons erected this as a sepulchral monument of Aurelius Ambrosius. But other writers in the 12th century discredit all these accounts; and it appears that even at that early time all knowledge of its origin and intention had passed away. Inigo Jones is of opinion that it was a Roman temple, from a stone, 16 feet long and 4 broad, placed in an exact position to the eastward, altar-fashion. Dr Charlton attributed it to the Danes, who were two years masters of Wiltshire. Many other theories have been since propounded, and supported with more or less ingenuity and plausibility; but in a matter so obscure little more than a probable conjecture of the truth can be hoped for. It seems most likely that Stonehenge was erected by the ancient Britons for solemn religious rites; and from the art displayed in its construction, it could not have been much earlier than the time of the Roman conquest. In the vicinity of Stonehenge are the remains of what seems to have been an ancient race-course; and as in early times the public games were generally connected with religious celebrations, it is highly probable that this was in connection with the temple at Stonehenge.

STONEHOUSE, a village of Scotland, Lanarkshire, 15 miles S.E. of Glasgow. It consists chiefly of thatched houses, and contains an Established church, a Free church, and a United Presbyterian church. The people are largely employed in weaving silk, cotton, and woollen fabrics, and there are in the vicinity coal-pits, lime-kilns, and brick-works. Pop. of the parish, 2781.

STONEHOUSE, a village of England, in the county of Gloucester, 3 miles W. of Stroud. It has an old parish church, places of worship for Wesleyans and Independents, an endowed school, and manufactories of cloth. It stands on the Stroudwater Canal, and is a station on the Great Western Union Railway. Pop. of the parish, 2589.

STONEHOUSE, a suburb of Plymouth. See PLYMOUTH.

STONE-MASONRY.

History.

Definition and derivation.

1. Stone-Masonry is the art of building in stone. The word *mason* is derived directly from the French *maçon*, which signifies indifferently a bricklayer or mason. Du Cange attributes the origin of the word to the low Latin *maceria*, a wall; others have endeavoured to show that it comes from *machina*, because builders use machines for hoisting materials; but by far the most probable derivation is that of the French *maison*, a house; thus *maisonner* is to build houses, and the *maçon*, the man who builds them. Among ourselves, at present, we reckon three sorts of artificers—rubble or rag-stone masons, freestone masons, and marble masons. This last branch, however, is rather that of the carver or statuary. The art of working or reducing stone to the proper shape for the mason to *set*, or place them in the walls, &c., has generally been called *stone-cutting*, and depends very much on the nature of the stone for its details.

Origin and history.

2. The art of building with stone is of very great antiquity; it was originally, no doubt, suggested by the holes in the rocks, or natural caves, in which our forefathers sheltered themselves from the inclemencies of the weather. The perishable nature of their wooden huts afterwards suggested an imitation of them in stone as a durable material; and the trunks of trees, and the beams laid across them, were probably the prototypes of columns and architraves.

Cromlechs, &c.

3. Among rude and barbarous people there seems to have been always a great desire to erect huge masses of stones, either as memorials of some event, or for the purposes of religion, and the early history of almost every country treats of some of these structures. (See *Cromlechs*, *Stonehenge*, *Architecture*, p. 423, &c.) The treatises of Dr Lukis, and other papers in *Archæologia*, give the fullest account of these structures.

Cyclopæan masonry.

4. The necessity for defence against predatory tribes seems to have given the next impulse to building with stone, and to this we probably owe those extraordinary walls, commonly called Cyclopean or Pelasgic (*Architecture*, p. 439). These are huge polygonal blocks of stone, carefully cut so as to fit exactly to each other without mortar, and forming walls which must have been impregnable at that time. An idea of their size may be gathered from the fact that in the Etruscan walls at Rusellæ, Mr Dennis (*Cities and Cemeteries of Etruria*, vol. ii.) measured a stone 12 feet 8 inches long by 2 feet 10 inches high. Most of the blocks forming these walls would weigh from 6 to 8 tons. It seems very difficult to understand in that state of civilization how they were hoisted and set. Pausanias (ii. 25), describing those of Argolis, says,—"The walls, the only remains of the city left, are the work of the Cyclops, and are made of rough blocks of such size that a yoke of mules would be unable to move the smallest."

Nineveh, Persepolis, &c.

5. At Nineveh the walls seem mostly of unburned brick, but they are lined with huge slabs of marble, or rather a species of alabaster, the working and carving of which show a very great advance in art. (See Nineveh.) The architecture of the Hindus, Persians, Phœnicians, and Jews, will be found under their respective heads. (Art. Architecture.) But there is nothing about their *masonry* differing from that of other similar structures on which it would be profitable to dwell.

Egyptian masonry.

6. The Egyptians, however, seem not only to have used gigantic masonry, but also to have had the power of working, carving, and polishing granite in a way which we certainly cannot at present attain to. The most marvellous fact connected with their masonry seems to be that the whole work was executed with copper or rather bronze tools, which seem to have answered their purpose better than even our best and hardest steel. Such seems to have been the facility with which they worked this, to us untractable material, that they were not content to cut and polish huge slabs and masses of granite, but they covered them all over with the most delicate and sharp-cut hieroglyphical inscriptions.

Greek masonry.

7. The masonry of the Greeks yet remaining is chiefly of beautiful marble. The workmanship is of the most exquisite character, the joints, &c., of the greatest truth. The artistic beauties of the carving, &c., have been unrivalled at any period. It seems difficult to believe that so enlightened a people were ignorant of the use of the arch, especially as it is clear it was known not only to the Egyptians, but was used at Nineveh. However, no example of a Greek arch exists at this time, as an architectural feature, although, as has been said before (art. Arch, § 8, p. 401), for necessary purposes (as covering drains), and concealed in the walls (as discharging arches), examples are to be found in Greek works. (See Ferguson's *Hand-Book*, p. 252; *Architecture Suppl.*, § 2, p. 500.) It is probable that, as they had plenty of marble in blocks of almost any size, they preferred to use it in horizontal bearings, to working it into arch forms.

Roman masonry.

8. It was, however, the contrary with Roman masons; although it is true many of their temples were Greek in character, and most of them rivalled those of that nation in size and in the vastness of their material.[1] But in general there was less of that ponderous strength that characterized the Egyptian and the Grecian Doric; and much more science in the construction, particularly as regarded economy; though in point of artistic beauty they were far below the Greeks. To what nation or race the invention of the arch may be attributed, it is clear the Romans were the first to bring it into general use; and though we read of a species of dome among the Greeks called θολος, and though the Hindus delight in domical construction, it is clear the Romans were the first in Europe to use the true dome in covering their temples. Besides this, they had not only good lime but plenty of pozzolano, and therefore their mortar and cement were of first-rate quality. To these advantages we may attribute the vast works which to the present day amaze the spectator, who cannot view their cloacæ, aqueducts, amphitheatres, basilicæ, walls, towers, tombs, domes, harbours, without wonder at the enterprise of the people and the skill of their masons.

Mediæval masonry.

9. After the ruin of the Roman empire, and the irruption of the savage hordes over the whole of civilized Europe, the art of masonry, like all others, declined to the lowest ebb. In fact, except for the erection of rude forts and towers, it became almost extinct. In England we owe its first revival to the works of the Norman invaders; and next, no doubt, to the return of the crusaders, who had witnessed with admiration the marvellous lightness of the buildings in the east, and who brought back with them the arts and learning of the Arabians, especially their mathematical science. From these sources, no doubt, pointed architecture took its rise, and massive cylindrical pillars, composed of many small pieces of stone; small circular-headed windows; walls of vast thickness, with very shallow buttresses; and plain groining without ribs, gradually became changed to

[1] There are pieces of the architrave of the Temple of the Sun now lying on the Quirinal at Rome, measuring 16 ft. 6 in. long by 9 ft. 6 in. high, and about 6 ft. thick, or nearly 50 tons in weight.

History.

light shafted piers, and delicately moulded arches; windows rich with varied tracery; pannelled walls, with bold buttresses, surmounted by niches, and crowned with pinnacles; and groined roofs, fretted with a net-work of ribs, and studded with richly floriated bosses.

Masonry of the sixteenth and seventeenth centuries.

10. The revival of classic architecture threw the arts into another channel, and the masons had hardly forgotten their old traditions when Jones and Wren introduced them to new details. The latter, in particular, formed an excellent school of masonry. The works at St Paul's, and his other public buildings, are executed in a very superior manner. He seems to have been very choice in the selection of his stone. Among all his buildings is scarcely a failure, or a defective block. Besides this, by the assistance of Gibbons, he formed an excellent school of architectural carvers.

Eighteenth and nineteenth centuries.

11. The art of masonry was well upheld by Hawksmoor, Vanburgh, and Chambers; but shortly began to languish, when the inordinate use of cements, first introduced by the Adamses, came into vogue. Besides this, the heavy duties imposed on the transport of stone by sea, and the high prices which all materials bore during the war, threatened to reduce masonry to its lowest. The revival of Gothic architecture has renewed the use of freestone, and has taught our masons the art of working tracery, groined roofs, flying buttresses, and such use of stone as was supposed, scarce a century ago, to be one of the lost arts. Besides this, the abolition of duties, and the introduction of many facilities of transport by steam, both by land and water, has so reduced the price of stone, that in many places the use of cement is a false economy. Again, our intercourse with the Continent has brought us into more familiar acquaintance with the great works of classic antiquity, and of the Italian Renaissance. In addition to these causes, the vast engineering works, our docks, harbours, lighthouses, bridges, and, above all, our railroads, which have lately been constructed all over the country, have given a vast impetus to the study and practice of constructive masonry on the largest scale; and the consequence is, we now have in Great Britain a body of masons of higher and more varied skill then perhaps ever was known in this country at any time, both as regards constructive ability and elegant taste.

State on the continent. Italy.

12. In Italy the old customs and traditions are still closely followed, and masonry is extremely well but slowly executed. The fine viaduct lately built at Albano is, however, a favourable example of Italian engineering in stone; and as railways gradually spread over the country we may expect still greater progress.

France.

In France masonry has always flourished, stone being so abundant, especially in the neighbourhood of Paris. The late works at the Great Exposition, particularly the beautiful bridge over the Seine, and the noble buildings which unite the Tuileries and Louvre, form probably the finest palace in the world, and speak highly of the state of the art in France.

Germany.

In Germany we may note the fine works at Munich, particularly the Valhalla, the Pinacothek, and the Glyptothek; at Berlin, the beautiful buildings of Shinkel;

Russia.

and in Russia the vast improvements at St Petersburg, particularly the cathedral of St Isaac, the dome of which is surrounded by twenty-four columns, each of one single piece, and each weighing more than 60 tons, and standing at the height of 150 feet above the ground. (See art. St Petersburg, vol. xvii., p. 490.)

Divisions of the subject.

13. It is now proposed to treat this subject under the following heads:—

I. Materials used in masonry.—1. The various kinds of stone. 2. Their durability and causes of decay. 3. Mortars and cements.

II.—Of the principles of stability and strength in masonry. Under this head it is proposed to give the whole of the scientific article written by the late Professor Robison expressly for this work.

III.—Of foundations.—1. On land. 2. In the water.

IV.—On stone cutting and setting.—1. General. 2. Mediæval.

V.—On artificial stones, and on the induration of soft stones.

Materials used in Masonry.

I.—Of Materials Used in Masonry.

Materials.

14. In our article on Mineralogical Science, vol. xv., p. 155, we have given an epitome of the various rocks which compose the fabric of the globe. We purpose to go through this list, showing those used in building as they occur *seriatim*, with some practical remarks upon each, which will give a complete epitome of the materials used by masons in all ages.

Igneous rocks of volcanic origin.

15. Of *Igneous Rocks* of volcanic origin, the varieties which have been used are those light stones called tufa and pumice, and that stone called peperino. The two former of these were extensively employed by the Romans in the filling in of vaulting, on account of their great lightness. The latter stone, which is obtained in large quantities near Rome; and which, though of volcanic origin, resembles a sort of coarse oolitic conglomerate, was used by that people extensively, particularly for substructures, for which it is fitted, being obtained in large blocks.

Trappean.

Of the second division of igneous rocks, the *trappean;* porphyry, and serpentine have been used, but chiefly as ornamental coloured stones, and have been generally classed as marbles.

Super-silicated stones.

Of this third division the granite alone is in use, and is now very extensively employed, not only in bridges and engineering works, but in public buildings and dwellings.

Granite.

It is got from the quarries by splitting the blocks with wedges, and is so hard it cannot be cut by any ordinary saws. It can only be worked first with large hammers, and then reduced by pointed chisels, and consequently is very expensive in building. Some very good specimens come from Cornwall and Devonshire, but by far the best are from Dundee and Aberdeen. A variety of the latter, called Peterhead, is only to be equalled by the finest oriental granites.

Aqueous rocks. Gravel and sand.

16. *Of Aqueous Rocks—Mechanically formed*, and of the *Arenaceous* varieties.—Gravel is used by masons for concrete, and sand in making mortar. Sandstones and gritstones are very extensively used.

York paving.

These are either laminated, as the York stone, and used generally for paving, as it can readily be split into large surfaces of small relative thickness;

Old red sandstone.

or compact as old red sandstones, which stand very well internally, but perish sadly with the weather, as may be seen at Chester cathedral.

Tunbridge sandstone.

The new sandstones, the best of which is the Calverley stone, got near Tunbridge Wells. These stones are easily quarried, but, if sawn, the wet saw and sand must be used.

Compact sandstone.

The finer grained compact sandstones, which are comparatively free from iron, and form very good building-stones, are very numerous. We name a few. These are the Bramley Fall, used by engineers for bridge copings, &c.; the Park Spring, Elland Edge, and Whitby, all from Yorkshire. Scotland can boast of some of the finest quarries of sandstone, the best of which, perhaps, is the Craigleith, much used at Edinburgh. The college, courts of law, registry, custom-house, royal exchange, national monument, and many churches and private residences there, are built of this excellent material, which has also been extensively exported to Hamburg, Altona, Gottenburg, and the continent.

Humbie.

Humbie stone has also been extensively used, both at Edinburgh and at Glasgow, where it forms the Royal Exchange and bank. It is easier to work than Craigleith.

Glammis.

Glammis is also a fine sandstone. The castle there, as well as those at Inverquharity and Cortachy, and Lindertis House, are built of this.

Culello.

In Fifeshire, at Culello, are

Materials used in Masonry.

quarries from whence the stones for the monument to Lord Melville at Edinburgh, and that to Lord Nelson at Yarmouth, were obtained. In addition to beauty and durability, these stones have the merit of being capable of receiving the finest and smoothest forms from the chisel of the workman. Another class of sandstones are commonly called *firestones*, as they endure the action of fire better than most others.

Reigate firestone.

Of these the best known is the Reigate stone, which is the principal material used at Windsor Castle, Hampton Court, and in many old buildings round London.

Argillaceous clunch.

Of *aqueous stones* classed as *argillaceous*, the Clunch only is used in building. It may be seen in Ely and Peterborough cathedrals, and many other mediæval buildings, and is a beautiful material for carving, but will not stand the weather.

Chemically formed. Travertine.

Of those *aqueous stones*, classed as *chemically formed*, and of the subdivision, the *calcareous*, we have none of note but the Travertine, or, properly speaking, Tiburtine. This is a coarse grained stone, of warm colour, found in large blocks, and extensively used at Rome, both in ancient and modern buildings; the great cathedral of St Peter's may be cited as an instance; but it is unknown in England.

Calcareous.

Of *aqueous rocks, organically derived*, and of the first subdivision, the *calcareous* claims our principal attention.

Limestones.

The chief of these are the *limestones*, which are generally considered by architects as compact, magnesian, or oolitic limestones. Of the former the best, in the south of England,

Chilmark.

is that called Chilmark, of which Salisbury Cathedral and Wilton Abbey, and many other fine buildings, have

Tottenhoe.

been erected. In the midland counties the Tottenhoe stone, of which Dunstable Priory, Woburn Abbey, Luton church, &c., are built, is an excellent stone. There is also a stone of high quality got near Wirksworth in Derbyshire, used at Chatsworth, Belvoir, Drayton Manor &c., &c.

Magnesian. Anstone. Tadcaster.

Of magnesian limestones we may name the Anstone, or Bolsover Moor stone, used formerly at Southwell Minster, and lately at the houses of Parliament; the Tadcaster stones, used at York, Beverley, and Rippon Minsters, and very many other buildings;

Roche Abbey.

and the Roche Abbey, used at the building of that name, and very many other churches in Yorkshire and Lincolnshire. These stones contain a great deal of carbonate of magnesia, from which they take their name, and are of beautiful texture, and stand well in the country as building-stones; but fail in London, from a cause which will shortly be stated.

Oolitic stones.

We now come to the most important subdivision of the limestones used in masonry—the *oolitic*—so called because they resemble, when broken, a conglomerate of globular eggs, also frequently called roe-stones, because they resemble what is called the hard roe of a fish. (See art. GEOLOGY, vol. xv., p. 146.) Very good examples of these

Barnack.

are the Barnack stone from Northamptonshire, of which Peterborough Cathedral, Croyland Abbey, Burleigh House,

Ketton.

&c., &c., are erected. Ketton stone, used at most of the colleges in Cambridge, and at Bury St Edmunds, Bedford, Stamford, &c., &c. But the principal English oolites used

Bath.

in masonry are the Bath and Portland. The former, as its name imports, is found in the neighbourhood of Bath. The chief quarries are the Box, Combe Down, Farleigh Down, and Corsham Down; all these quarries vary in quality at different depths. The Corsham Down is said to produce the finest in quality, and the Box Ground stone to be the hardest; but everything in the use of this stone depends on the judgment in selection.

Caen.

Large quantities of a similar stone are imported from Caen, in Normandy. They are more compact in texture than Bath, and therefore fitter for carving; but do not appear to stand the weather of our climate so well. The best variety of this stone is said to be D'Aubigny stone. Almost all these oolites can be sawn with a common dry saw, which saves a great deal in the labour of conversion. But, without doubt, the best of all this class of stones is that from the Island of Portland; for beauty of texture and for durability, it perhaps exceeds any stone in the world. It seems the only stone unaffected by the smoke of London; and therefore the greater number of its buildings, St Paul's among the rest, are of this

Portland.

stone. It must, however, be sawn by the use of sand and water; and, being of hard texture, is much more expensive to work than the softer oolites. There are between fifty and sixty quarries on the island. The best are said to be those on the north-eastern side; but, like all stone, there is good and bad in every quarry, and everything depends on the selection. It is said, when Sir Christopher Wren built St Paul's, he had this stone quarried, and exposed to the weather on the sea-beach for three years, before he suffered it to be used. A very excellent limestone for walling, especially for Gothic work, is that called *Kentish Rag*.

Kentish Rag.

It is found in large quantities in the neighbourhood of Maidstone, and is very hard, and worked, like granite, with large hammers instead of the saw. Jambs, strings, and mouldings are sometimes worked out of it, but the hardness makes the work expensive.

Flint.

Of siliceous stones, flint is sometimes used for rough walling; but in England this work is done by the bricklayer, and not the mason. (See BUILDING, p. 737.)

Metamorphic rocks.

17. The only remaining class is that of the *metamorphic rocks*, of which the crystalline and saccharine, and the serpentinous limestone are used; but these are all species of marbles, and used more as ornamental than as constructive

Marble.

building-stones, and need not be dilated upon in this article.

The Durability and Causes of Decay in Stones.

Durability of stones.

18. The causes of durability of stone, and the correspondent causes of failure and decay, are either chemical or mechanical, and may be described either as decomposition or disintegration. Durability also depends much on the power of resistance to wear.

Decomposition.

19. Decomposition is caused by some of the elements of the stone entering into such new combinations with water, gases, or acids as render them soluble either by the air or water. Granite, though the hardest of building-stones, is

Alkalies.

liable to serious decomposition when the feldpars are alkaline (see art. GEOLOGY, vol. xv. p. 136), and will unite with water or acids. Some qualities of this stone are rapidly decomposed by the sea. The same is the case with many of the limestones, as is described in the article above quoted, page 151.

Oxides of iron.

Stones containing iron are also liable to decay. In its native state it is usually in a low state of oxidation, and is liable to be acted upon by additional quantities of oxygen or carbonic acid. This sort of decomposition is much increased by being alternately wet and dry, or by frequent changes of temperature. Stones, however, containing iron in a high state of oxidation, as rosso-antico, porphyry, &c., do not readily become decomposed. The most curious discovery of modern times is with regard to the magnesian limestones and dolomites.

Magnesia.

These were chosen for the new Houses of Parliament on account of their durability. The work at Southwell Minster, 800 years old, bears every mark of the tool to the present day, and every circumstance seemed to justify its selection. It appears, however, that magnesia has a great affinity for sulphur; and the consequence is, the sulphurous acid which

Sulphurous acids.

is present in such quantities in the smoke of London, has already caused serious decomposition in that building, as well as in the Lincoln's Inn Hall. This acid has also so much effect on the softer limestones, that the fronts of several important buildings, Buckingham Palace among the rest, have been obliged to be painted, to save them from decay.

Disintegration.

20. Disintegration, as has before been said, is the separation of parts of stone by mechanical action. The chief cause

Freezing.

is the freezing of minute portions of water which get into the

Materials used in Masonry.

pores, or fissures, or between the laminæ of stones, and swell slowly as crystals of ice are gradually formed, and consequently burst open the pores, or split the grain of the stone. The south sides of buildings, in northern climates, suffer more than others, as their surface becomes thawed and filled with wet in the day, and frozen again at night, more frequently than the others. A very common error in the present day, is the not taking care to set stones with their laminæ, or grain, or, as the workmen call it, "bed," in a horizontal direction. If work be "face-bedded," the action of the weather will cause the laminæ to scale off, one after the other, just as the leaves of a book fall over, if the volume be placed on its back in an upright position. For fuller illustration of the subject of decay and decomposition of rocks, we must refer our readers to the article MINERALOGICAL SCIENCE.

Face-bedded work.

Resistance to wear.

21. Resistance to wear is another obvious cause of durability; but this depends rather on the toughness than the mere hardness of material, a quality often attended with brittleness, as also on its situation. The crushing weight of Portland is about 10,000, while that of York is about 12,000, or one-fifth more; but in many situations Portland steps will last much longer than York. Again, the crushing weight of Peterhead granite is about 18,000, or not quite double that of Portland; whereas, if used as street-paving, it would outlast six sets of the latter.

Of Mortars and Cements.

History of mortars and cements.

22. The use of some material, not only to cause stones to adhere together in building, but to fill up crevices between them, and irregularities in bedding them, is of the remotest antiquity. The earliest mention of mortar is in Genesis xii. 3, where the builders of the Tower of Babel are said to have had "slime for mortar," which the LXX. called ἄσφαλτος (bitumen) and πηλός. Herodotus (Clio, 179) tells us the walls of Babylon were built of bricks, cemented together by hot asphalt. The Egyptians used mortar of lime and sand, almost exactly in the proportions we do, as was proved from an analysis of some taken from the pyramid of Cheops. The Grecian mortars and cements are very fine and strong. Vitruvius gives careful directions how to make mortar (lib. 2, ch. 5), and his instructions are probably the best, and his observations the most sound, of any author, at least till the time of the researches of Vicat and the French chemists.

Definition.

23. Mortar is generally considered under two heads: as common mortar, or that mixture of lime and sand ordinarily used in building; and hydraulic mortar, or that which will set under water. Cement is a name given to the produce of certain argillaceous stones, after calcination, which will set rapidly in the air, and become a hard, adhesive substance in a short time; and which will also set under water, both without admixture of any other substance. The name is also given to certain artificial imitations of these substances, possessing the same properties; and besides, to various bituminous, or oleaginous compositions, used in building for similar purposes.

Lime.

24. Pure lime is an oxide of a metal called calcium, but does not exist in a natural state. It is, however, found abundantly in the conditions of carbonates and sub-carbonates, in chalk, and the various other descriptions of limestones. Its chemical qualities and analysis will be found under the proper heads. The first thing is to drive off the water, which all limestones contain in a greater or less degree, and the carbonic acid gas, which is done by calcining or burning in a kiln at red heat, which must be kept up for several hours, taking care, however, to avoid any approach to vitrification. By this process it is slightly diminished in bulk, and it loses nearly half its weight, and becomes caustic lime.

Materials used in Masonry.

Classification.

25. Limes are generally classed, since the publication of the work of Vicat, as—1. rich limes; 2. poor limes; 3. limes slightly hydraulic; 4. hydraulic limes; and 5. eminently hydraulic limes. In treating of mortar, we have to deal with the first two of this division.

Production of hydrates

26. The lime must next be converted into a hydrate. This is done by a process called "slacking," or throwing water over it from time to time till it hisses and cracks with considerable force, and some noise, gives off a large quantity of hot vapour, and falls into a powder. The rich limes, which are the purest oxides of calcium, increase to double their bulk in the process. The poor limes swell to a much less degree. The hydrates thus formed absorb water, and easily take the form of a paste. They contain rather less than one-third water to two-thirds lime. In this state, if treated with pure water, frequently renewed, every particle of rich limes, and very nearly the whole of the poor limes, will be taken up in solution. In the process of slacking, too much water should not be used, as it "drowns" the lime, according to the expression of the workmen. When in the form of paste it begins to absorb the carbonic acid, which, though no component part of air, is always present in it, in large quantities; and gradually to crystallize again, and so to harden. If the air be excluded from the hydrate of pure lime, it may be kept for almost any length of time. Alberti (lib. 2, cap. 2) says that he once discovered some in an old ditch, which, from certain indications, must have been there 500 years, and was as soft as honey or marrow, and as fit for use as it could be.

Rich limestones.

27. The rich limestones give a white lime, which easily slacks, and increases in bulk; but it is curious that, though the stones differ so much in outward appearance and in texture, the lime, if they be well burned, is the same. The softest chalk, and the hardest rag-stone, or marble, yield an equally good lime, the calcium which they contain being the same mineral. But as chalk generally contains water, irregularly distributed in some places and not in others, and as it is does not exhibit the change that marble or stone does, it is frequently unequally burned, and therefore slacks imperfectly. It is said, however,[1] that lime, made from chalk absorbs the carbonic acid more rapidly than that made from stone; but our own experience does not warrant this conclusion.

Poor limestones.

28. Poor limestones are those which contain silica, magnesia, manganese, or metallic oxides. In consequence of this they are more liable to vitrify in burning, and do not slack so freely. The lime is generally of a browner colour than that from rich limestones, which is said to be a proof of the presence of the above-named metallic oxides. If, however, they be ground so as to facilitate the slacking of every particle, and if used immediately it is made up, poor limes produce a mortar which becomes harder than that from the rich limes, and which resists water better. In fact, works where the latter have been used, have been found to fail entirely by the action of running water, which, as before has been said, will continue to remove the whole of a rich lime, particle by particle.

Use of sand.

29. It is found that the mixture of some kind of hard matter in particles or granules facilitates the setting of mortar, renders it harder and more adhesive than when used alone, besides the saving of limestone and expense of burning. The harder this material, and the sharper the particles the better, as the brick or stone has always some irregularities on the surface, into which these angles or sharp points may enter, and form what is called a key. The substance most generally used is sand, which is generally classed as river-sand or pit-sand. The former is

[1] Higgins *On Mortars and Cements*, p. 29.

Materials used in Masonry.

generally preferred, as it is more free from any earthy matters, particularly soft loams or clay. If pit-sand be used it should be well washed. Scarcely any material is better than crushed quartz, or flint, from the sharpness of the angles of the particles; in fact, it is said, that very sharp sand, with an inferior lime, will make a more adhesive mortar than soft sand with the best lime. For observations on the practical mixing of mortar, see BUILDING, p. 731.

Other materials. Burned clay.

30. Where sand is scarce, other materials may be used, the principal and cheapest of which is burned clay. The Romans used this extensively in the form of pounded brick. At present the custom is to throw up clay mixed with any fuel in loose heaps, and burn it slowly. The French writers at one time asserted that burned clay, if not equal to pozzolano, was very nearly so; and large quantities were used as hydraulic mortars at various public works. Where the water was fresh, as at Strasbourg, the work stood very well; but where these mortars were exposed to the action of sea-water, they failed and went to powder in three or four years. Vicat gave great attention to the subject; and though he attributed much of the fault to the imperfect carbonization of the materials, it appears with but little doubt there is some inherent difference between the pozzolanos and other volcanic products, which will be treated of shortly, and those produced artificially.[1]

Slag and cinders.

31. The vitrified refuse of furnaces, called slag, and the scoriæ from the iron-works, have also been crushed and used instead of sand; and with lime slightly hydraulic, produce good mortar. The former is preferred to the latter, as having sharper and harder particles, and containing much less iron. Coal cinders have been used, and seem to have some hydraulic properties; they should, however, be employed with caution, for it is considered they make the lime "short." Wood cinders are too alkaline to be used with safety. A very excellent mortar, much used by engineers in tunnels, is composed of one part of moderately hydraulic lime, one part of coal ashes, one part of burned clay, and two parts of sharp sand.

Volcanic products.

32. The vitrified and calcined products of volcanoes make most excellent materials for mortars, particularly where required to be eminently hydraulic. The principal of them is the Pozzolano, which abounds in Italy. It is called so from being found in great abundance at Pozzuoli, near Naples, and is, in fact, the basis of all the best Roman mortars, ancient as well as modern. It varies in colour from reddish brown to violet red, and is sometimes grayish. It is usually sent to England from Civita Vecchia. It has a roughly granulated appearance, and sometimes resembles a cinder in texture, and has frequently a spongy appearance. Acids have little effect on it, and it is not soluble in water. A similar earth is found in the centre of France. But one more familiarly known in this country comes from the village of Brohl, near Andernach, on the Rhine; this is called terrass or trass. These materials have a wonderful effect in rendering even the rich limes eminently hydraulic, and in less proportions improving the hydraulic limes. Vicat says, these mortars begin to set under water the first day, grow hard in the third, and in twelve months are as hard as the bricks themselves. The mixture of common lime with these materials, according to the French writers, should be 1 of pounded lime to 2½ of pozzolano, or to 2 of terrass; or 1 of lime to 1 of sand and 1 of pozzolano. The analysis given by them is nearly as follows:—

Pozzolano and trass.

	Terrass.	Pozzolano.
Silica, per cent.	57	44
Alumina	12	15
Lime	3	8
Magnesia	1	4
Oxide of iron	5	12

Cements.

33. In addition to those which we have called hydraulic limes, there is a peculiar class of stones, which, when burned and pulverized, may be used as a species of mortar, without admixture of sand or any similar substance; and which will not only set rapidly under water, but will acquire an unusual degree of hardness and tenacity.

Natural cements.

34. These are called natural cements. The inventor is supposed to have been a Mr Parker, at any rate that gentleman took out a patent about sixty years ago for what he called Roman cement. His material were those argillo-calcareous nodules, or septaria, which are found in the Isle of Sheppey, and commonly called bald-pates. They contain about 70 per cent. of carbonate of lime, about 4 per cent. oxide of iron, 18 per cent. of silica, and 6 or 7 per cent. of alumina. The process is simply to break the stones into small pieces, and burn them in running kilns with coal or coke; they are then ground to a powder, and headed up into casks for use. The success of Parker's cement led to experiments in other places, and the same process was carried on with other argillo-calcareous nodules, as the septaria at Hawick; those in Yorkshire, which produce the cement called Atkinson's; and those in the Isle of Wight, which produce the Medina cement. Similar substances were also discovered, and the same processes carried on in France and in Russia. All these cement-stones effervesce with acids, and lose about one-third of their weight in burning. Parker considered the more the stones were burned short of absolute vitrification the better; but this is not the practice in the present day, though no doubt sound in theory. When taken from the kiln these stones will not slack without being pulverized; and if kept dry, and not exposed to the air, the cement will be good almost any length of time; but it rapidly absorbs both water and carbonic acid if not carefully closed, and falls back into a state of subcarbonate, from which it is said it may be recovered by fresh burning, but it is doubted whether it is ever so good as on the first calcination.

Artificial cements.

35. The great utility of these cements, and the expense of obtaining the stone, induced the manufacturers to endeavour to discover some method of making an article by artificial means which should resemble the natural cements. Mr Frost seems to have been the first who attempted it on a large scale; but though assisted by the talent and science of General Pasley, the results did not come up to the expected standard. Of course, the object was to produce an argillo-calcareous substance, containing the same chemical qualities as the natural nodules, and which might be burned in kilns as they are. The attempt to combine argil in the form of burned clay, to be mixed with lime instead of pozzolano, had partially failed, as has been stated before. Our space will not allow us to relate the various experiments by General Pasley here, nor by Vicat at Meudon in France. They were all based on the principle of mixing together, in a mill, with a quantity of water, masses of chalk and clay, just as the brickmakers do for the production of malm bricks, but in the proportion of about four of the former to one of the latter. The fluid mixture is run out into shallow receivers, and when dry is cut into small blocks or lumps, and burned exactly as the natural nodules are. The difficulty seems to have been to give the materials the full degree of calcination short of vitrification. This seems to have been at last attained by the inventors of the Portland cement, so called from its near resemblance to Portland stone in its colour. It not only possesses the property of setting more quickly, and has greater powers of cohesion than the natural cements, but it may be used with a superabundance of water in the

Portland cement.

[1] After long investigation, Vicat was of opinion that this failure was due to the quantity of hydro-chloride of magnesia always present in sea-water; but in what way this affected the burned clay and not the volcanic products, he was unable to explain.

form of grout, which they cannot; and, above all, it seems to resist the action of sea-water beyond all others. It also forms a very superior cement, as is described hereafter. From a series of trials made on the Portland cement, manufactured by Messrs J. B. White of Millbank, it appeared it required more than two tons to separate two blocks of stone 6 inches cube, which had been put together with a joint of Portland stone, one-eighth to one-fourth inch thick. This gives a resistance of 146 lb. per inch of sectional area, that of Bramley Fall being 76 lb., and Whitby stone 57 lb. Its power to resist compression was tested on blocks 9 inches square and 18 inches long, the pressure being exerted on their ends.

			Tons.	
Roman cement,	and two parts sand, bore....		5·33	per sq. foot.
Portland do.	and three do.	do....	44	„
Roman do.	pure		50	„
Portland do.	and two parts sand...........		80	„
Do. do.	pure		146	„

Marble cements.

36. A class of cements capable of taking a brilliant polish resembling marble, and consequently very suitable for internal decoration, had lately been invented. The chief of these is Keene's marble cement, and the Parian cement. They become excessively hard in a short time, and are capable of being painted in a few days. The principal component part is said to be obtained by the precipitation of alum by an alkali, which gives a white powder of great brilliancy. It is, however, more matter for the plasterer than the other building trades.

Oleaginous cements.

37. Cements made by the mixture of oil with various substances were formerly much used both here and abroad. The best known in England was called Hamelin's mastic, that in France the mastic de Dhil. These cements being very expensive, and requiring to be constantly painted, have now gone nearly out of use. For outside plastering they form a very fine clean surface, as may be seen in tbe quadrant in Regent Street.

Bituminous cements.

38. The asphaltum, or mineral pitch (see Asphaltum), have lately come into extensive use for pavings, and for covering the backs of arches, or rendering the walls of basements where wet is likely to soak through. The best is said to be that from Seyssel, in France. For their chemical properties see Bitumen. It is used thus—A bed of concrete, made of the best hydraulic lime, is first prepared, and made fair at top by a rendering of similar mortar. The asphalte will not dissolve with heat by itself, but will calcine in the caldron. A small quantity of pure mineral pitch is therefore first put in; when hot the asphalte is added, and soon dissolves; into this is stirred a quantity of powdered stone-dust, and a small portion of quick-lime. The mixture is then laid hot on the bed of concrete (which must be quite dry), and spread close and fair, some sand being sprinkled over the top and well trowelled in. The best proportions are said to be about 2 pints of mineral pitch to 10 lb. of asphalte, and one-fourth bushel of stone-dust. A very inferior imitation is made by mixing a quantity of sharp sand with gas-tar, heated in a caldron, and then adding some quick-lime. This may do for rendering walls, &c., to keep out wet, but is of very little use in paving.

II.—OF THE PRINCIPLES OF STABILITY AND STRENGTH IN MASONRY.

39. The strength and the stability of stone-work depends partly on its mass or weight, and partly on the resistance of the materials. And, since we cannot imagine incompressible fulcra, nor that the materials of masonry are infinitely hard and inflexible, as writers on elementary mechanics consider them to be, therefore, it is essential that the resistance of materials should be considered, and the effect of their weight allowed for in estimating the power of the straining force.

The resistance of stones being dependent on their state of aggregation, and not on the hardness or density of their elementary parts, their comparative strength cannot be judged of by these qualities; indeed there are few kinds of materials of which the resistance is so uncertain as that of stone, and hence, it is not at all adapted for any support where its resistance depends on its cohesion only, unless it be very carefully examined, and abundant strength be allowed. The resistance of stone to compression is less affected ,by its irregular nature, particularly as it is usually employed in blocks of inconsiderable height; and, in general, there is scarcely any reason to be sparing of a material which it is often more expensive to reduce than to employ in large blocks. When, however, works of great magnitude are to be constructed, the weight of the materials themselves forms the chief part of the straining force; and, consequently, in such cases it becomes desirable to form a tolerably accurate estimate of their power.

40. This power is limited by a property of bodies that has not received that degree of attention which its importance would lead us to expect. We shall in this place make it the basis of an investigation of the power of materials to resist a force applied in any given direction, and show its application to some of the cases where a mason is most likely to need the assistance of calculation.

When any material is strained beyond a certain extent, every time the strain is increased to the same degree, there is a permanent derangement of the structure of the material produced; and a frequent repetition will increase the derangement till the parts actually separate. (See the article Carpentry.) When a small base rests upon a considerable mass of matter, as a pier on the ground, the quantity of derangement will increase only till the mass be compressed to that degree which renders the increase insensible; but in many cases a number of years will elapse before the settlement becomes insensible.

41. The strain which produces permanent derangement in the structure of a material varies from one-fourth to two-fifths of that which would destroy its direct cohesion. In stone the lower value should be taken, on account of its being subject to so many defects; and, for the present, let this strain be denoted by f lbs. upon a superficial foot.

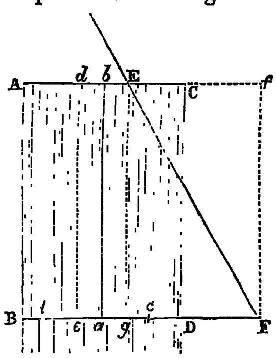

Fig. 1.

42. Imagine ABCD to be a block, fig. 1, strained either in the direction EF or FE, by a force W; and let BDF be a line drawn in the same plane as the direction of the straining force, and perpendicular to the axis ab of the block. Now, if we consider the resistance of the block to be collected at the centres of resistance t and c, then tF will represent a lever acted upon by three forces; that is, the resistance at t and c, and the straining force at F.

If the angle FEg be denoted by α, then the effect of the force W, reduced to a direction perpendicular to the lever, will be expressed by $\cos\alpha$W. . . . . (1.)

Also, if T be the resistance at t, and C the resistance at c, we shall, in the case of equilibrium, have $C - T = \cos\alpha W$. . . (2.)

And, by the property of the lever,

$$\frac{\overline{tc} \times T}{\overline{cF}} = W\cos\alpha \qquad (3.)$$

$$\text{Hence, } \frac{\overline{tc}}{\overline{cF}} = \frac{C}{T} - 1 \qquad (4.)$$

43. Without stopping to notice some maxims furnished by this equation (see the article Bridge), we will proceed to explain the notation used in the investigation which follows:—

$l=$ the length AB.
$d=$ the depth BD, measured in the same plane as the direction of the strain.
$b=$ the breadth.
$z=$ the distance of the neutral point e from the axis ab.
$y=$ the distance of the point g from the axis ab.
$p\left(\frac{1}{2}d-z\right)$, and $p\left(\frac{1}{2}d+z\right)$ the respective distances of the centres of resistance t and c from the neutral point; and, consequently,
$pd=$ the distance, ct, between them. And,
$g\left(\frac{1}{2}d-z\right)$, and $g\left(\frac{1}{2}d+z\right)$ the respective distances of the centres of gravity of the sections into which the neutral axis divides the block, counted from the neutral point.

The leverage cF, expressed in this notation, will be

$\frac{l\sin a}{\cos a}+y-\frac{1}{2}pd+(-p)z$; consequently, equation (4) becomes

$$\frac{pd}{\frac{l\sin a}{\cos a}+y-\frac{1}{2}pd+(1-p)z}=\frac{C}{T}-1 \quad (5.)$$

44. Now, it has been shown, by writers on the resistance of solids, that the resistance of any section, collected at its centre of pressure, is equal to its cohesive force multiplied by the distance of its centre of gravity from the neutral axis, and divided by the distance of the point of greatest strain from the neutral axis. (Emerson's *Mechanics*, prop. 77, 4to ed.)

Accordingly we have $$C=\frac{fbg\left(\frac{1}{2}d+z\right)^2}{\frac{1}{2}d+z} \quad (6.)$$

And $$T=\frac{fbg\left(\frac{1}{2}d-z\right)^2}{\frac{1}{2}d+z} \quad (7.)$$

Therefore $\frac{C}{T}=\frac{\left(\frac{1}{2}d+z\right)^2}{\left(\frac{1}{2}d-z\right)^2}$; which being substituted in equation (5), we obtain

$$(3p-2)z^2-2z\left(\frac{\sin a.\ l}{\cos a}+y\right)+\frac{1}{2}pd^2=o \quad (8.)$$

If the block be rectangular $p=\frac{2}{3}$, and therefore the distance of the neutral point from the axis is

$$z=\frac{d^2}{12\left(\frac{l\sin a}{\cos a}+y\right)} \quad (9.)$$

45. The value of z for a rectangular section being determined, the magnitude of the straining force is easily found, so that it may not exceed the power of the material; for, by the properties of the lever—

$W\cos a=\frac{pdC}{\frac{l\sin a}{\cos a}+y+\frac{1}{2}pd+z(1-p)}$; and since $C=fbg\left(\frac{1}{2}d+z\right)$ by equation (6), and

$z=\frac{d^2}{12\left(\frac{l\sin a}{\cos a}+y\right)}$ by equation (9), and $g=\frac{1}{2}$ by the form of the section, we have

$$W=\frac{fbd^2}{d\cos a+6l\sin a+6y\cos a} \quad (10.)$$

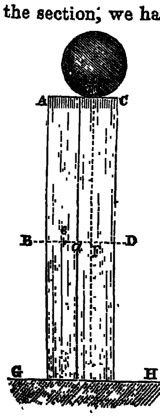

Fig. 2.

46. In particular cases this formula becomes more simple; as, for example, when the distance of the point g from the axis ab is o, that is, when $y=o$,

$$W=\frac{fbd^2}{d\cos a+6l\sin a} \quad (11.)$$

In a column or pillar the section of greatest strain will be at the middle of the length, as at BD in fig. 2; and the direction EF of the straining force is usually parallel to the axis; and then $\sin a=o$, and $\cos a=1$, and therefore,

$$W=\frac{fbd^2}{d+6y} \quad (12.)$$

When the direction of the straining force coincides with the axis, or when $y=o$, the strain on a column or pillar is expressed by the equation $W=fbd$ (13.)

These equations apply also to tensile forces.

When the strain becomes transverse, or when EF is perpendicular to the axis, as in fig. 3, then $\cos a=o$, and $\sin a=1$, hence $W=\frac{fbd^2}{6l}$ . . . (14.)

If the block be supported at the ends, and the load be applied in the middle of the length, as in fig. 4, the fracture will take place at BD; and W in equation (14) will be the pressure on either support, which is obviously half the load in the middle.

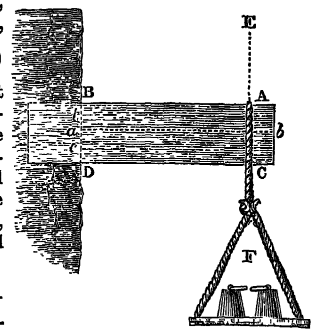

Fig. 3.

47. In any of these equations it is perfectly immaterial how the load be distributed, provided the line of direction be that which passes through the centre of gravity of the mass supported, and the weight be the whole weight of that mass; or, if the strain be the combined effect of several pressures, then the direction must be that of the resultant of these pressures, as determined by the principles of mechanics. (See the article CARPENTRY.)

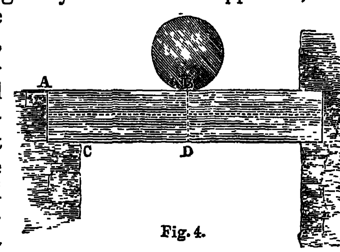

Fig. 4.

48. If a slab of equable thickness and width be supported along two of its sides, as at AC, AB in fig. 5, and it be strained by a force acting at D, in a direction perpendicular to its surface, and DE be made equal to DB, then the fracture will take place in the direction EB; for it may be shown, by the principles of the maxima and minima of quantities, that the resistance, according to that line, is a minimum. And since, in that case, EB $=2$ FD, we shall have, by equation (14), $W=\frac{fd^2}{3}$ . . . (15.)

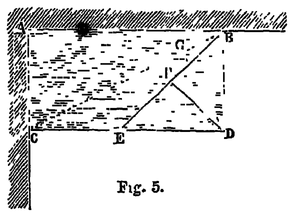

Fig. 5.

A force uniformly diffused over the surface of the slab would fracture it in the direction CB, shown by a dotted line in the figure, and if w be the load in pounds upon a square foot of the surface, then the proper values being substituted for the leverage and breadth in equation (14), $w=\frac{fd^2\left(\overline{CD}^2+\overline{DB}^2\right)}{\overline{CD}^2+\overline{DB}^2}$ . . . (16.)

The strength of a series of steps bearing upon one another, as in the perspective sketch (fig. 6), may be determined with sufficient

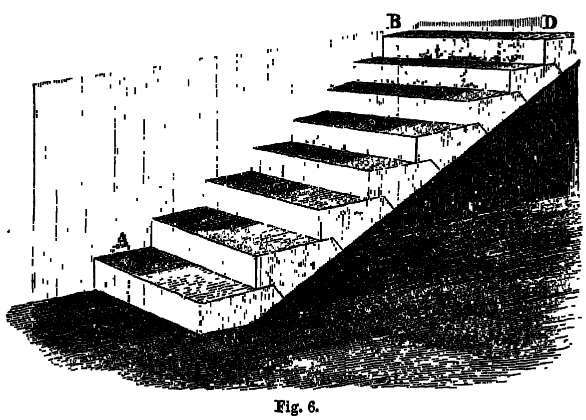

Fig. 6.

accuracy by the last equation, supposing the depth to be the mean vertical depth of any one step; as, for example, taken at GH in fig. 7, the figure showing the ends of the steps.

49. The case to which equation (14) applies, affords the most convenient, as well as the most accurate, means of determining the value of f for any material; and, suppos-

ing it to be one-fourth of the absolute cohesion (§ 34), the last column of the following table of experiments gives its

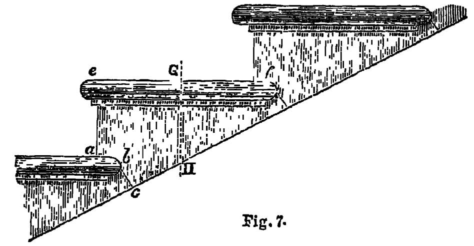

Fig. 7.

value for various stones, mortars, &c., in the nearest simple numbers under the calculated value :—

Table I.—*Experiments on the Transverse Strength of Stones, &c., to the Case Equation* (14).

No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Length, l.	Depth, d.	Breadth, b.	Breaking Weight.	Values of $f = \frac{1}{4}$ of the absolute Strength of a Sq. Foot.
		lb.	in.	in.		lb.	lb.
1	Statuary marble	169·12	15	1·075	1·075	25	65,000
2	" "	...	7·5	1·08	1·05	55	73,000
3	" "	...	7	1·075	1·075	65	78,000
4	Dundee stone	163·80	7	1·5	1·45	207	95,000
5	Portland stone	132	21	1·5	2	28	28,000
6	" "	...	12	1·45	2	50	30,000
7	" "	...	6	1·55	2·07	135	35,000
8	" "	...	15	1·25	1·2	30	26,000
9	Craigleith white sandstone	147·6	7	1·55	1·55	68·5	26,000
10	White sandstone from Hailes Quarry	134·8	7	1·5	1·55	61·5	26,000
11	White sandstone from Longannet	138·25	9	1·525	1·45	46	26,000
12	" "	...	4·5	1·45	1·525	80	23,000
13	" "	...	3·5	1·55	1 55	116·5	24,000
14	Bath stone	...	2·75	1	1	29	17,000
15	Red porphyry	...	2·5	0·4	1	60	101,000
16	Welsh roof slate	...	6	0·25	1½	30	414,000
17	Scotch roof slate	...	6	0·25	1½	25	345,000
18	Common brick, new	...	4	2·5	4	201·5	6,900
19	" " old	...	4	2·5	4	171·5	5,900
20	Best stock brick	...	4	2·5	4	222	7,600
21	Mortar from an old castle in Sussex	...	3	1	1	18·5	12,000
22	Mortar, common	...	0·75	0·35	1⅝	11·5	9,300
23	Mortar in the joints of two inch cubes of stone, one month after being joined	...	pou. 8	pou. 2	pou. 2	liv. 6·75	1,400

Numbers 18, 19, and 20 are from Barlow's *Essay on the Strength of Timber* (p. 250), each being a mean of three trials. Number 23 is from Rondelet's *Traité de l'Art de Bâtir* (tome iii. p. 377), lowest result; the rest of the experiments were made by the writer of this article.

Table II.—*Experiments on the Direct Resistance of Stones, &c., to the Case Equation* (13).

No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Area of Specimen.	Weight that pulled it Asunder.	Value of $f = \frac{1}{4}$ of the absolute Strength of a Square Foot.
1	Hard stone of Givry	147 lb.	96 lines	164 livres	8,400 lb.
2	Tender stone of Givry	130 "	324 "	183 "	1,400 "
3	Mortar of sand and lime sixteen years old	...	1 pouce	53 "	1,800 "
4	Plaster of Paris	...	1 "	76 "	2,500 "
5	Adhesion of mortar to lias stone, joined six months	...	4 "	64 "	547 "
6	Adhesion of mortar to brick, joined six months	...	4 "	138 "	1,180 "
7	Adhesion of mortar to tile, joined six months	...	4 "	141 "	1,200 "

We have not here availed ourselves of the experiments of Gauthey (Rozier's *Journal de Physique*, tome iv.) on the transverse strength of stones; because those he fixed at one end appear to have been injured in fixing, and only a calculated result is given for the other specimens supported at both ends. As to this, see the article on the Strength of Materials.

50. Several experiments have also been made, with the intention of measuring the direct resistance to extension or compression; but theory indicates so nice an adjustment of the direction of the straining force as necessary in these experiments, that the reader may expect the results to differ as widely amongst themselves as they are found to differ from theoretical calculation.

The experiments, Nos. 3, 4, 5, 6, and 7, are extracted from Rondelet's *L'Art de Bâtir* (tome i. p. 312). Nos. 1 and 2 are by Gauthey (Rozier's *Journal de Physique*, tome iv. p. 414.)

51. In the resistance to actual fracture, from a compressive force, the joint effect of cohesion and friction is concerned, and, therefore, a much greater force is required to crush than to tear asunder the same quantity of material. The resistance to fracture might be investigated on principles analogous to those we intend to employ in determining the pressure of earth against retaining walls, &c. (See the article Carpentry.) But we conceive that it is neither prudent, nor useful, nor necessary, to load the parts of a structure beyond that limit we have made the basis of our investigation. (See § 34.) Rondelet has observed, that the load under which a stone began to split was nearly always two-thirds of that which crushed it; but that stone of some kinds began to split with half the load that crushed it (*L'Art de Bâtir*, iii. 86 et 101). The value of f should, therefore, not exceed one-fourth of the force which splits stone; and, supposing the splitting force to be always half the crushing one, we shall have f = one-eighth of the crushing force.

52. In this, as in the preceding tables, the reader will observe, that the results of all experiments are given in the original weights and measures; but that the value of f and the weight of a cubic foot are in English pounds avoirdupois, and for an English foot. The foreign weights and measures are distinguished by their foreign names.

The experiments, Nos. 1, 21, 22, and 36, were made by Gauthey (Rozier, *Journal de Physique*, tome iv. p. 406). Those numbered 3, 4, 5, 8, 9, 11 to 20, 30, 31, 32, 34, 37, 38, and 39, were made by Mr George Rennie (*Philosophical Transactions* for the year 1818). The others were made by Rondelet (*Traité de l'Art de Bâtir*, tome i. and tome iii.) We have selected those which will be most useful, with others of a more interesting and curious nature; such are Rondelet's experiments on the effect of

beating mortar, the strength and density of ancient mortar, and the resistance of stones used in ancient and in modern structures.

53. It was observed by M. Rondelet, in the course of his very numerous experiments, that it was not the heaviest stones which offered the greatest degree of resistance to compression, but those of a fine even grain and close texture, with a deep colour; that of granites, the most compact and perfectly crystallized was the strongest (*L'Art de Bâtir*, tom. i. 213, 215); and that, when all other qualities were the same, the strength was in proportion to some function of the specific gravity.

The writers who have contributed to our experimental knowledge of the strength of stones are not numerous. The chief are Emerson, in his *Mechanics*, 4to ed., p. 115; Gauthey, in his *Mémoire sur la Charge que peuvent porter les Pierres* in Rozier's *Journal de Physique*, tome iv., 1774, and in his *Construction des Ponts*, tome i., p. 267; Coulomb, in his *Mémoires presentés à l'Académie*, 1773; Rondelet, in his *Traité de l'Art de Bâtir*, tome i. et iii. (the latter volume contains the experiments made by Perronet and Soufflot); Rennie, in the *Philosophical Transactions* for 1818, or *Philosophical Magazine*, vol. liii.; and Tredgold, in the *Philosophical Magazine*, vol. lvi., p. 290.

Actual load put on stone in practice.

54. The last column in each of the three tables of experiments shows the greatest load that we suppose should be borne by a superficial foot of the different kinds of stone contained in those tables. We now propose to give the results of some calculations respecting the extent to which stone has in practice been loaded. The foreign ones are reduced to our own weights and measures, and the whole stated in round numbers.

TABLE III.—*Experiments on the Resistance to Crushing.*

No. of Expts.	Substance Tried.	Weight of a Cubic Foot.	Area of Specimen.	Weight that Crushed it.	Value of $f=\frac{1}{8}$ of the Crushing Force for a Square Foot.
		lb.			lb.
1	Porphyry	179·44	20 lines	5,208 livres	640,000
2	„	174·9	4 pouces	119,808 „	500,000
3	Granite, Aberdeen blue	164·06	2·25 inch.	24,556 lb.	196,000
4	„ Peterhead, hard and close grained	...	2·25 „	18,636 „	149,000
5	„ Cornish	166·37	2·25 „	14,302 „	114,000
6	„ gray	171·06	4 pouces	39,168 livres	165,000
7	„ rose oriental	166·32	4 „	52,704 „	220,000
8	Marble, white statuary	172·5	2·25 inch.	13,632 „	109,000
9	„ „	...	1 „	3,216 „	57,000
10	„ „	168.37	4 pouces	19,584 „	83,000
11	„ veined white, Italian	170·37	2·25 inch.	21,783 lb.	174,000
12	„ variegated red, Devonshire	...	2·25 „	16,172 „	129,000
13	Dundee stone	158.12	2 25 „	14,918 „	119,000
14	Craigleith stone, with strata	153·25	2·25 „	15,550 „	124,000
15	„ „	...	2·25 „	12,346 „	98,000
16	Bramley Fall sandstone near Leeds, with the strata	156·62	2·25 „	13,632 „	109,000
17	Portland stone	151·43	2·25 „	10,284 „	82,000
18	„ „	...	4 „	14,918 „	67,000
19	Culello white sandstone	151·43	2·25 „	10,264 „	82,000
20	Yorkshire paving stone	156·68	2·25 „	12,856 „	102,000
21	Hard stone of Givry	147·31	324 lines	11,208 livres	85,000
22	Tender stone of Givry	129·43	576 „	5,880 „	25,000
23	Saillancourt stone arches of bridge of Neuilly	141.31	4 pouces	7,280 „	30,000
24	Fourneaux stone pillars of All Saints at Angers	160·68	4 „	62,600 „	110,000
25	Bagneux stone pillars of the Pantheon at Paris	137·12	25 centim.	6,125 kilog.	62,000
26	Stone bridge of St Maxence	156·25	4 pouces	23,380 livres	97,000
27	Casertè stone, in Italy	169·87	4 „	36,142 „	150,000
28	Stone of temples at Pæstum	140·87	4 „	13,720 „	58,000
29	Travertino, ancient buildings at Rome	147·37	4 „	18,112 „	77,000
30	Derbyshire grit, a friable red sandstone	144·75	2·25 inch.	7,070 lb.	56,000
31	„ „ from another quarry	151·75	2·25 „	9,776 „	78,000
32	Roe stone, Gloucestershire	...	2·25 „	1,449 „	11,500
33	Tufa, from Rome	76·00	4 pouces	3,520 „	15,000
34	Chalk	...	2·25 inch.	1,127 „	9,000
35	Pumice-stone	37·81	4 pouces	2,100 „	8,900
36	Brick, hard and well burned	97·31	378 lines	5,280 „	34,000
37	„ pale red	130·31	2·25 inch	1,265 „	10,100
38	„ red, mean of two trials	135·5	2·25 „	1,817 „	14,500
39	„ Stourbridge fire	...	2·25 „	3,864 „	30,900
40	Mortar of lime and sand 18 months old	118·31	4 pouces	2,552 livres	10,900
41	„ „ 16 years old	...	4 „	2,864 „	12,000
42	„ „ not beaten 18 months old	101·56	4 „	1,866 „	7,900
43	Mortar of lime and pit-sand. 18 months old	99·25	4 „	2,475 „	10,600
44	„ beaten together, 18 months old	118·93	4 „	3,420 „	14,600
45	„ of lime and pounded tiles, 18 months old	91·06	4 „	2,896 „	12,300
46	„ beaten together, 18 months old	103·93	4 „	3,970 „	16,900
47	„ „ 16 years old	...	4 „	4,948 „	21,000
48	„ from an ancient wall at Rome	89·37	4 „	4,248 „	18,000
49	„ from the Pont du Gard	93·75	4 „	3,090 „	13,000
50	Lastrico, brought from Naples	62·5	4 „	4,664 „	19,400

The pillars of the Gothic church of All-Saints at Angers, of the stone, No. 24, Table III., support on each superficial foot a pressure of 86,000 lb.[1] The pillars of the dome of the Pantheon at Paris, the lower part of which are of Bagneux stone (No. 2151, Table III.), support on each superficial foot 60,000 lb.[2] The pillar in the centre of the chapter-house at Elgin, which is of red sandstone, supports on each superficial foot 40,000 lb.[3] The piers which support the dome of St Paul's in London sustain a pressure on each superficial foot of 39,000 lb.[2] The piers which support the dome of St Peter's at Rome sustain a pressure on each superficial foot of 33,000 lb.[2] The pressure on the key-stone (No. 23, Table III.) of the Bridge of Neuilly has been estimated for each superficial foot at 18,000 lb.[4]

In regard to these examples we have to remark that the calculators of them have considered the pressures as uniformly distributed over the pressed surface; but this can only be true when the direction of the resultant of the straining force coincides with the axis of the pier or pillar; besides, stones cannot be wrought absolutely level, nor bedded in perfect contact. From these circumstances, the strength of piers, columns, pillars, and arch-stones,

[1] Gauthey, Rozier's *Journal de Physique*, tom. iv., p. 409; and *Construction des Ponts*, tom. i., p. 273.
[2] Rondelet, *L'Art de bâtir*, tom. iii., p. 74.
[3] Telford, *Edinburgh Encyclopædia*, Art. "Bridge," p. 505.
[4] Gauthey, *Construction des Ponts*, tom. i., p. 260.

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should be estimated by equation (12), and when the line of direction falls within the pier, always making y=half the least dimension of the section, an allowance which will include the effect of the greatest possible inequality of action. We shall, in that case, have

$$\frac{fbd^2}{d+\frac{6d}{2}}=\frac{fbd}{4}=W \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17.)$$

If the pressure on the Bagneux stone in the piers of the dome of the Pantheon at Paris be estimated by this formula, it will be found that it is sufficient to split the stones, and this has actually happened.[1]

Principles of arches, domes, &c.

55. The chief elements of the theory of arches have already been given in the article BRIDGE (sect. ii.), to which we refer the reader, at the same time expressing a hope that the excellent article referred to will be useful in correcting some absurd notions respecting catenarian and other curves, which are too commonly entertained. The conical support of the lantern of St Paul's is a fine example of an appropriate form, whilst the catenarian dome of the French Pantheon exemplifies a scientific blunder of the first magnitude.[2]

The principles of domes, of groins, and of vaulting of every kind, are the same as those of arches, excepting that each kind has its peculiar manner of distributing the load on the different parts. See prop. M and N, art. BRIDGE.

Of the pressure of Earth, Fluids, &c., against walls.

Pressure of earth against walls.

56. When a high bank of earth, or a fluid, is to be sustained by a wall, as it is often necessary to do in forming bridges, locks, quays, reservoirs, docks, and military works, the construction is very expensive, however economical the means employed may be; hence it is desirable to devote some space to an object of which the importance is manifest.

Let EC, fig. 8, be the line according to which the earth would

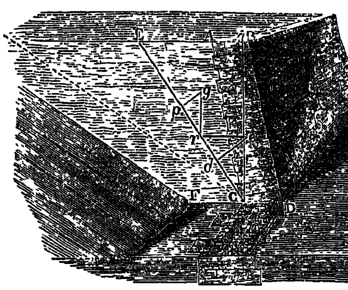


Fig. 8.

separate, if the wall were to yield in a small degree; then AEC will represent the section of the prism of earth, the pressure of which causes the wall to yield.

Put W = the weight of the prism AEC, when its length is unity.
R = the resistance of the wall, when its length is unity.
a = the angle ECa, which the plane of fracture makes with a vertical line.
c = the angle ACa, which the back of the wall makes with a vertical line.
F = the friction of the earth when the pressure is unity.
h = the vertical height of the wall a C in feet.
and S = the weight of a cubic foot of earth, water, or other matter to be supported.

If g be the centre of gravity of the prism of earth, the triangles $r p g$, C a E, being similar, the effort of the prism to slide in the direction EC, reduced for the friction, will be

$$=\frac{W(1-F\tan a)}{\sec a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18.)$$

This effort is to be opposed by the resistance of the wall, which let us suppose to be collected at c, the centre of pressure, and, reducing to the direction CE, the effect of friction being allowed for, it becomes

$$\frac{R(F+\tan a)}{\sec a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19.)$$

Hence, in the case of equilibrium,

$$\frac{W(1-F\tan a)}{\sec a}=\frac{R(F+\tan a)}{\sec a};$$

$$\text{Or, } R=W\left(\frac{1-F\tan a}{F+\tan a}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (20.)$$

57. But, in the case now considered the radius being unity, $W=\frac{h^2S}{2}\left(\tan a-\tan c\right)$ Therefore, R =

$$\frac{h^2S}{2}\left[\frac{(\tan a-\tan c)\times(1-F\tan a)}{F+\tan a}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21.)$$

And, from the state of the variable quantities in this equation, it is obvious that it has a maximum value, which determines the angle of fracture. By the principles of maxima and minima, the maximum pressure takes place when

$$\tan a=-F+\left(1+F\tan c+\frac{\tan c}{F}+F^2\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (22.)$$

If the angle which the plane of repose (BRIDGE) makes with a vertical plane be denoted by i, then

$$F=\frac{1}{\tan i}\text{; and } \tan a=$$

$$\frac{-1+(\tan c\tan^3 i+\tan^2 i+\tan c\tan i+1)^{\frac{1}{2}}}{\tan i} \quad . \quad . \quad . \quad . \quad . \quad . \quad (23.)$$

If the back of the wall be vertical, $\tan c = o$, and then this equation reduces to the simple form, which Prony obtained, of $\tan a=\tan\frac{1}{2}i$. . . . . (24.)

58. When we substitute in equation (21) the value of the $\tan a$, which has been found in equation (23), it becomes R =

$$\frac{h^2S}{2\tan i}\left\{\tan i+\tan c+\frac{2}{\tan i} - 2\left(\tan c\tan i+\frac{\tan c+1}{\tan i}+1\right)^{\frac{1}{2}}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25.)$$

And when the back of the wall is vertical, it becomes

$$R=\frac{h^2S}{2}(\tan^2\tfrac{1}{2}i). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26.)$$

The $\tan i$ being the co-tangent of the angle of repose, if the matter to be supported be of so fluid a nature that it naturally assumes a sensibly level surface when at rest, the $\tan\frac{1}{2}i$ becomes equal to unity, and consequently,

$$R=\frac{h^2S}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27.)$$

The same result may be obtained from the common principles of hydrostatics in the case of fluids.

Since the only variable quantity which enters into the calculation of the distance of the centre of pressure is the height h, whatever the nature of the supported material may be; therefore that distance counted from the base will always be $\frac{1}{3}h$, as in the pressure of fluids.

59. TABLE IV.—*Table of Constant Quantities necessary for calculating the Pressure of some Materials.*

Substance.	Angle of Repose.	Weight of a Cubic Foot = S	Value of R in Equation (26).	Value of R in Equa. (25) when $c=10°$.
Water...............	0°	62·5 lb.	$R=31\frac{1}{4}h^2$	$R=31\frac{1}{4}h^2$
Fine dry sand ...	33°	92 „	$R=13{\cdot}8h^2$	$R=4{\cdot}8h^2$
Do. moist	...	119 „	$R=17{\cdot}85h^2$	$R=6{\cdot}2h^2$
Quartz sand (dry)	35°	102 „	$R=13{\cdot}77h^2$	$R=4{\cdot}64h^2$

In sand, clay, and earthy bodies, the natural slopes should be taken when the material is dry, and the clay and earth pulverised. When any of these bodies are in a moist state, the parts cohere, and the angle of repose is greater, though the friction be actually less. The preceding table shows that the pressure of water is greater than that of any of the other kinds of matter, and from the nature of fluids it is evident, that if water be suffered to collect behind a retaining wall, calculated to sustain common earth only, it will

[1] Gauthey, *Construction des Ponts*, tom. i., p. 273.

[2] La charge considérable que cette voûte devait porter à son sommet, a déterminé à choisir pour la courbe de son ceintre *la chainette*. *Traité l'Art de bâtir*, ii. 308.)

Principles of Stability and Strength.

most likely be overturned. Such accidents may be prevented by making proper drains.

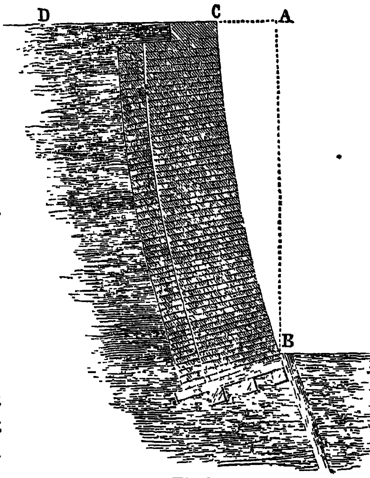


Fig. 9.

60. The preceding analysis will apply, without sensible error to the curved walls which have lately become fashionable. Fig. 9 is a section of one of these walls, as executed from a design by Rennie. The vertical height, AB, 21 feet; the wall of uniform thickness, with counterforts 15 feet apart; and the front of the walls described by a 69 feet radius, with the centre in the horizontal line DA produced. The wall is built of brick, and the uniform part is 4·5 feet thick. The radius is usually thrice the vertical height of the wall; when this proportion is adhered to, the angle c will be ten degrees, for which the value of R is calculated in the table.

Resistance of Walls.

Resistance of walls.

61. In the first place, we propose to investigate the resistance a wall offers to being overturned; and, in so doing, it appears desirable that the resistance of the mortar in the joints should be considered one of the elements of the strength of the wall. Good mortar adds much to the firmness of walls, aud still more to their durability, and, all things considered, its first cost is less than that of bad; besides, the resistance of mortar to compression must be considered, for, in practice, we have no perfectly hard arrises to fulfil the conditions of common mechanical hypotheses.

Put A = the area of the wall.

w = the weight of a cubic foot of masonry.

y = the horizontal distance, $g\,a$, between the vertical passing through the centre of gravity of the wall, and the point where the axis cuts the plane of fracture, the same notation being applied to the other quantities as in the foregoing equations.

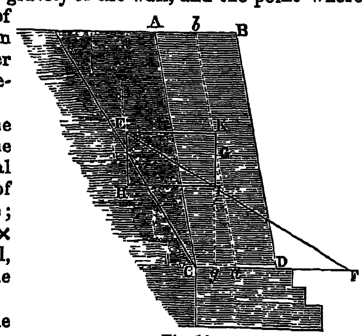


Fig. 10.

Let G, fig. 10, be the centre of gravity of the wall; and on the vertical Gg set off gI, the height of the centre of pressure; also, let IK represent $A \times w$ = the weight of the wall, and HI the force R of the earth.

Then, completing the parallelogram, EI will represent the direction and intensity of the straining force; consequently, $\frac{R}{Aw} = \tan a$ . . . . (28.)

Which determines its direction, and its intensity is

$$W = \frac{Aw}{\cos a} \quad \ldots \ldots \ldots \quad (29.)$$

But, we have found,

$W = \frac{fbd^2}{d\cos a + 6l\sin a + 6y\cos a}$; and as $W = \frac{Aw}{\cos a}$ (equa. (29.)); $\tan a = \frac{R}{Aw}$; equa. (28.); $l = \frac{1}{3}h$, art. 51; and b = unity; the equation reduces to $fd^2 - Adw - 6\,Awy = 2Rh$. . . . . (30.)

If the section of the wall be a parallelogram, then $A = hd$, and $-\frac{1}{2}h\tan c = y$; these values of A and y being substituted in equa. (30), it becomes $-whd^2+fd^2+3h^2wd\tan c = 2Rh$. . . . (31.)

Principles of Stability and Strength.

$$\text{Or, } d = \frac{h^2w}{f-hw}\left(\frac{-3\tan c}{2}+\sqrt{\frac{2R(f-hw)}{h^3w^2}+\frac{9\tan^2 c}{4}}\right) \quad \ldots \quad (32.)$$

When the section of the wall is a rectangle $y = o$, therefore equa. (31) reduces to

$$d = \sqrt{\frac{2Rh}{f-hw}} \quad \ldots \quad (33.)$$

This last equation is also correct for a wall of which the back is vertical, and the front sloping. We suppress the investigation, to afford the young student an opportunity of proving that the diminution of weight is exactly counterbalanced by the alteration of the distance of the centre of gravity from the axis.

The tendency of a wall to slide forward may be easily prevented, by giving an inclination to the joints.

62. To illustrate these rules we shall give two examples, and in these show the construction of a table, which the reader may enlarge at his pleasure.

Example I. Let it be required to determine the thickness of a rectangular wall for supporting the front of a wharf 10 feet in height, the earth being a loose sand, and the wall to be built of brick.

The weight of a cubic foot of brick-work may be estimated at 100 lbs., and the resistance of mortar being valued at 5000 lbs. *per* superficial foot, the experimental value being 7900 lbs., Table III., Experiment 42, and the difference an allowance for any irregularity in building, consequently, $f = 5000$; $w = 100$; and by Table IV., $R = 13{\cdot}8h^2$; hence equa.

(33), $d = \sqrt{\frac{2Rh}{f-hw}} = \sqrt{\frac{2 \times 13{\cdot}8 \times h^3}{5000-100h}} = \sqrt{\frac{h^3}{181-3{\cdot}62h}}$. When $h = 10$ feet, then the thickness of the wall $d = 2\,644$ feet. If h be made successively 10, 20, 30, 40, &c., feet, the numbers under the head of dry sand in the following table will be obtained, observing that they are only calculated to the nearest tenth of a foot.

The proper thickness being found for supporting one kind of material, that for any other may be easily determined; as the thickness varies as the square root of R, equa. (33). Let the thickness for dry sand be d, then

$\sqrt{13{\cdot}8} : \sqrt{31{\cdot}25} :: d : 1{\cdot}5d$ the thickness for supporting water.
$\sqrt{13{\cdot}8} : \sqrt{17{\cdot}85} :: d\ 1{\cdot}14d$ the thickness for supporting moist sand.

In this manner, by means of Table IV. the thicknesses for other kinds are easily calculated.

Example II. If a retaining wall be intended to support a sandy and loose kind of earth, to be constructed of brick, and to be inclined 10 degrees from the vertical, the thickness being uniform; it is required to determine that thickness for any given height.

By equa. (32), $d = \frac{h^2w}{f-hw}\left(-\frac{3\tan c}{2}+\sqrt{\frac{2R(f-hw)}{h^3w^2}+\left(\frac{3\tan c.}{2}\right)^2}\right)$ and as $c = 10°$, $\tan c = {\cdot}18$, hence $\frac{3\tan c.}{2} = {\cdot}27$, and its square $= {\cdot}0729$. Also $f = 5000$, and $w = 100$, consequently, $d = \frac{h^2}{50-h}$

$$\left(-{\cdot}27+\sqrt{\frac{2R({\cdot}5-{\cdot}01h)}{h^3}+{\cdot}0729}\right)$$

For sandy earth $R = 4{\cdot}8h^2$, therefore $d = \frac{h^2}{50-h}$

$\left(-{\cdot}27+\sqrt{\frac{4{\cdot}8}{h}-{\cdot}0113}\right)$; and making h successively 10, 20, &c., feet, the numbers obtained will be the same within one-tenth of a foot, as those in the following Table, column fifth, in which the thickness of leaning and curved walls for supporting dry sand is shown, at an inclination of 10 degrees.

Foundations.

63. TABLE V.—*A Table of the Thicknesses for Retaining Walls, Revetments, Dock-walls, &c.*

Height of Wall.	Thickness of Rectangular Walls to support.			Thickness of Leaning and Curved Walls for supporting Dry Sand, the angle of inclination being 10°.
	Water.	Dry Sand.	Moist Sand.	
10 feet	4·0 feet	2·7 feet	3·1 feet	1·1 feet
20	12·9	8·6	9·8	2·8
30	29·2	19·4	22·2	5·2
40	62·5	41·7	47·5	9·2

Our investigation informs us that the mortar of high walls must be of a superior strength; indeed, we know that when its consolidation takes place, under considerable pressure, it is of much greater strength. According to what function of the pressure the strength increases, we have not experiments to determine, and we therefore point out the circumstance to the notice of experimental inquirers.

Construction of walls.

For further particulars as to construction of walls, particularly of railway embankments, see article CONSTRUCTION.

64. The proper quantity of mortar to be employed in stone-work is another point to which it will be useful to direct the mason's attention. A stone cannot be very firmly bedded upon a very thin layer of mortar; and if the stone be of an absorbent nature, the mortar will dry too rapidly to acquire any tolerable degree of hardness (Vitruvius, lib. ii., cap. viii.), however well it may have been prepared. On the other hand, if the bed of mortar be thicker than is necessary to bed the stone firmly, the work will be a long time in settling, and will never be perfectly stable.

When the internal part of a wall is built with fragments of stone, they should be closely packed together, so as to require as little mortar as possible. Walls are often bulged by the hydrostatic pressure of mortar, when it is too plentifully thrown into the interior, to save the labour of filling the spaces with stones.

The walls of houses are frequently built with hewn stone on the outside, and rubble stone on the inside. The settlement of these two kinds of stone-work during the setting of the mortar are so different, that the walls often separate; or where this separation is prevented by bond stones, the wall bulges outwards, and bears unequally on its base. These evils are best prevented by using as little mortar as possible in the joints of the interior part of the wall, and not raising the wall to a great height at one time.

III.—OF FOUNDATIONS.

On Land.

Foundations.

65. Having considered the nature of the materials to be used, and the scientific principles on which we should proceed in their disposition, we must turn to practical results, and first consider the foundations, or the base, upon which these superstructures are to be placed, so as to stand safely. When a good hard soil is easily accessible, as solid gravel, chalk, or rock, we have nothing to do but to excavate the surface mould to the sound bottom, and to build at once, first putting in the footings, which are one or more courses, forming a sort of steps, each a little wider than the other, and the wall that stands on them (see BUILDING, Pl. 147, fig. 5), according to the judgment of the architect. On hard ground one course of masonry, about half as wide again as the superincumbent wall, is ample. On softer ground it was usual to employ footings at least double the width of the wall, and frequently more; but since the invention, or rather revival, of the use of concrete, this is seldom or never done. In this case, or when the ground is a deep clay, be the material used what it may, it should at least go so deep as not to be affected by change of temperature, or the rising and falling of springs, as the alternate shrinking and swelling of the ground must affect the building. As has been shown (article CLIMATE, p. 768), frost seldom penetrates a foot into the ground in this country; but in clay soils, fissures, the consequences of drought, are found three feet and more in depth. The basis should, therefore, be below this point in such a stratum. If the ground be springy, it should be drained, if possible; if not, a foundation should be made with concrete as low as the lowest level of the water; or if very deep or boggy, piles must be used. The plan of building on sleepers and planking, so common a few years ago, is very bad, as they soon rot, and the building settles in all directions, as the greater weights crush the decayed timbers sooner than the lighter portions of the building. Where ground is alternately wet and dry, the best timber soon decays; even piles should always be wholly below the water.

Footings. Depth of footings.

Definition of concrete.

66. The use of concrete, except in very peculiar occasions, has entirely superseded every other artificial foundation. It may be defined as a sort of rough masonry, composed of broken pieces of stone or gravel, not laid by hand, but thrown at random into the trenches, cemented together with lime prepared in various ways, and thoroughly mixed with it before it is so thrown in. In this country, the lime is generally ground and mixed, when hot, with the stones; in France, the lime is first made into a paste, and the mixture is then called *bêton*, not concrete.

History of concrete.

67. The use of this material is of very remote antiquity. It is no doubt the *signinum opus* of Vitruvius, and is described by Alberti. It is very common in mediæval buildings, walls and even arches frequently being made of it. In Rochester castle the staircases are composed of it; the under sides, or soffites, show to this day the marks of the boards which sustained it till it was set. Smeaton states that he was induced to employ it from the observation of the ruins of Corfe castle. Dance employed a sort of concrete in rebuilding Newgate, 1770-1778. The foundation of part of the new structure was a deep bog, and it was rendered available by shooting a quantity of broken bricks into the holes, mixed with occasional loads of mortar, in the proportions of four to one, and suffering them to find their bed.

Materials of concrete.

68. Any hard substance, broken into small pieces, will make good concrete. That most used is gravel, or ballast. This should not be sifted too fine, as the sand which is left will mix with the lime, and form a sort of mortar, and assist to cement the stones together (see I., sec. 29). If broken stones, or masons' chips, are used, it is well to mix some sharp sand with them. The general rule is, that no piece should exceed a hen's egg in size. In this country the lime is generally ground, and used hot. It is mixed with the ballast by scattering it among the stones, and turning them over with a shovel, water being at the same time thrown upon the mass. It is then immediately filled into the trenches, sometimes by shooting from stages erected for the purpose, six or eight feet above the work. But this process has been very justly censured as uncertain by eminent engineers, who prefer to put it in layers of not more than 1 foot in thickness, and to level each course, and ram it down thoroughly. About one-sixth part of lime is generally used. When too hastily put into the trenches, the lime, which has not had time thoroughly to be slacked, will continue to do so, and the mass will puff or swell, and sometimes cause considerable mischief. The author has seen the wing walls of bridges thrust out by this means. From some experiments made by the Architectural Publication Society, where the materials were carefully mixed, no change took place in the bulk. The lime, if it can be procured, should be hydraulic; and concrete is much improved by the addition of the volcanic sands. The French authors recommend, as good proportions, one-fifth hydraulic lime, one-fourth pozzolano, one-eighth sharp sand, and the rest

Laying concrete. Swelling of concrete.

broken stone or gravel; or 20 per cent. hydraulic lime, the same of terrass, the same of sharp sand, 15 per cent. of gravel, and 25 per cent. of broken stone. Perhaps, after all, the very best concrete is made of a simple mixture of gravel with Portland cement.

Foundations in Water—Ancient Systems.

Loose stones shot in.

69. These are often made by shooting quantities of loose rough stones, &c., into water, at hazard, till the mass finds its own bottom, and becomes solid by degrees. When a sufficient quantity has been shot, so as to appear above the surface, the material is levelled, and the superstructure erected upon it. Most of the *break-waters* (see Art.) have been thus constructed. This method is called by the French, foundations *à pierre perdue* (see BREAKWATER, HARBOUR, &c.) Concrete has been used in the same way with great success. Where it is practicable, it is very desirable first to bring the bottom to a level by *dredging*. (See NAVIGATION, INLAND, p. 68.)

Piling.

70. Another method is to drive a number of piles, side by side, through the mud or other soft soil till they reach a sound bottom, the heads are then cut off to a level, and a platform of timber, or better still, of flat stones, is laid on them, and the superstructure erected. The heads of the piles should always be under water. For small operations they may be driven without dams; but for larger a more elaborate system must be pursued, the most effectual of which are coffer-dams.

Coffer-dams.

71. These are of as great antiquity as the time of Vitruvius, and most probably much older. That author, however (lib. 5, cap. *ult.*), describes the method of forming them, and calls them *arcæ*. Like those of later times, they were composed of two parallel rows of piles driven into the water, and kept together by strong horizontal timbers, and continued around the place where the proposed work is to be erected, so as to form a sort of box or coffer entirely round it. The two rows are kept in their places by other timbers, and the vacant space between such double row stuffed full of clay and weeds, till the whole is quite tight, the water is then pumped out by proper engines till the ground appears, which is then levelled and excavated to a solid stratum, if such is readily accessible. The foundations of the pier, &c., are then laid, and the superstructure carried up to above the water-level, when the dam is removed. If solid ground is not easily accessible, structural piling is resorted to. In large works these are of whole timber, pointed at the end, and shod with iron, to facilitate their penetrating the earth.

Pile-engine.

They are driven by a weight called a monkey, which is raised by a machine called a pile-engine, worked by horse or other power, now frequently by steam. When the monkey is raised to a sufficient height, it is suddenly liberated by a contrivance much like a double pair of scissors, and falls with great impetus on the head of the pile, and of course forces it downward into the bed of the stream. When driven to a proper depth, the heads are cut off to a level line, cross timbers are bolted on these, and the superstructure erected, as shown in BRIDGE (Plate CXLV. fig. 3.) The piles of the dam should not be drawn, as that would allow the water to form holes, and to work under the foundations, but they should be cut off close to the bottom of the stream. Fig. 11 shows a plan of the coffer-dam and pier of a bridge erected by Rennie on the Thames. The outer lines are the parallel piles which keep out the water, and form the coffer; these, as will be seen, are strongly bolted together, both across and lengthwise, and also braced diagonally. The general plan is elliptical, the better to resist the pressure of the water,—a course afterwards adopted in the coffer-dams of London Bridge. The plan of the pier is within this, and is shown in four quarters:—A shows the plan of the great piles, driven down to the solid; B shows the heads of the same piles, when cut off and tied together by strong cross timbers; C shows the planking laid thereon; and D the first courses of the masonry.

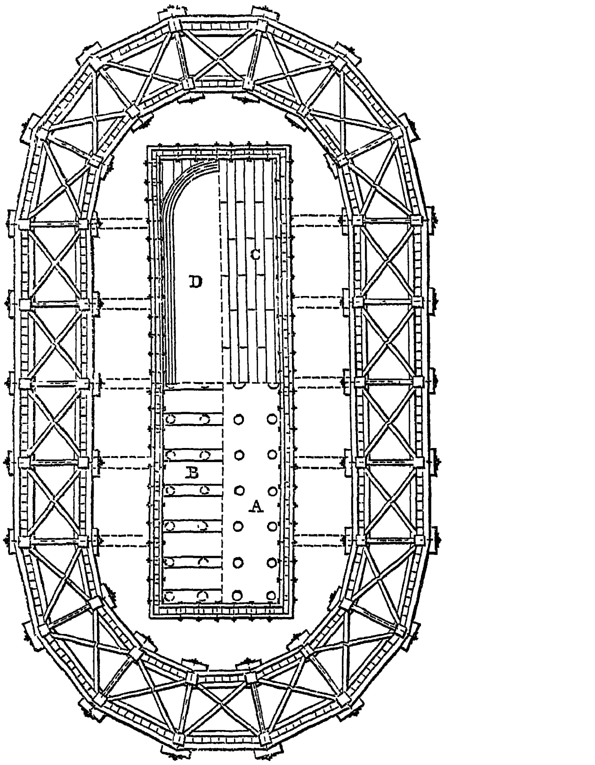


Fig. 11.

Caissons.

72. As the system above described is extremely expensive, especially before the introduction of steam-power for pumping, &c., a very ingenious method was introduced into this country by a Swiss named Labelye, and first used at Westminster Bridge. The bed of the stream was first carefully levelled by dredging. (See NAVIGATION, INLAND, page 68.) Strong frames of timber were then constructed, having upright sides like those of a box, and being about the same area as a coffer-dam. These were floated over the place where the piers were to be built, and the masonry of each pier commenced inside these large cases (the word caisson meaning a large box or *caisse*). It was, in fact, like building in the bottom of a large flat-bottomed barge. Of course, as the weight increased this barge or caisson would gradually sink. The sides were somewhat deeper than the river, and well caulked and pitched to keep the water out and enable the men to work. When the first course of stone was laid and cramped together, the water was let into the caisson by sluices, and the whole sunk to the bottom. It being found this was not sufficiently level, the sluices were closed, the water pumped out, when the whole floated again, and the bottom was again dredged and levelled. This operation was performed three times before the work settled to a level bed. The pier was then built up to a height above water-level, when the sides of the caisson were removed, and used again for the next pier. Blackfriars Bridge was afterwards built on the same plan, but in consequence of the removal of old London Bridge, the scour of the river increased so much as to work under the piers; these directly began to settle in all ways, and the bridges must both be rebuilt. The system of caissons might, perhaps, nevertheless, be used in still waters, but it is manifestly improper for a sharp current, and still worse for a tidal river.

Foundations.

Foundations in Water—Modern Systems.

New systems.

73. The great advance in all objects of engineering, and the desire to avoid expense, has led to some very ingenious and novel systems of laying foundations in water.

Diving-dress.

74. The first of these is chiefly owing to the invention of the diving dress. (See DIVING, vol. viii., Plate CCV.) This has now been brought to such perfection, that excavating, levelling the bottom, setting large blocks of stones, cutting off the heads of piles, in fact, all engineering operations are effected under water almost as easily as on land; the men, in fact, working in a large bag filled with air. The most extraordinary work of this kind is now being carried on at Dover, where a huge mole projects into the ocean, of an extent and construction that exceeds any thing yet achieved. Our limits prevent our giving a full account of this work. It must suffice to say, that the outsides of the pier are composed of two parallel walls, built with large blocks of granite, which are sunk into the solid chalk partly by dredging and partly by excavation. A number of piles[1] are driven into the sea, on the tops of which are strong cross-sleepers, each traversed by a series of iron rails, on which a number of travelling cranes move in all directions. These convey the stones exactly over their intended beds, on to which they are lowered, according to signals given by the divers below, who then cramp them together as well as they can. Between these two outer walls is a filling-in, composed of immense blocks of concrete, made of the ballast from the beach and Portland cement. These blocks are cast, as it were, in wooden boxes, the sides of which are removed when the concrete is set. Pieces of rope or chain are cast within the body of the block, and by them they are raised and lowered just as if they were masses of stone. The pier, therefore, is composed of concrete faced with granite; and the work stands extremely well.

Dover harbour.

Iron piles.

75. The next important change in building in the water is the substitution of iron piles for those of timber. Their success emboldened engineers, and from small piles, driven in the usual way, large cast-iron cylinders came into use. These vary, according to the nature of the work, from 3 or 4, to 6 or 7 feet in diameter. They are first lowered into the water in a vertical position, and driven down as far as they will go without much difficulty. A quantity of clay is then thrown in round the outside of each, to keep the water from coming in under the bottom as little as possible. That inside is then pumped out, and workmen descend and excavate the bottom, sending up the stuff in buckets, just as a well is excavated. The cylinder then sinks partly by its own weight, and partly from weights above, as the earth is excavated beneath to the depths required; each cylinder has a series of flanches, on which another is screwed from time to time as the former sinks into the bottom. When the cylinders are sunk to a proper depth, they are brought to a level at the top, and a platform of girders and planking is fixed for permanent use. In many instances the cylinders have been filled in solid with concrete after they have been thus submerged.

Cylinders.

Rochester new bridge

76. The most extraordinary operation of this kind has, however, just been executed in the piers of the new bridge at Rochester. The ground here was very difficult to work, being composed partly of rag rock and partly of very hard chalk, and it was found almost impracticable to sink the piles in the manner last described, which is successful enough in clay. To overcome this difficulty the following plan was devised:—a proper stage of piles, sleepers, &c., was first erected, and a number of cast-iron cylinders, each 9 feet long and 7 feet in diameter were bolted together in proper lengths. As it was necessary to employ diving-bells to dredge the bottom, it was considered that each cylinder might easily be converted into a sort of bell by putting on it an air-tight cap. This was done, and an ingenious method contrived by which the men could pass in and out of the cylinder without admitting the air. It would exceed our limits to go into all the details of this invention, which was called an air-lock, probably from its permitting or hindering the passage of air, much as the lock-gates on a canal do with that of water. But there was this great difference between the method described in [sec. 75] and this new method. In the former the water was pumped *out* of the cylinder, but in this air was forced *into* the cylinder below the air-tight cap and locks, and the water *driven out* by its pressure. The men then entered through the air-locks, and excavated the ground under the cylinder, which descended by its being heavily weighted above. As each cylinder sunk, the cap was removed and another cylinder screwed on, so that some of the piles (as in fact they may be called), consisted of seven pieces, and measured over 60 feet in length, one half of which was buried in the bed of the river. The girders, tying the heads together on the top, as well as the skew-backs, &c., from whence the arches spring, were then fixed in the usual way. (See IRON BRIDGES.)

Screw-piles.

77. A still more curious method of employing iron piles is the invention of Mr Mitchell, and succeeds admirably in soft ground and even in sands. These are hollow, and of wrought-iron, varying in diameter from 5 or 6 inches to about a foot. They terminate at the end with screws of various shapes (see figs. 12, 13, and 14), and are screwed into the bed of the river or the bottom of the sea, as the case may be, to such a depth as to hold the pile firm, their heads are then connected together with sleepers, &c., and the intended superstructure erected. The lighthouse on the Chapman Sand, in the mouth of the River Thames, is built on piles 7 inches in diameter and about 40 feet long, the screw part is of cast-iron about 4 feet in diameter. They are screwed down till only 2 or 3 feet remain above the sand; on their heads are cast-iron cylinders, braces, &c., which support the lighthouse, which is entirely of wrought-iron. The piles are only seven in number; one driven in the centre, and the others at equal distances around it.

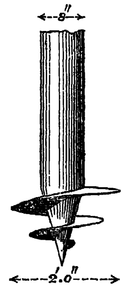


Fig. 12.

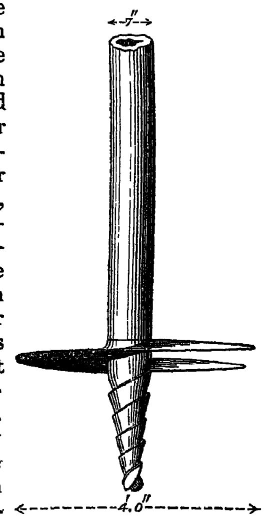


Fig. 13.

Iron coffer-dams.

78. Several very ingenious adaptations of iron for coffer-dams have been tried with success in various places; they are all, however, more or less expensive, not only in construction and removal, but because they entail constant expenses in pumping.

Westminster new bridge.

79. The method lately invented by Mr Page for getting in the piers of the new bridge now in course of erection at Westminster is, however, so novel and so important, we feel our work would not be complete without a short description of it. Figs. 15, 16, and 17 show the plan, the long and cross-sections of half each pier. Rows of

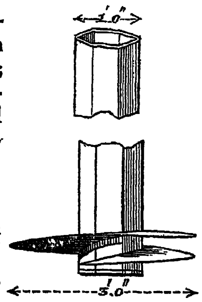


Fig. 14.

[1] These piles form a scaffold, and are removed when the work is done.

Foundations.

strong elm piles, AA,[1] about 30 feet long, are driven into the bed of the river, as shown in the plan, passing first through the gravel, which is about 4 or 5 feet thick, and then going about 20 feet into the London clay. There are about 140 or 150 piles to each pier, ranged alternately in threes and fives, around these a range of cast-iron piles

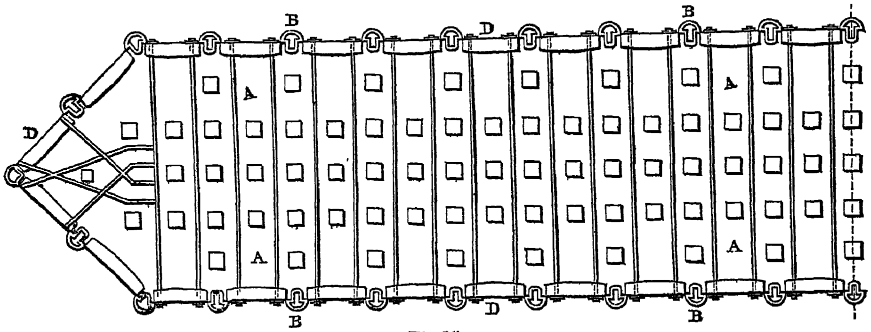


Fig. 15.

BB, are driven about 4 feet apart, as shown in the figure. These are round, 15 inches in diameter, and have strong grooves cast on each side of them. They, however, go into the clay only 10 or 12 feet. Into these grooves large plates of iron, which the engineer calls "plate-piles," are fitted and driven down between the piles, BB. They are marked CC on the cross-section (fig. 16), and, as will be seen, go about 10 feet into the blue clay, and extend to about a

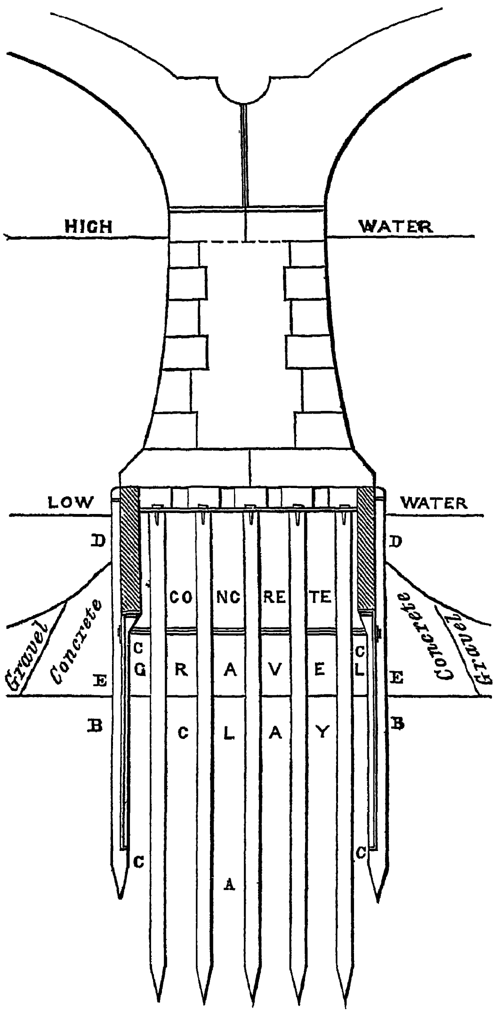


Fig. 16.

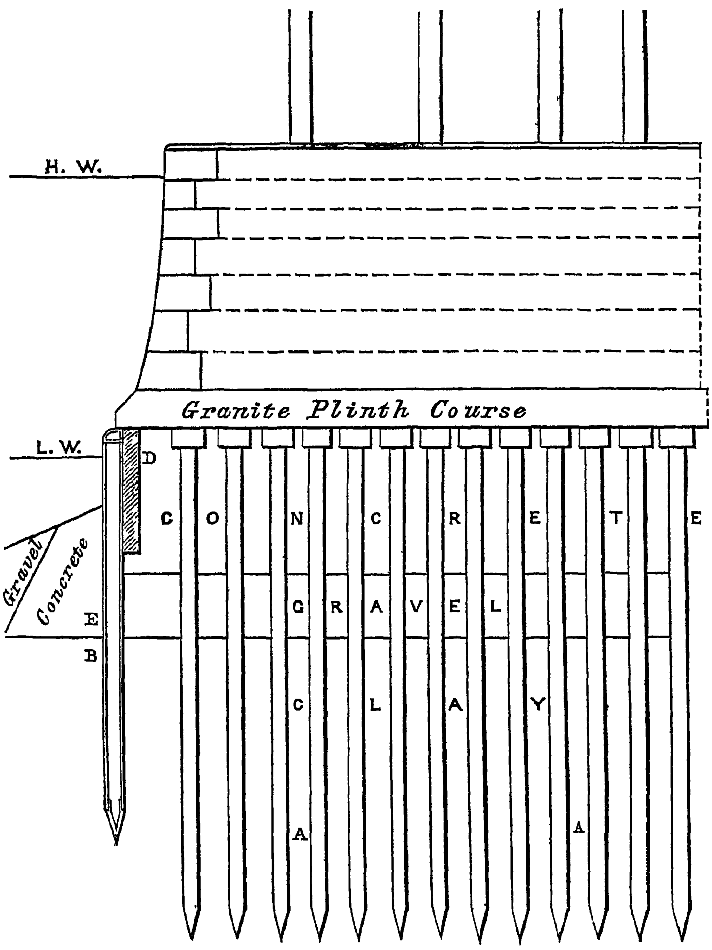


Fig. 17.

foot or two above the natural bed of gravel. Upon these are a series of slabs of granite, DD, placed edgewise, retained in their places thus,—The bottom rests on the "plate-pile," CC, the edges are secured to the round iron-pile A, and the tops to the other masonry. The plate-piles are secured together by two sets of ranges of iron-rods passing through the pier and tying them together. These are all fixed by the divers. It will be seen, therefore, a sort of case or box is made which surrounds the wooden piles AA on all sides. The loose sand and mud

[1] The same letters apply to all three figures.

Stone-Cutting.

is then dredged out, and the case filled up solid with hydraulic concrete, in which, of course, the piles are embedded, and the whole forms one solid mass to about a foot above low water-mark. At this level the tops of the piles are cut off, and on each top a stone 2 feet square and 1·6 thick is bedded, the spaces between which are again filled in solid with concrete. The gravel is then dredged out around the pier on the outside of the case, and the space also filled with concrete, as shown at EE. It has been urged that the steamers will come into collison with the round piles, BB, and break them, so that the granite slabs, DD, will escape, as it were, and fall into the river. This, however, cannot be as long as the concrete E remains in its place, as the top of the slab D is secured by the masonry, and the bottom would not be accessible. It is, however, intended to protect the piles by floating booms, which would prevent the chance of collison, and would act as safeguards for the steamers as well as the bridge.

For the action of waves, running water, &c., on walls, piers, &c., see HARBOUR.

IV.—STONE-CUTTING.

Previous descriptions.

80. The different methods of reducing stones to shape by the axe or scabbling-hammer, the saw, or the tool; of dressing by the chisel or point; the nature and value of plain work, sunk work, moulded work, and beds and joints; the various sorts of bond, and of rubble, coursed, or ashlar, with their proper backings and quoin-stones; the mortar, and such methods of working and setting the beds of stones, that the faces may not chip or flush; the mode of securing and strengthening work, by discharging and relieving arches; by hoop-iron bond, cramps, dowels, joggles, plugs, &c.; the descriptions of copings, cornices, string-courses, blocking-courses, sills, landings, balconies, paving, curbs, steps, hearths, chimney-pieces, &c.; and of columns, with their beds, joggles, flutes, &c.; in short, all that relates to the mechanical part of stone-cutting, has been already given, article BUILDING, pages 737 to 741, to which we refer our readers.

Moulds, and to find the lines for.

81. Before working the various pieces of stone, it is necessary to prepare certain moulds, which are generally of thin metal, wood, mill-board, or some similar substances, of the exact form with which each face of the stone is to be worked; and which are applied to the sides of the stone, and their shapes marked or "scribed" thereon. They serve the double purpose of guiding the workmen, and of enabling him to select pieces of stones of convenient sizes, so that there should be as little waste and labour thereon as may be. We shall now proceed to show how to find these lines, the most important thing a mason can learn.

Making working drawings.

82. The general principles of the making working drawings; the projection of lines, of planes, and of curved surfaces; the finding the angles of planes inclined to one another; the describing mouldings, and the methods of finding the lines where they mitre, on the level or on the rake; in short, all the general principles of projection are given in JOINERY, sect. I., 1 to 20.

Arches, to Describe.

Lines for arches.

83. But as arches form no part of joiners' work, and as our articles ARCH, ARCHITECTURE, BRIDGE, &c., though containing full scientific developments on the subject, necessarily involve the highest branches of pure mathematics, we shall refer the readers of abstract science to these articles, and shall proceed to give a few problems in descriptive geometry for the use of masons, as we have done before for joiners.

84. First, of circular arches. These, if of moderate size, may be set out by a long lath, one brad awl as a centre, and another to trace, or by beam compasses; but if they are flat, the centre is frequently at such a distance as to render this inconvenient, if not impossible. The best way

Circular arches, to draw.

Flat arches.

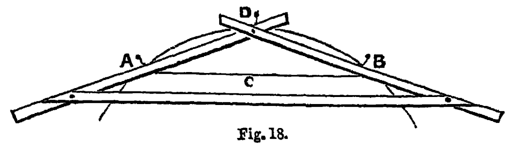


Fig. 18.

to proceed, far better than most of the cyclographs, is thus:—Let AB (fig. 18), be the width of the arch, and CD its height; set out their width and height on a floor, or on some boards joined together for the purpose; drive pins at A and B. Take two straight rods AD, DB, place them so that their sides may touch A and B, and their intersection coincide with D. Tack them together, and also a third lath across, to keep them at the same angle; place a pencil at D, which will trace the curve if the rods are moved to the right and left, and are kept pressed against the pins A and B.

85. Another way (fig. 19), let the letters represent the same): join AD, draw DE parallel to AB, and make DE equal to AD, then cut out a triangle in wood, or form one as above with three laths; put a pin into the board at D, and a pencil at the same point of the triangle, and it will trace half the curve AD; reverse it, and it will trace the other half DB.

Another way.

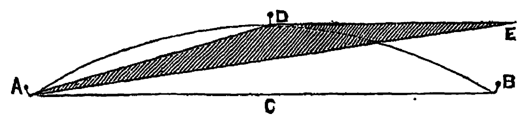


Fig. 19.

86. Next to circular forms, the most common are those from the sections of a cone, of which the most usual is the ellipse; the parabola is sometimes used, and so is the hyperbola, but very seldom. As these forms are necessary in setting out Grecian mouldings, as well as in almost all problems in masonry, it is proposed to treat of all three as shortly as possible.

Arches from conic sections.

87. Let ABC (fig. 20) be the section of a cone, or one cut through its axis downwards to its base, and ABD be half the plan of its base. If the cone be cut by a plane passing through EF, in other words, if it was cut into two parts by

The ellipsis.

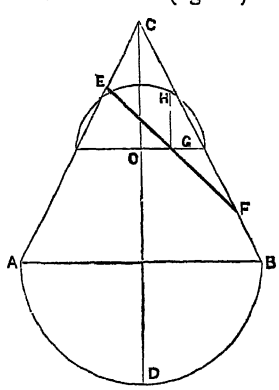


Fig. 20.

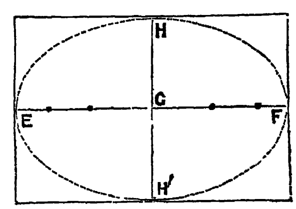


Fig. 21.

a large flat knife passing in that direction, but wholly above the base, its section would be an ellipse. Then EF would be its length, or axis-major. To find its height or axis-minor, bisect EF in G, through G draw a line parallel to AB, touching the sides of the cone; bisect this in O, and on it describe the semicircle as shown; then draw GH parallel to the axis of the cone CD, and this line GH will be the half the height, or the semi axis-minor, and the ellipse will be described within the parallelogram EF, HH' (fig. 21).

Stone-Cutting.

Various ways of describing the ellipsis.

88. This may be done, first, by finding the foci,[1] and describing the ellipsis by a cord or string, thus:—Take the distance FG (fig. 22) in your compasses, and from H as a centre strike the portion of a circle 1, 2, 3, then 1 and 3, where it cuts EF, are the foci. Stick two pins, or brad awls, in their points, and strain a string round H, 1 and 3; place a pencil at H, and move it round, keeping the string tight. The pencil will draw the ellipse, Or it may be done by a trammel. (See vol. viii., Plate CCXXXI. fig. 1; and see article ELLIPTOGRAPH.)

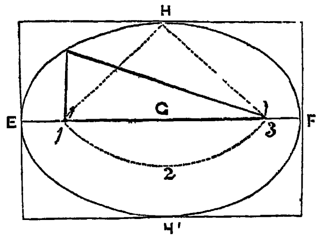


Fig. 22.

To describe an ellipsis by ordinates.

89. Let the parallelogram be, as before (fig. 23). Divide EG, E 4, each into any number of equal parts; here they are divided into 4; from HH' draw lines through 1, 2, 3, as shown, and where they intersect are points in an ellipsis; mark these points, bend a thin lath round them, and strike the curve. The same repeated for the other quarters will complete the ellipse. These methods are mathematically true; but as it is difficult to get laths to bend round a large curve, and very difficult to tie a string exactly to the proper length; and also to prevent its stretching when tied, other means have been taken as approximations.

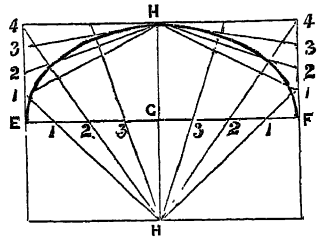


Fig. 23.

To describe an ellipsis by compasses.

90. It is of the utmost importance to the mason, whether in Gothic or other work, to remember, that in all cases where two circles touch each other, the two centres from which they each are struck, and the point in which they touch, must lie in the same straight line; in other words, a line drawn from one centre to the other must pass through the point of contact, a point where they each touch without cutting each other. If this rule be not strictly attended to, any curve coming out of another will not flow freely, but must be crippled. If we attempt to draw an ellipse with the compasses, we must strictly attend to that rule. Now, if we take a diagram similar to fig. 23, but instead of four parts, we suppose the diameter EG and the side E divided into two parts, as fig. 24. Now, joining the lines H 1, H' 1, we get at their intersection, a point K, which, as has been shown before, is a point within the true curve of the ellipse. To prevent the confusion of so many lines, we will now suppose a similar point found in the right hand quarter, and will call it L. Now, we have to draw two portions of circles, one through L and F, the other through LH and K, and they are, of course, to touch each other in L; then this point of contact L and the centres of the circles must be all in the same straight line. To do this we have to join HL by a straight line, and bisect it by a perpendicular line. This is done by taking any convenient opening of the compasses, and from the points H and L cross two small segments, as shown, and draw a line through them on till they meet HG produced to M. Join ML, cutting EF in N. From N as a centre strike the segment of a circle LF; and as LN and M are in the same straight line from the centre M, strike the segment KHL, which will pass through H, and touch LF at L. We have, therefore, a curved line passing through the points KHLF, all of which points are in the curve of a true ellipse, though the curve itself is not so, but parts of circular arcs. Proceed in the same way for the other side of the parallelogram, and the ellipsis is complete. If greater accuracy is required, divide EG, E 2, each into three or four or even more points, instead of two, and proceed on the same principle given above, viz., join the first pair of points so formed (beginning at the top) by a straight line, bisect this by a perpendicular projected till it cuts the line HG, and then join the next pair of points, and bisect again as before.

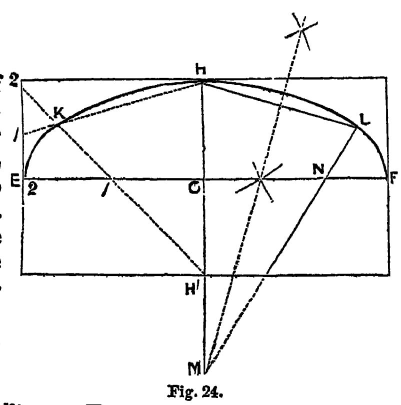


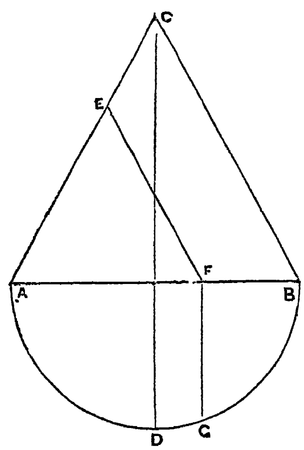
Fig. 24.

Stone-Cutting.

The parabola.

91. Let ABC (fig. 25) be the section of a cone as before, and ABD half the plan of its base; if the cone be cut through by a flat straight cut or plane in the direction EF, but it always must be parallel to one of the sides (as it is here to the side CB), the section of the cone thus cut will be a parabola, and its height or axis will be EF. From F draw FG at right angles to the base AB, and FG is half the base of the same.

Fig. 25.



To describe the parabola.

92. Draw a parallelogram (fig. 26) of which the height shall be equal to FE, and the base equal to twice FG. Divide the height and each half the base into any number of equal parts (in this case they are divided into 4), draw co-ordinates crossing each other as shown, and *a b c* will be points in the curve; bend a lath round, and strike the curve, which will be a parabola. In a similar way a parabola may be drawn, any height and width being given.

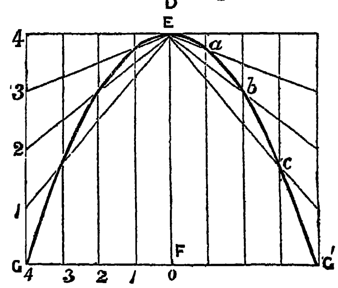


Fig. 26.

The hyperbola.

93. Let ABC, &c. (fig. 27), be the cone and its plan as before, and let it be cut by a plane at EF, falling within the base, but not parallel to the side. The curve of the section is a hyperbola, and FE is its height. From F draw FG at right angles to AB; then twice FG is the base of a parallelogram, within which the hyperbola lies.

To draw the hyperbola.

94. Construct a parallelogram (fig. 28) of the height EF, and width twice FG; then in fig. 27 produce the side AC and the line EF till they meet in H, and make EH (fig. 28) equal EH (fig. 27), divide the sides as shown into any number of equal parts, cross the co-ordinates as before, and through their intersections draw the curve.

The regular solids.

95. It is now necessary to say a few words on the regular solid figures with which the mason has most to do. These are the cone, the cylinder, the globe, and the spheroid. The cone may be considered to be formed

[1] For the definitions of the words *foci, ordinate, axis*, &c., see CONIC SECTIONS, pp. 252, 258, and 269.

Stone-Cutting.

by taking a right angle triangle (ABC, fig. 29), holding it upright, and turning it round as if the perpendicular side AB was an axis. The surface traced by the hypothenuse AC as it turns, would be the surface of a cone, and that

Fig. 27.

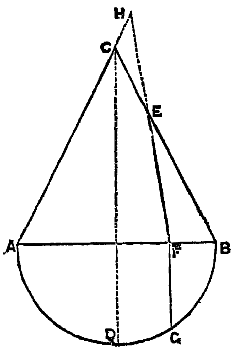
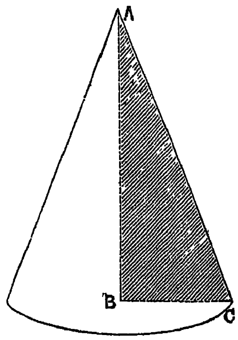


Fig. 29.



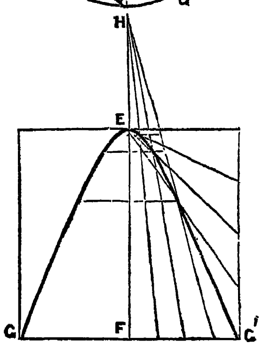


Fig. 28.

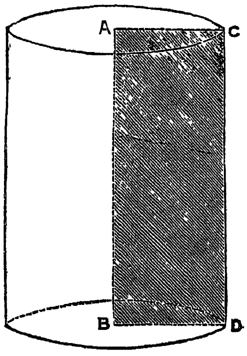


Fig. 30.

by the third side BC the base. In the like manner the parallelogram ABCD (fig. 30), turned round on one of its sides, as AB, would describe a cylinder; a semicircle (ABC, fig. 31) turned on its chord AB, a globe; and a semi-ellipsis, on its axis, a spheroid.

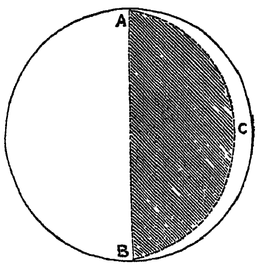


Fig. 31.

Sections of a cone.

96. If a cone be cut by any plane surface passing through its vertex, the section will be a triangle; if cut at right angles to its axis, the section will be a circle; if cut obliquely (as fig. 20), but at so flat an angle that the plane does not cut into the base, the section is an ellipsis; if by a plane parallel to one of its sides (figs. 25 and 26), which, of course, must cut the base, it is a parabola; if of less angle, or perpendicular (figs. 27 and 28) to the axis, it is a hyperbola.

Development of a cone.

97. If a piece of paper could be wrapped round any figure so as to cover its side exactly, and this then be spread out flat, it is called its development. Let ABC (fig. 32) be a right cone, the plan of which is drawn beneath it. Suppose this plan divided into any number of equal parts, as 12,

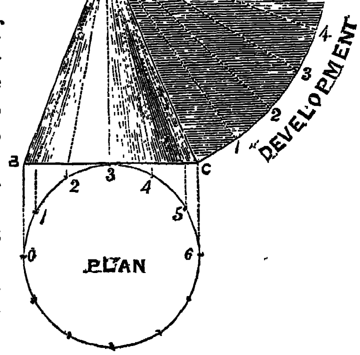


Fig. 32.

and the cone divided in a similar way by lines drawn to the apex A; suppose these lines drawn in wet ink, or paint, and the cone then rolled on its side along a flat surface, A 1, A 2, A 3, &c., would mark the different portions of the cone; and C 1 2 3–6 will be the stretch out of half its base, and AC 6 the development of half its surface. The other half will be merely a continuation of the same. To draw this development from the centre A with the radius AC, describe the segment of a circle, and set off upon it the openings 0, 1–6, equal to the circumference of the half-circle 0–6 on the plan, and join A 1, &c. Each division will be the development of a portion of the cone—thus, AC 3 will be a quarter of the cone, AC 4 one third, &c.

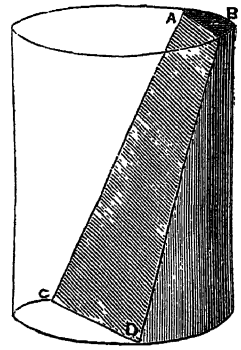


Fig. 33.

Sections of a cylinder.

98. If a cylinder be cut parallel to its axis, the section is a parallelogram; if the plane be inclined from the axis so as not to pass outside the ends or bases (fig. 33), a trapezium, ABCD; if at right angles to the axis, a circle; and if cut obliquely to its axis, the plane not cutting into the ends, the section is an ellipsis (fig. 34), of which AB is the larger and CD the lesser axis.

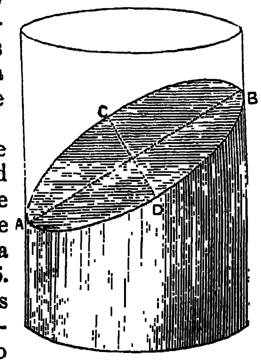


Fig. 34.

Development of a right cylinder.

99. Let ABCD (fig. 35) be the elevation of a cylinder, and its plan be below it; and suppose it divided as directed for the cone, and then rolled along a plain surface from E o to F 6. 0–6 is the stretch out of half its base, and E o–F 6 is the development of half its surface. To draw this proceed as directed for the cone.

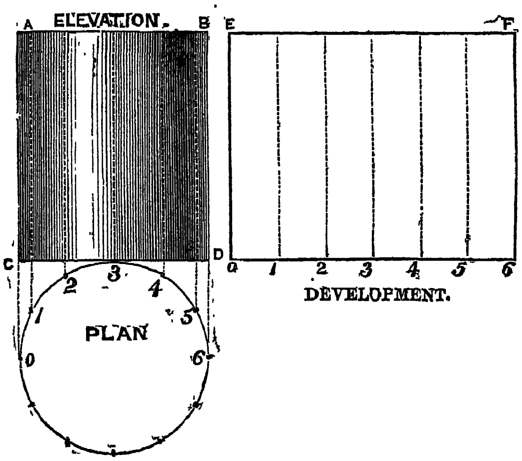


Fig. 35.

100. Let ABCD (fig. 36) be a cylinder cut square at the base BC (of which the plan is below), but obliquely at the top, as AD.

Development of an oblique cylinder.

The upper section (sec. 98), will be an ellipse, of which AD will be the length, and the radius of the circle (on the plan) equal to half the height EF. This may be described by any of the foregoing methods. Divide the circle at the base as before, and draw lines on to the surface of the cylinder; set out the stretch out from 0 to 6 as before directed, and draw the perpendiculars—as 0 0′, 1 1′, 2 2′,

Stone-Cutting.

&c. Again, draw perpendiculars from 0 1 2, &c., on the stretch out, and cross them by horizontal lines drawn from

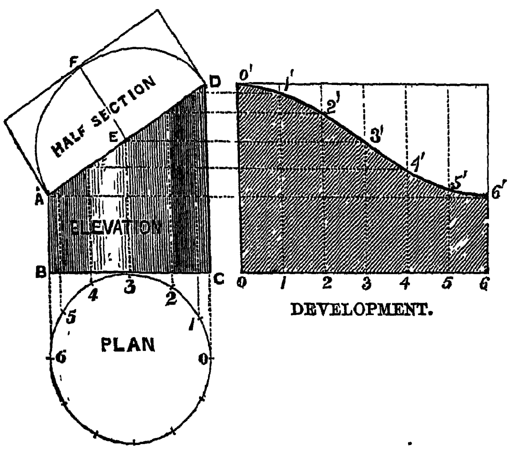


Fig. 36.

similar points in the elevation, cutting the lines on the development at 1′ 2′ 3′, &c., the surface between the curved and the straight line is its development. In like manner the other half may be drawn.

Sections of a globe.

101. If a globe be cut through by any plane, the section is a circle. If the plane passes through the centre of the globe it is called a great circle, being the largest that can be cut out of that solid. For the development of a globe see 117, 118.

Sections of a spheroid.

102. If a spheroid be cut by a plane at right angles to its larger axis, the section is a circle; all other sections are oval, of which all parallel sections are similar.

These foregoing problems are indispensable to a mason, and should be carefully studied and gone over till they are thoroughly understood. Several other mathematical curves have been used for arches, as cycloidal, catenary, cassinoidal, &c.; but the trouble of setting them out, and the difficulty and confusion the workmen often get into has led engineers and architects to the use of circular and elliptical arches almost exclusively. Indeed, in many cases where the latter were formerly used, it has been found better and cheaper practically to substitute segments of circles.

To find the Joints of Arches.

Circular arches.

103. In all cases the joints of all arches should be at right angles to the tangents of the curve. For this reason those of circular arches should simply be drawn to the centre of the circle of which they form a part. If that be very distant, as is frequently the case with very flat arches (fig. 37), divide the arc into as many equal parts as may be

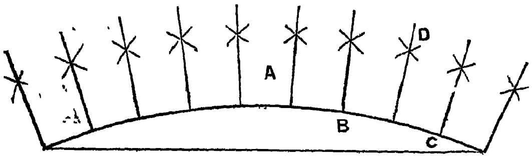


Fig. 37.

convenient, having relation to the size of the arch-stones or voussoirs, and taking care that the middle of the key-stone A shall be exactly in the centre of the curve. Then, from every alternate centre as B and C, with any convenient opening of the compasses, strike two small arcs, as at D, crossing each other; these will give the angles for the joints. In fact, this way is very nearly true for all flat arches, whether circular or elliptical.

Stone-Cutting.

Joints of elliptical arches.

104. Let EHF be an ellipse, and a the point from which the arch-joint should be struck; find the foci 1 3 (sec. 88, fig. 22), and draw lines from each through the point a, as shown towards b and c. Bisect the angle $b\,a\,c$, by the segments as shown; draw $b\,a$, which is the arch-joint. In cases of arches drawn by segments of circles, as fig. 39, the arch-joints are simply parts of radii from the respective centres ABC. This figure

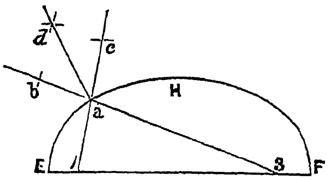


Fig. 38.

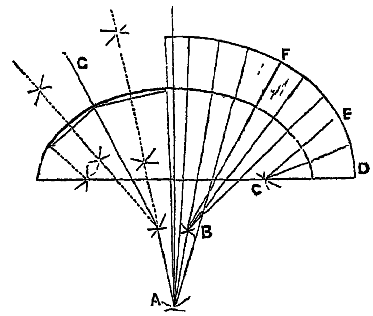


Fig. 39.

shows the case of an arch drawn from three centres in each quadrant instead of two. The arch-joints from D to E are to be ruled from C, from E to F they are to be drawn from B, and F to G from A. The method of finding these points is shown on the other half of the diagram. (See also sec. 90.)

Joints to parabolic arches.

105. The same rule holds good with parabolic arches as with others, that the arch-joint shall be at right angles to a tangent, passing through the point whence it rises. Then let ABC be a parabola, drawn as shown, sec. 92, figs. 25 and 26. It is required to find the arch-joint at D, draw DE

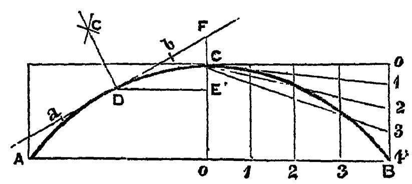


Fig. 40.

parallel to AB, and make CF equal to CE; through D, draw FD a as shown; take a, b equal distances from D, and raise the perpendicular D e, which is the arch-joint.

To find the Arch-Stones or Voussoirs.

Voussoirs of right arches.

106. Let fig. 41 be the elevation of the arch, below which is its plan. Then, as the stones are generally longer than they are high, the workman will take a block of about the size required, and will work any long side, say the bed $a\,b\,e\,f$ (see plan). He will then work the ends square, and of course they will be parallel with the face of the wall; he will then, by means of bevels, set off the angles $a\,b\,c$, $b\,a\,d$, $b\,c\,d$, and work these sides; he will then apply a mould the exact shape of the arch-stone, as shown by the shaded lines, to each end of the stone he is working, and describe its exact shape, taking care to keep the moulds out of winding, and work off the waste between the dotted lines $a\,d$, $b\,c$, reducing them to the curve shewn by the mould, and the work is complete.

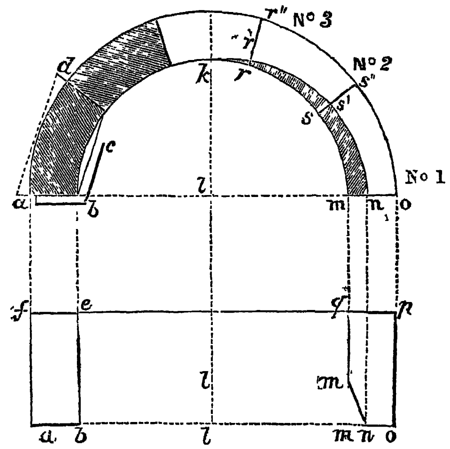
107. If the arch be splayed inside, as on the right hand

Stone-Cutting.

Arches splayed inside.

side of the plan, fig. 41, and lm be the half of the width of the square part, and ln that of the splayed, then the

ELEVATION.

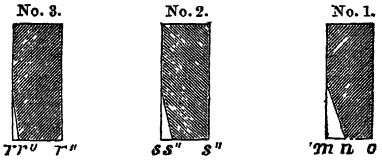


PLAN.

Fig. 41.

line marked r', s', n', is an ellipsis. Draw this by any of the methods given above, taking ln as the length and lk as the height. Then the plan of the bed (No. 1) at the springing will be $mnopq$ (see plan, fig. 41). The next bed $ss's''$, fig. 42, No. 2; the third, r, r_1, r_2, &c., &c.—the

No. 3. No. 2. No. 1.



PLANS OF BEDS OF ARCH-JOINTS.

Fig. 42.

depth of the square part, and the entire thickness of the arch being always the same.

Arches in oblique walls.

108. Let AB represent the plan of an opening (as a door or window) which cuts obliquely into a wall. If the

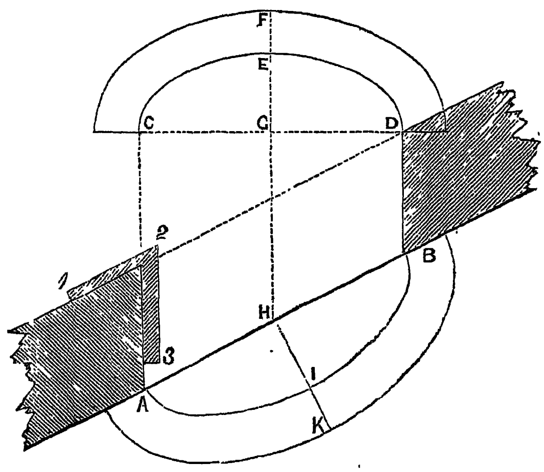


Fig. 43.

face of the arch be a circle, proceed as in 41; but instead of working the stones square at the end, they must be worked according to the bevel 1 2 3. The face bevels are obtained as shown before. But if the section of the arch be an ellipse, as CED (fig. 43), and the depth of the voussoir EF, the delineation of the face will be found by drawing HI at right angles to and bisecting AB, and making HI equal to GE as the height, and AB the length, and describing an ellipse; also make IK equal to EF, and describe a second ellipse through K as shown; AKB will be the face of the arch. If these arches are of great length, or very oblique, another method has been lately used, which is given in the separate article SKEW ARCHES.

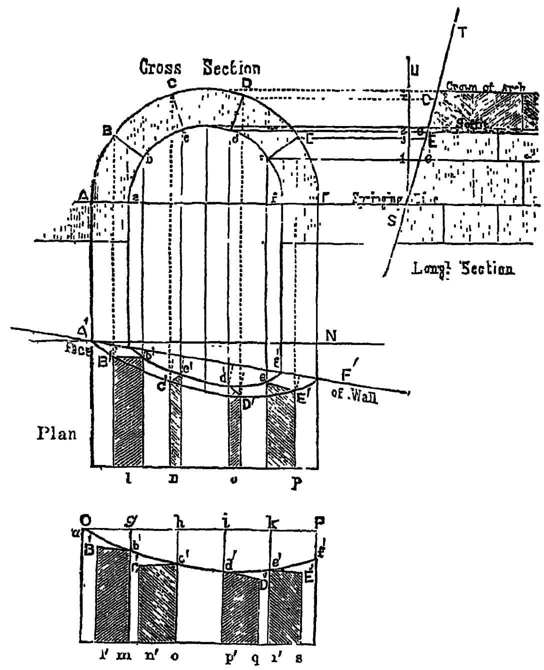
Skew arches.

To find the soffits.

109. The soffit of an arch may always be found by considering it to touch a cylinder placed as a centre under it, and by finding the development of such cylinder by the methods given in JOINERY, and in the sections 99, 100.

Arches in oblique walls, which also batter.

110. Let ABC . . F, abc,f (fig. 44) be the section of the arch of a tunnel, or of one in a terrace wall, the face of



Development.

Fig. 44.

which is not square with the section, but inclined on the plan at the angle NAF′, and which also batters or falls back out of the perpendicular at the angle UST on the longitudinal section, SU being perpendicular to the springing line. From the intrados def, &c., draw the faint lines to ST, as 1e, 2d, &c., and from the extrados draw the dotted lines 3E, 4D, &c.; also let fall the perpendicular bb', cc', dd, on A′F′. Then take the several divisions intercepted between ST and the perpendicular US, and transfer them to the line A′F′, and set them off at right angles to it as shown; then $a'b'c' \,.\,.\, f'$, will be the line of the intrados on plan, and A′, B′ . . F′, that of the extrados; and the portion between those lines will represent the battering face of the arch. From B′b', C′c', &c., let fall perpendiculars as shown, and the shaded portions will represent the places of the arch-joints on the plan.

The moulds for the soffits and arch-joints.

111. Take any line OP equal to the stretch out of the inner circle of the arch $ab \,.\,.\, f$, and divide it into as many parts as there are arch-stones. Draw perpendiculars from these points as shown in the figure, and set out on them gb', hc', &c., equal to the same on the plan. Then $a'b'$, c', &c., is the development of the line of the intrados; and each portion, as $c'd'op$, $d'pre'$, is the mould for the soffit of each respective stone. Next make lm, no, &c., equal to Aa, or Dd, in the section which will represent the depth of each arch-joint, and make B′l', C′n, &c., in the development equal to B′l, &c., on the plan. B′blm,

Stone-Cutting.

$d'D'pq$, &c., are the moulds for the arch-joints, as shown by the shaded surfaces.

Arches in circular walls.

112. Let $Aabc$, &c. (fig. 45), be a circular-headed arch

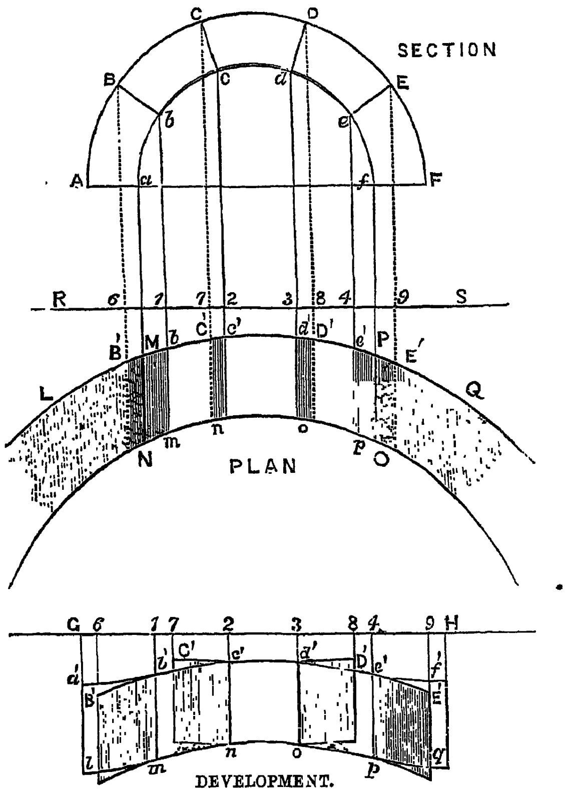


Fig. 45.

over a door or window, in the wall of a circular bow or tower; the plan of which is LMNOPQ. Draw the arch-joints bB, cC, &c., in the section, and let them fall on the plan in b'B′, c'C′, then the shaded part will represent the lines of the arch-joints on the plan.

To find the moulds for the soffits.

113. Draw any line in the plan RS perpendicular to the lines let fall. Also draw GH in the development, and make it equal to the stretch out $ab\,..f$, and divide it into as many parts as there are arch-stones at 1, 2, 3, &c.; draw the perpendiculars, and set down 1, b', 2, c', on the development equal to 1b', 2c', &c., on the plan. Do the same with 1m, 2n, 3o, &c., and the line $a'\,b'\,c'$, &c., is the front line of the soffit, and $l\,m$, q, the inner line of the same; also $c'd'\,n\,o$, $b'c'\,m\,n$, will represent the soffit of each arch-stone.

To find the arch-joints.

114. From the lines $b'm$, $c'n$, &c., set out the depth of the arch-stone equal to Bb, &c., on the cross section, and on the line GH set down 6B′, 7C′, &c., equal to the same on the plan. The shaded portions will then be the moulds for the arch-joints.

General remarks.

115. The above problem may be used for any sort of arch, or any form of wall, whether cylindrical or conical, care being taken that all section lines be first carefully transferred to the plan and then to the development. Perhaps the method of finding the arch-joints will be better understood if the reader will suppose the stones of an arch to be transparent or made of glass; and the joints or surfaces where they touch to be blackened. If the eye were placed exactly above such an arch, it would present the appearance as shown in our plans.

Spherical Vaults, Domes, Niche Heads, &c.

116. Spheres or globes may be developed in two ways,—*first*, in horizontal sections or zones; and, *second*, in vertical sections or gores.

Stone-Cutting.

To develop a sphere.

117. Let Ao, 1, 4 (fig. 46) be the section of a dome, and 1, 2, 3, 4 the places of the arch-joints; AB 4, the springing line; B, o, the line through the vertex; produce this line towards C, and through 2 1, 3 2, 4 3; draw chords to the vertical line, cutting it in a, b, C. Then o is the centre of the eye of the globe, or the key-stone of the dome; a the centre of the development of the first zone, 1, 2; b, the centre of the second 2, 3, C, of the third 3, 4; and so on for as many divisions as you may think proper to divide the globe into.

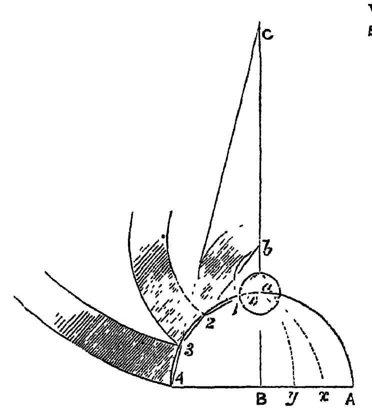


Fig. 46.

The same vertically or in gores.

118. Let xy, in fig. 46, be a gore or section of globe, made by two vertical planes passing through its centre. Then those planes are portions of great circles 101, and their sections are quadrants. Let ADB (fig. 47) be one of these quadrants, draw DC parallel to AB, and make it equal to half the gore required. Draw CF parallel to DB; produce AB to F, and CF to E, and join DF. Divide AD into any number of parts, as 0, 1, 2, 3, &c., and draw ordinates parallel to AB, cutting DF and CF. On CE set out 0, 1, 2, &c., so that CE will be the stretch out of AD. Draw ordinates through these points, and make 1, a; 2, b; &c., in CE, equal to the same lines intercepted between DF and CF. The curved line which passes through Dabc, &c., will be the development of half the gore. Transfer these points to the other side, and the whole is completed.

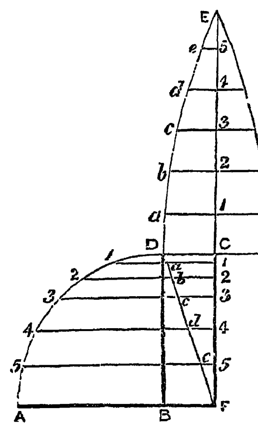


Fig. 47.

By these two methods any portion of the surface of a globe may be drawn, and if cut out of any thin material will form a mould for any of the curved surfaces.

To find the joints of a dome.

119. Let fig. 48 be the section, and fig. 49 the plan of a semi-circular dome, or a niche head. For greater clearness this is drawn with only two ranges of arch-stones besides the key, but the theory is the same for any number. Then $a\,b\,c\,d$ upon the plan will be the bed; $a\,b\,e\,f$ on section, the end mould of the first voussoir; the face moulds will be found by the preceding problems. It remains to find the upper bed at $e\,f$. With the radius Of strike part of a circle (fig. 50), and set out on it the line $f\,p\,g$, equal to $f\,g$ stretched out on the plan. If the thickness of the dome be parallel, as on the left side of the diagram, set out such thickness $e\,f$ (fig. 48), and then describe the circle $e\,h$, and $e\,f\,g\,h$ is the mould. The bevels can easily be set from the plan and section. If the arch-stones are intended to bond in with the level masonry, as shown on the right side of the section (fig. 48), make $p\,q$ (fig. 50), equal to $p\,q$ in the section, and proceed as before. In this latter case it will be better to work the arch-stones thus: from the point 1 on section let fall (through p) the perpendicular 1 p 2, and draw 4, 3, parallel thereto; then 2, r, 3, 5, 6, on the plan

Stone-Cutting.

(fig. 49), will be the mould of the bed: 1, 4, 2, 3, on the section, fig. 50, of the end: and the plane 1, 2, 3, a square angle

SECTION.

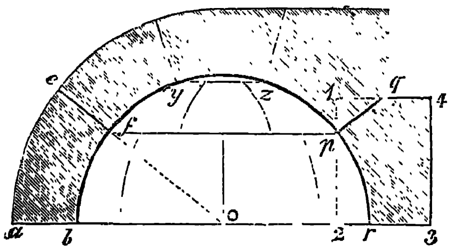


Fig. 48.

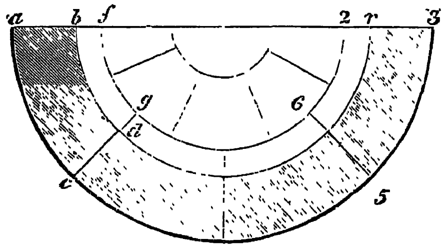


Fig. 49.

PLAN.

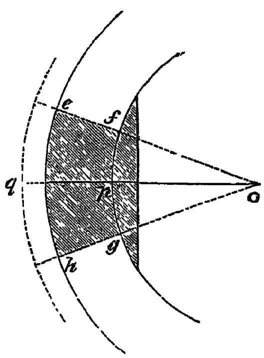


Fig. 50.

with the plan. The block will be the portion of an upright cylinder shown by 1, 2, 3, 4, 5, 6, 7, fig. 51. Then make q 4, 2 r, 2 p, &c., equal to the same on the section, and work off the waste as shown. As the radii of a globe are all equal, the curve is alike in all parts. A radius rule is therefore very convenient, this is found (fig. 50) by simply making $f g$ a chord to the curve, and the section included by the lines forms the rule. The key is simply part of a cone, the widest diameter of which is w x, and narrowest y z.

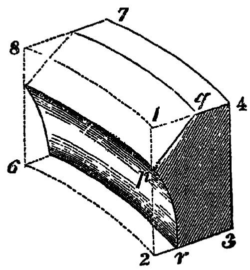


Fig. 51.

Arched Vaults which intersect each other or Groins.

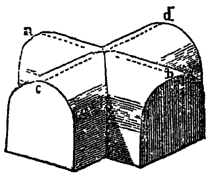
Cylindrical vaults with equal apertures.

120. Almost all groins (except the mediæval) are either circular or elliptical, and their crowns a b, c d (fig. 52), form straight lines. If the openings and heights be equal, the two sections (Nos. 1 and 2, fig. 52), will be alike, and the centers will intersect on the groin lines. Then (99) the intersection of two cylinders will be an ellipse of the length a b on the plan, fig. 53, and of the height of c d equal to that of either of the sections. Having thus the width and height, the ellipse may be drawn by any of the methods given above.

Unequal apertures, but equal heights.

121. If arches are of equal height, and level both at crown and springing, but of unequal widths, one arch at least must be the portion of an ellipse, and the intersection an ellipse more or less regular. Let the main arch, No. 1, be semi-circular ABC (fig. 54), and the cross arch, No. 2, of the width DE, but of the same height OC as No. 1. Join AB on plan No. 3, and draw OC perpendicular to AB, and equal to OC, Nos. 1 and 2. Then the

Fig. 52.



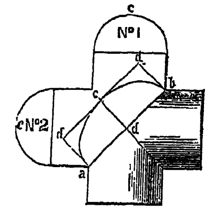


Fig. 53.

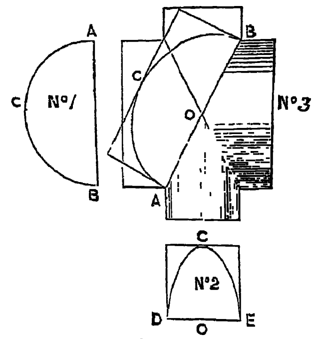


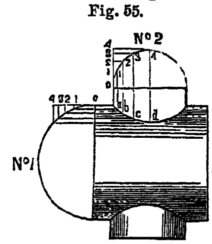
Fig. 54.

line of intersection will be an ellipse, the length of which is AB, and the height OC. The section, No. 2, will be an upright ellipse, the greater axis of which is OC and the less DE, all which may be drawn as before. If the cross vault be a semicircle, the main vault will be a flat ellipse, and the groins found as before.

Arches of different heights, but same springing.

122. These are either from the same springing, in which case the crowns of the intersecting arches are not level; or the crowns are level, in which case the springing of the lesser arch is higher than that of the greater. In fig. 55, No. 1 is the section of the main arch, No. 2 of the cross arch, No. 3 is the plan of a groin in which both arches are semicircular, but No. 2 is less than No. 1, and of course of different heights. In the smaller arch, No. 2, take any number of points, 0, 1, 2, 3, 4, and draw horizontal lines from them to the perpendicular 0, 1, 2, 3, transfer them to No. 1, return them to the curve, and draw co-ordinates from these points, meeting in the line a b c d, which is the curve of intersection. These are called under-pitch groins, and sometimes Welsh arches. In the same way the lines may be formed where one arch intersects another obliquely (fig. 56), where the respective numbers and letters refer to the same things.

Fig. 55.



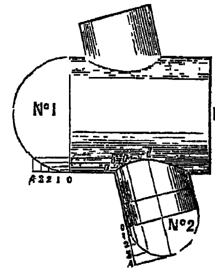


Fig. 56.

Arches of different heights, but level at the crown.

123. In this case the springing of the smaller arch must be higher than the other. This often occurs in Roman work, and almost always in Norman groining. No. 2 (fig. 57) is the smaller semicircle, the springing line of which is AB. Make OC in No. 2 equal to OC in No. 1, which is the height from the crown to the springing of the main arch. Take any points in the curve 0, 1, 2, 2, 3, &c., of No. 2, draw them to the perpendicular A 4, and transfer them to No. 1, and cross the co-ordinates as before, and the line of intersection will be found. But it must be noticed this is a curved line, and not a straight groin point, as will be the case in the next problem.

To find the lines when a cylinder is intersected by a portion of a cone.

124. This is often the case at the end of a building with a canted bow, or a church that ends with a hexagonal apsis. Let ABCD (fig. 58, No. 3), be the plan of cylindrical vault, the section of which is DEF, No. 1, and let it be pierced by the portion of a conical vault GHIK. Produce

Stone-Cutting.

GH, IK, O, till they meet in O the vertex of the cone, and till de in No. 2 is made equal to DE in No. 1,—de, of course, being parallel to GI. Draw the semicircle def in No. 2 equal to DEF in No. 1, and divide each into the

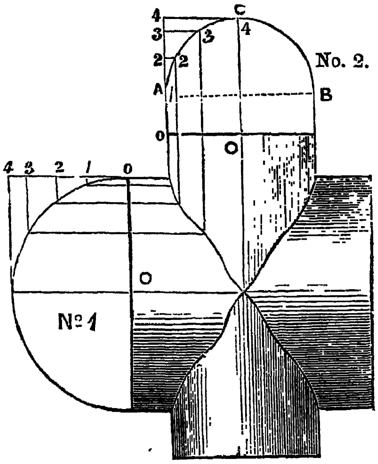


Fig. 57.

same number of equal parts. In No. 2, draw ordinates, first perpendicular to de, and thence radiating to the point

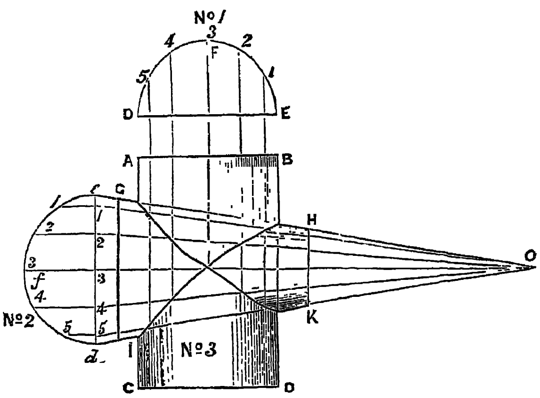


Fig. 58.

O; cross these by the co-ordinates from No. 1, all as shown in the diagram, and the curved lines GK, IH, will show the intersections.

Descending vaults. 125. The lines for these may be formed on exactly the same principles, viz., from a plan, two sections, and a double set of ordinates. In descending vaults, however, we have to remark, if it is intended the cross arches should be cylindrical, the groined points will be curved, as in 123 and 124. If it be intended that the groined points shall be straight, and should intersect in the middle of each bay, then the section of the cross arch will be an oblique oval.

If a mason will carefully master these problems, he will find very little difficulty in any methods of stone-cutting.

The same problems give the lines for centering, the practical method of executing which is found in CARPENTRY, CENTERING, &c., &c.

Mouldings.

Greek and Roman mouldings. 126. All the sections for Roman mouldings are given in JOINERY, p. 807, but as those used in stone work, particularly in Grecian architecture, are parts of Conic Sections, and not struck by compasses, we give a short problem by which they may all be easily set out.

127. Let (fig. 59) the moulding required, be an ovolo, the height of which (to the point where the moulding curves backward) is AC or BD, and the greatest projection AB or CD; and let CE be a tangent line, or line which the curve must touch but not cut. Produce CA to F, and make AF equal to AC, and AG to ED. Divide GB BE each into the same number of equal parts as 5. Draw the co-ordinates from F and C to the respective numbers, their intersections will trace the curve. If BE be more than

To draw a Grecian moulding, having its height, its greatest projection, and a tangent to the curve.

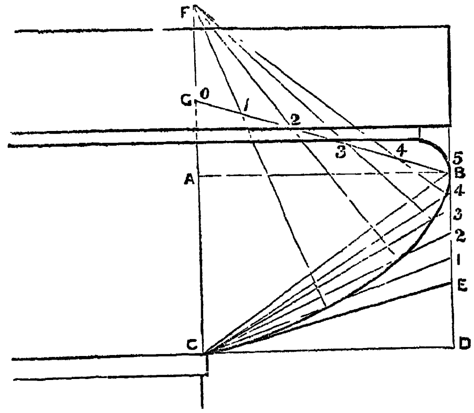


Fig. 59.

half the whole height, the curve is an ellipsis; if exactly half the height, it is a parabola; and if BE be less than half BD, the curve will be a hyperbola. All other moulding can be drawn by this method, remembering that cymas, ogees, and all reflex curves, must be divided and drawn in two separate portions.

Staircases.

128. The general principle of designing staircases, as regards the rise and tread of steps, setting out curves, curtails, landings, &c., are given in the article JOINERY (35, &c.) The chief difference between these and other staircases consists in the fixing, the one being framed with wooden strings, while the other have no strings, but are supported entirely by the walls. If there be a wall at each end, they are simply built in at the time the work goes up; but if they are supported at one end only, they are called geometrical stairs, and depend entirely on their being securely wedged into the wall; on which, and on the support each derives at one edge from the step below, they wholly rely. If they are square in section, they are called solid steps; but as the under side or soffit, then, is irregular, it is usual to make the steps of somewhat a triangular shape, so as to present a regular soffit. In this case they are called arris, or feather edge steps. Care should be taken that there are no sudden or irregular changes in the curves. These may be easily avoided by the method shown for the easing of the curves and ramps in handrails. (See JOINERY.) Stairs. Solid steps. Arris steps.

129. Landings should also be very carefully pinned into the walls. Fig. 60 will show the danger, should they not be so, through the full length of their insertion. If the front edge be pinned up, as at A, but a vacancy be left, as at B, the point C will become the fulcrum of a lever, and the landing have a tendency to turn at that point, and to break at the edge C. Every step and landing should have 8 inches hold in a brick wall. Landings.

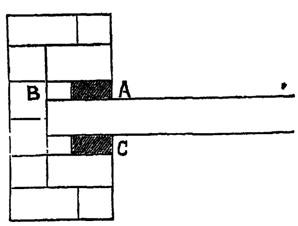


Fig. 60.

(130.) All landings should be well joggled; the joint Joggles

made as at *a* (fig. 61) is called by workmen a he, and that at *b* a she, joggle. The late accident at the Polytechnic Institution in London arose no doubt from the carelessness of the workmen, who put two landings together, on which two she joggles were worked (fig. 62), and filled the open space with plaster. There happened to be a large fossil in the stone close to the wall in the landing *b*, which having no support from the other landing *a*, gave way, and caused the destruction of the staircase below, upon which it fell.

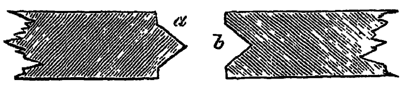


Fig. 61.

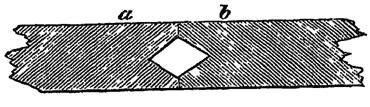


Fig. 62.

V.—STONE-MASONRY—MEDIÆVAL.

Materials.

131. It has already been stated (secs. 67, 68) that many of the early buildings of the middle ages were entirely constructed of masses of concrete, often faced with a species of rough cast. The early masonry seems to have been for the most part worked with the axe and not with the chisel. A very excellent example of the contrast between the earlier and later Norman masonry may be seen in the choir of Canterbury cathedral. In those times the groining was frequently filled-in with a light tufa stone, said by some to have been brought from Italy, but more probably from the Rhine. The Normans imported a great quantity of stone from Caen, it being easily worked, and particularly fit for carving. The freestones of England were also much used; and in the first pointed period, Purbeck and Bethersden marbles were employed for column shafts, &c. As time went on the art of masonry advanced with us, till in point of execution it at length rivaled that of any country. The methods of working and setting stone were much the same as at present, except that, as the roads were then in a very bad state, and in many places the only means of conveyance was by pack-horses, the stones were used in much smaller sizes than at present. The methods of setting out work were, however, different from those of other styles, as might be expected from the difference of forms.

Arches.

132. The earliest arches were circular (see ARCHITECTURE, page 480, and figs. 1 to 9, Plate LXVII.), and of course easily set out. But as the pointed styles came in, several methods were used for describing them. Pointed arches may be classed as—1st, lancet; 2d, equilateral; 3d, depressed; and 4th, four-centred or Tudor.

Lancet arches.

In the first the centres (1, 2, fig. 63) are without the arch *a b*. At Westminster Abbey the arches of the choir are so acutely pointed, that the distance from 1 *a*–2 *b* is nearly two-thirds of the entire opening *a b*. In the nave at York the points are without the arch at a distance of about one-fifth the opening *a b*.

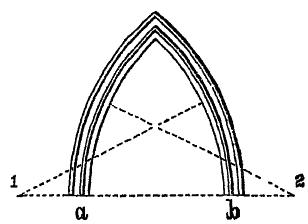


Fig. 63.

Equilateral arches.

In equilateral arches the centres are exactly on the points *a b* (fig. 64), so that the apex *c*, joined to *a* and *b*, will form an equilateral triangle. The nave arches at Wells are of this description, and also those at Lincoln (Plate LXIX., fig. 1).

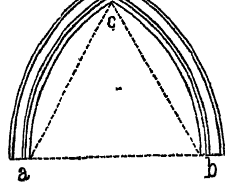


Fig. 64.

Depressed arches.

In later times the arches were of lower pitch, and then of course the centres 1, 2 (fig. 65), were within the arch *a b*. At Salisbury Cathedral (Plate LXVII., fig. 14), the distance *a* 1 is one-sixth of *a b*, while in the choir at Lincoln (fig. 2, Plate LXIX.) it is as much as two-fifths.

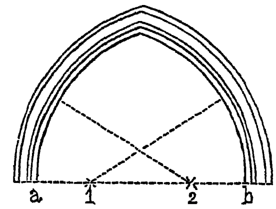


Fig. 65.

To describe similar arches.

133. To describe arches which shall be similar to one another throughout a building, however the openings may differ, this principle must always be borne in mind: that the centres shall always be distant from the points *a b* by some aliquot portion of the whole opening. This is the more important, as the lines of tracery will not fall into their proper places except the arches are set out upon some regular principle (sec. 136). If the arches are not equilateral, some distance from each point, *a b* should be first determined on (say one-third the opening *a b*), and after this, whatever the span of the other arches may be, one-third its own opening is to be taken from the points *a b*, as the centres from which to strike its curves. The only exception is, that in mediæval buildings, the arches to the doorways are frequently somewhat flatter than those of the windows.

To describe four-centred arches.

134. In the Tudor period the arches are very frequently drawn from four centres instead of two. It must be remembered that it has already been stated (sec. 90) the point where two circles touch each other must always be in the same straight line that is drawn through both their centres. As there has been great misapprehension as to four-centred arches, some persons treating them as parts of conic sections, whereas they are really parts of segments of circles, it is thought well to give two methods of describing these arches. First, when the width AB, and the apex height OC, are given, and a tangent to the upper circle CD. In this case draw AD perpendicular to AB, and set out A 1 equal to AD; draw C 3 perpendicular to CD, and make CE equal to AD or A 1; join 1 E and bisect the same as shown by a perpendicular meeting CE produced in 3; join 3 1 and produce towards F, then 1 and 3 will be the centres for half the arch; and, transferring the points across, 2 and 4 will be the centres for the other half. In the second case, when the width AB and the height OC, and the centres of the small circles 1, 2, are given. Make AD equal to A 1, join CD (which will be a tangent to the upper curve), draw C 3 at right angles thereto, make CE

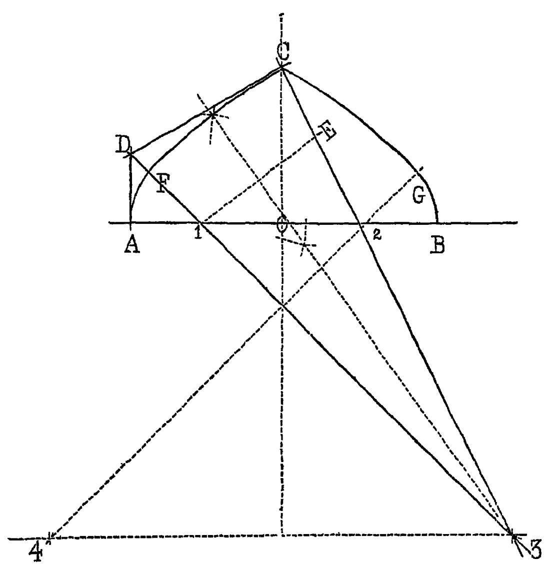


Fig. 66.

equal to A 1, join 1 E, bisect the same, and proceed as before. The points FG, as has before been explained, are the points where the circles will touch each other. The joints to these arches will all radiate to their respective centres, as has been before explained in secs. 103, 104.

Archjoints.

Mouldings.

135. The mouldings of mediæval architecture are almost infinite in variety, and even a short description of those used in each style would exceed our limits. They are sometimes set out with the compasses, and many often appear to have been drawn by eye. We must refer our readers to the works of Willis, Paley, and particularly of J. H. Parker, for their description. A very curious treatise was published by the former gentleman called the *Architectural Nomenclature of the Middle Ages*, which goes at great length into the subject. A bead or astragal seems to have been called a bowtelle; a torus, a grete bowtelle; a hollow or scotia, a casement; an ogee, a ressaunte, &c., &c.; but the subject is too long to be discussed in our pages.

Nomenclature of.

Window tracery.

136. The various sorts of tracery which adorn the windows of the mediæval periods, and are in fact their greatest glory, are treated of in the art. ARCHITECTURE, and specimens given in the different plates, particularly Plate LXVIII., figs. 4 to 8. The designs for these are almost infinite, and the various methods of setting them out would fill a volume. But although they display such ingenuity and fancy that one would think the design to be quite arbitrary, it is a curious fact they are all, or very nearly all, set out on the principle of geometrical intersections. An example, therefore, is given (fig. 67) to show the principles on which the mediæval architects proceeded to describe the tracery, and also the method of finding the joints of the various pieces of stone. Let *a b* be the opening of the arch; as there are to be two mullions, divide the same into three equal parts, as *a c*, *c d*, *d b*; then determine the points from which to strike the arch. In this instance, for the sake of simplicity, we make it equilateral (sec. 132 and fig. 64); *a* and *b* then are the centres for striking the main arch *a e g*, *b f g*, and the height *o g* is that of an equilateral triangle. Produce the springing line, and the same opening of the compasses through *c*, and *d* will give the principal inner branches of the tracery *c e*, *d f*. From the centre *o*, with an opening extending to the middle of the lights *a c*, *d b*, strike a semicircle, raise perpendiculars from *c* and *d* to 1 and 2; draw a line through 1 and 2; on this and the springing line will be found the centres of the

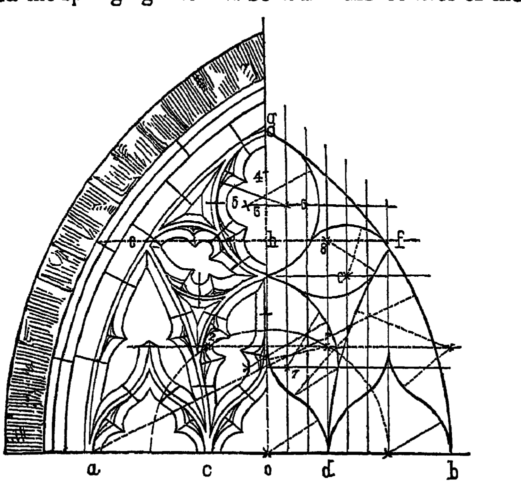


Fig. 67.

lower ogees; bisect the line from the intersection 1, 2, in *h*, which is in fact the same thing as dividing the whole height *o g* into three; divide *h g* into three parts, as 3, 4; through 3 draw a horizontal line, and set off from 3 equal to one-third of the width *o d*, or draw the perpendicular lines as shown, which is better; then 5, 6, will be the centres of the upper quatre-foil. From the line 1, 2, on the same perpendicular as last, set down similar points as at 7. These will be the centres for the lower sub-division as shown. Next draw *e h f* and sub-divide by similar perpendiculars, and where the lines intersect, as at 8, 9, will be the centres for the upper sub-divisions. The lines thus drawn will form a species of skeleton diagram, as shown on the right side of fig. 67, which is called the *element of the tracery*, and is in fact the centre line of the mullion, as shown by *a*, fig. 68. On each side of this, using always the same centres for the same branches, draw lines, showing the face (or what the workmen call the *nose*) of the mullion, and answering to *b c*; and then others answering to the sides of the mullion as *d e*. Any other mouldings upon their sides or faces may be drawn in like manner. Put in the cuspings as shown, and the tracery is complete. The practical stone-mason will take care never to make a joint where there is an angle of any sort, as the point of a cusp. In all cases the joints must tend to the centres of the circles from which they are struck, and where the lines branch off in two directions, the joints must not be in one line, but must tend in two, or as many directions as there are branches, and each to the centres of such respective branch. When the lines are perpendicular, as at *c d*, and at the joint below *h*, the joints are horizontal. A close inspection of fig. 67, where they are carefully drawn, will elucidate the matter more than any number of words can do. Our readers would scarcely believe that the elaborate west window at York is entirely set out on this principle; and so is the still more remarkable instance, the eastern window at Carlisle, which is composed of 86 pieces of stone, and the design for which is drawn from 263 centres. On no account should iron be used as cramps or dowels in Gothic work, as it rusts and breaks pieces out of the stone. The best material is slate run with the Portland cement. Lead is often used; but any metal will expand and contract with heat and cold, and its use is much better avoided altogether. All the upper construction of windows and doors, and of aisle arches, should be protected from superincumbent pressure by strong relieving arches above the labels (see fig. 67), which should be worked in with the ordinary masonry of the walls, and so set that the weight above should not press on the fair work, in which case the joints of the tracery, &c., will sometimes flush or break out.

Element of tracery.

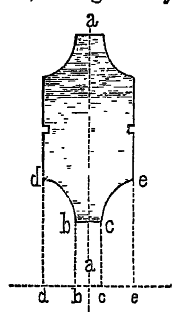


Fig. 68.

Joints of tracery.

Cramps, dowels, &c.

Relieving arches.

Vaulting.

137. Mediæval vaults differ much from those before described, principally that the crowns *ab*, *cd*, are not level, as shown in fig. 52, but all have a slight curve or spring, and the filling-in between them also is slightly curved, so as to partake in some degree of the character of the dome as well as of the groined arch. Bearing this carefully in mind, and setting the lines out thus on the sections, the rules we have given for finding the various lines for groins (120–125) will apply as well to Gothic groins as to those of ordinary character; the principle of working from plan, section, and stretch-out being the same, though for the most part the ribs in early vaulting are not true segments of ellipses, but approximations drawn by the compasses. The triumph of mediæval stone-masonry, however, is that species of

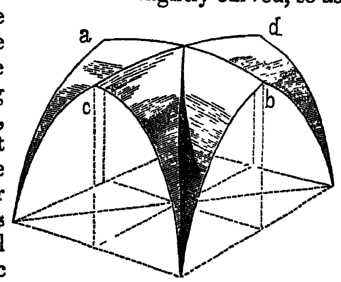


Fig. 69.

Artificial Stones.

groin known as fan vaulting. This is unlike that of any other age or time. The roofs of King's College Chapel, Cambridge, and of Henry VII.'s Chapel at Westminster, are eminent examples. It is impossible in our limited space to give demonstrations of them, and we must refer our readers to the admirable treatises on the subject by Professor Willis, published in the first volume of the *Transactions of the Institute of British Architects.* The filling-in between the ribs of mediæval groins is generally of clunch or some soft stone, over which some concrete is placed in such manner as to bind all together, and to resist the thrust.

Fan vaulting.

Spires.

138. The bold and beautiful termination to mediæval towers, which the French call flêches and we call spires, is another proof of the skill of the mediæval masons. These are generally octagonal, and rise partly from the walls of the tower and partly from arches thrown anglewise from wall to wall, to cut off the corners, as it were, and afford a springing to the spire. The wonder of these constructions is their extreme thinness and lightness. The top of the spire at Salisbury is 411 feet from the ground, of which 207 is taken up by the tower, leaving, of course, 204 feet for the height of the spire itself; this is only 9 inches thick at the bottom, diminishing to 7 inches, or on an average only about the three-hundredth part of its height. It has been attempted to show mathematically that the joints of a spire would be stronger if at right angles to its face; but they would then slope inwards and hold the wet, which in sudden frosts would do most serious injury; practically, therefore, it is found best to lay the courses on a level bed. They should, however, be frequently dowelled and cramped together, but not with metal, as above stated.

VI.—ON ARTIFICIAL STONES, AND ON THE INDURATION OF SOFT STONES.

Cements and terra cottas.

139. The great expense of obtaining and working Portland has driven our masons into the use of the softer freestones. These (as has before been described, sec. 19, &c.), are liable to rapid decay from the action of frost and wet, and in towns from the action of the sulphurous acid in the coal-smoke. To avoid these inconveniences several contrivances have been resorted to within the last century to obtain a cheap and durable material in which to execute external architectural ornament; or to invent some process by which soft stones may be so protected by an outer coat of impervious matter as to throw off the wet; or may be so indurated as to resist the ordinary wear to which Portland or the harder stones may be subjected. The earliest attempts were to manufacture a hard hydraulic cement, which might be modelled with the tool, or cast into moulds. The earliest use of this is said to have been by the Adam's, it suiting very well with the low relief of their style of ornamentation. (For an account of cements, see this article, sec. 22, *ut supra.*) Another method, which has been frequently tried with success, but seems too expensive to come into general use, was to model the ornaments in good plastic clay, as colourless as possible, and burn them in kilns. The best known of these systems was that called Coade's artificial stone, the manufactory of which, however, is now discontinued. (For an account of this species of manufacture, see POTTERY, TERRA COTTA, &c.) A method, however, which seems to bid fair to excel them all in beauty, cheapness, and durability is that patented by Mr Ransome of Ipswich. It appears, the idea suggested itself to him as long back as 1844, that if he could mix sand, or pounded flint with anything that would make a sort of fluid glass, and stick it together, as it were, in a pasty state, it might be pressed into moulds, and when dry it would form a sort of strong glass. After a variety of experiments, and trying to accomplish his object through a number of changing theories, he at length succeeded in the following process. He first obtains a strong caustic alkali, which is purified by a most ingenious process. This is made, by the assistance of steam and heat, to act upon some broken flints, which it does, and the alkaline solution is then drawn off and evaporated till it becomes the thickness of treacle. One part of this is mixed with ten parts of sand, one of flint, and one of clay. The whole is kneaded up till like putty, so as to be readily pressed into moulds, and so as to take the sharpest forms. Our space will not permit us to give the full details; but it may suffice to say that the objects, after being dried in close stoves, are then submitted to a strong red-heat in a kiln like that of a potter, which drives off all the alkaline and other chemical agents in the process, and leaves the granules of the sand and flint enveloped in, and, as it were, stuck together by a sort of glass. Time alone, however, can only ultimately show the results. At present the material seems of beautiful colour, texture, and sharpness; and unless some unknown or unforeseen chemical agent should act upon it, Ransome's stone appears to be indestructible.

Coade's artificial stone.

Ransome's.

Induration of stone.

140. The rendering soft stones hard, and the protecting the surfaces from the weather when worked and set, has been the subject of great investigation lately. The idea of the latter seems to have originated with the late well-known John Sylvester, who tried the method of washing over the faces of stone walls with first a solution of soap and then of alum. Another method was that of washing with what was called water-glass, or silicate of potash, both of which are said to have failed. The next idea was to soak the stone, or in some way to cause the surface to imbibe a quantity of oily or fatty matters to throw off the wet, as well as to harden the stone itself. The first patent was taken out by Mr Hutchison, at Tunbridge Wells, in 1847, and was applied to the new sandstone there. The stones, when worked, were boiled in a solution of resin, turpentine, wax, oil, &c., and sometimes, we believe, pitch, till they were impregnated a sufficient depth from the surface. In 1851 Mr Barrett took out a patent something like the preceding, but far more elaborate; in fact, too long to be described in our pages. The main elements, however, were resins, fats, and tallows, some of which were mixed with gutta-percha, unslacked lime, copperas, and a number of other ingredients. In April 1856 Mr Daines took out a patent, not so much to indurate stone, but to preserve stone, or cement walls from damp and efflorescence. His process was to apply, first, a solution of sulphate of zinc, or solution of alum, to the wall, and then a composition of sulphur dissolved in oil. In the same year, and in the next month, Mr Page took out a patent for a similar purpose; his material was wax dissolved in coal-tar, naphtha, or, for more delicate work, in camphine. We are informed the manufacture of the first of these patents is discontinued, but not from any failure of process. Of the others it is impossible to say much, as so little time has elapsed since they commenced, and as early experiments in all manufactures often fail; judging, however, on the grounds expressed as to mastic (37, *supra*), we should fear they would fail from a like cause, especially as such very volatile media as naphtha, camphine, &c., are used. Mr Ransome's, however, seems to promise better. His is deduced from his experiments on the artificial stone. It consists of treating the surface of the stone first with a solution of silicate of potash or soda, and then with a solution of the chloride of barium, or chloride of calcium, by which means an insoluble silicate, either of barium or lime, is deposited in the pores of the stone. The most extraordinary results, however, are promised by Mr Szerelmey's process. The author of this article has been informed by that gentleman that it will not only entirely protect the surface of stone or brick, or cement, but of iron; as a proof, he states that an anchor coated with it was sunk in the sea many months, and raised

Sylvester's. Water-glass. Oleaginous processes. Hutchison's. Barrett's. Daines's. Page's. Ransome's. Szerelmey's.

again without trace of oxidation. As his process is a profound secret, and his experiments are now in progress, it is impossible to pronounce an opinion on the subject.

The principal works on Stone-Masonry are as follows:—

Foreign.—Jousse de la Flêche, *Secrets d'Architecture*, fol. 1642. Bosse, *La Pratiquè du Trait pour la Coupe des Pierres*, fol. 1643. Francois Derrand, *Des Traits et Coupe des Voutes*, fol. 1643. De la Rue, *Traité de la Coupe des Pierres*, fol. 1728. Frézier, *Traité de Stéreotomie*, 4to, 1737–57; *Elements de Stéreotomie*, 1759. Simonin et Delagardette, *Traité de la Coupe des Pierres*, 4to, 1792. Douliot, *Traité Speciale du Coupe des Pierres*, 4to, 1825. *Vorlegeblatter, per Maurer*, fol. 1835. Adhémar, *Traité de la Coupe des Pierres*, fol. 1836–40. Normand, *Epures d'Escaliers en Pierre*, 4to, 1838. Le Roy, *Traité de Géometrie Descriptive*, 4to, 1850. Claudel et Laroque, *Maçonnerie Pratique*, 8vo, no date. Besides these see the article Maçonnerie in the various Encyclopédiès, and the famous general treatise by Rondelet, *L'Art de Bien Bâtir*, and the older work of De L'Orme, fol. 1643.

In English.—Moxon, *Mechanick Exercises*, 4to, 1677–93, 1700. Batty Langley, *Ancient Masonry*, fol. 1736. Nicholson, *Practical Builder*, 4to, 1823, &c.; *Practical Treatise on Masonry*, 8vo, 1828; *Guide to Railway Masonry*, 8vo, 1839–46. *Practical Masonry, Bricklaying*, &c., 4to, 1830. Dobson, *Rudimentary Treatise on Masonry*, 4to, 1849–56. Besides the valuable articles in Gwilt's well-known *Dictionary of Architecture*, and Cresy's on *Engineering*. (A. A.)

STORACE, Stefano, a very popular English composer in the latter part of the 18th century, was born at London in 1763. His father, a Neapolitan, performed for many years as a contrabassist at the King's Theatre in London, and married a Miss Trusler of Bath. The family name is said to have been really Sorace, and not Storace. Stephen, under his father's instructions, acquired considerable command of the violin when only ten years old. His father then sent him to study the violin, the harpsichord, and counterpoint, in the conservatory of Sant' Onofrio, at Naples. On leaving the conservatory, he visited different Italian cities, and then proceeded to Vienna. His sister, Anna Selina Storace, a pupil of Sacchini, travelled with him. She had become one of the best singers of the day, and had been received with great applause at several theatres in Italy. In 1784, the Emperor of Germany engaged her for the Imperial Italian Theatre, at L.500 for the season. Storace composed an opera, *Gli Equivoci*, for that theatre. He and his sister returned to England in March 1787, and Signora Storace was instantly engaged for the King's Theatre, where she appeared on the 24th of that month as *Gelinda*, in Paisiello's opera, *Gli Schiavi per Amore*. Her brother becoming disgusted with the intrigues of the theatre, retired to Bath, and devoted himself to drawing, in which he had considerable skill. Returning to London in 1788, he brought out, at Drury Lane, Dittersdorf's music to *The Doctor and Apothecary*, an opera, translated and adapted by Mr John Cobb. On 24th November, 1789, he produced his first English opera, *The Haunted Tower*, written by Mr Cobb. This had a run of fifty nights the first season, and for many years remained a favourite opera. In 1790, Storace produced *No Song no Supper*, written by Prince Hoare, which also had great success. On 1st January 1791, the Spanish composer Martin's celebrated opera *La Cosa Rara*, altered by Mr Cobb, was brought out by Storace (who added to it some music of his own), under the name of *The Siege of Belgrade*. It had a run of sixty nights the first season. In the same year, *The Cave of Trophonius*, translated by Prince Hoare, with music selected by Storace from Salieri's opera, did not succeed. On 26th November 1792, the opera of *The Pirates*, composed by Storace, and the scenery from drawings made by him at Naples, was performed with great success. His next operas were—*Dido; The Prize; The Glorious First of June; The Cherokee; Lodoiska*, the music from Kreutzer and Cherubini; *The Three and the Deuce; My Grandmother; The Iron Chest;* and the opera of *Mahmoud*, unfinished at the time of his death, on 19th March 1796. This last opera was completed by Michael Kelly and Signora Storace, and performed on 30th March 1796, for the benefit of Storace's widow and child. Storace married a daughter of Mr Hall, the engraver. His sister died in 1814. Among Storace's contemporaries, who distinguished themselves as composers of English operas, were Shield, Arnold, Hook, Dibdin, Mazzinghi, and Thomas and William Linley. (G. F. G.)

STORNOWAY. See Lewis.

STORY, Joseph, an eminent American judge, professor of law, and jurist, was born 18th September 1779, at Marblehead, a small fishing town in the county of Essex and state of Massachusetts. His father had been a surgeon in the army, and had served with General Washington, but had afterwards retired, and was in good practice in Marblehead and the adjacent towns. As a boy, he was remarkably intelligent and studious, and his precocious talents were developed by his becoming early a favourite of the village barber, and being permitted to frequent the shop, and listen to the interesting miscellaneous talk of the host and his customers, thereby receiving impressions which continued through life. At the age of fifteen, Joseph, after showing unusual firmness and determination in preparing himself for matriculation, was entered at Harvard College, where he was a fellow-pupil with the Rev. Dr Channing, the distinguished divine and philanthropist, and his immediate chum was the Rev. Dr Tuckerman. Though he had been brought up as a Calvinist, he became, during his college career, a Unitarian, a faith which he continued throughout his life to hold; while, at the same time, the prevailing temper of his mind was a settled tolerance of every other creed. He was not only in youth, but throughout his life, more or less inclined to poetry, and wrote many verses; but these seldom, if ever, attained mediocrity; and it does not appear that he gave way to this habit, except at leisure hours, and as a variety to graver studies. His career at college was very distinguished. The constitution of his mind, which was eminently legal, no doubt insensibly impelled him towards the law. On leaving college, he entered the office of Mr Sawell, then a distinguished advocate at the Essex bar, and a member of Congress. Though at first somewhat repelled by the dryness of legal authors, which presented so great a contrast to the more elegant and various studies of his youth, he soon conceived a great love for its principles and a settled desire to master its details.

At the age of 22, Joseph Story was admitted to the Essex bar, and opened his office at Salem. His progress was not rapid, but sufficiently encouraging to admit of his falling in love and soon marrying his first wife, whose early death threw a gloom over this period of his life, which was, however, dissipated by time, and, in 1808, he married again. During his early career at the bar, he devoted much time to the study of composition, and to poetry and declamation, the practice of delivering annual orations, commemorative of the Independence and other great events, offering attractive opportunities to young American lawyers. He also mixed in politics, and, in 1805, he became member for Salem in the legislature of Massachusetts. Here he developed his talent as a debater, and gained so great distinction in the House that he was elected a member of Congress. Having declined a re-election to Congress, in consequence of an early disgust at the meanness and petty intrigues of public life, and its incompatibility with success at the bar, he returned to the Massachusetts legislature, and was elected speaker of the House of Representatives. At this period, his reputation for ability, and for frankness of character, had gradually increased. During the same year, a vacancy having occurred in the Supreme Court, the appointment,

after two successive refusals from other persons, was unexpectedly offered to him. At this period, his age was only 32; he was then making an income of upwards of L.1000 a year, and the salary of associate justice was under L.800 a year. He fully considered the subject, and after balancing the advantages and disadvantages, he preferred the serenity and dignity of the judicial office, to the rough and ready warfare of the bar, and accepted the appointment.

Shortly before Mr Story's appointment to the office of associate justice of the Supreme Court, he had edited three English law books, in general request in America, viz., Chitty on *Bills of Exchange*, Abbot on *Shipping*, and Lawes on *Assumpsit*. He had not, however, as yet shown that eminence as a scientific lawyer which he afterwards attained. His cotemporaries no doubt gradually arrived at the conclusion that he was peculiarly fitted for the office of a judge. They observed, in all his judgments, a philosophical mind, well equipped with all the learning of his profession, stored with details, as well as anxiously careful of first principles. His acuteness was more than equalled by his singular fertility in illustrations; and his judicial eloquence, readiness, and urbanity of manner, soon led him to be marked out as the most able and popular judge of his day. He was, however, no popularity-hunter, in the vulgar sense of the word, but seemed always to be actuated by a strong sense of duty, and was zealously attached to the great principles of the American constitution. Marshall was then the chief justice of the court—a thoroughly able and upright judge—and it was often said, that the same relations existed between him and Justice Story as existed between Lord Mansfield and Mr Justice Buller. Story was distinguished above all his contemporaries for the extent of his reading and his familiarity with the English reports, and indeed his interest in everything English extended far beyond his own profession; for he devoured, with unceasing interest, throughout his life, the English newspapers, and was always well versed in their minutest details.

In 1829, eighteen years after Mr Justice Story's appointment as a judge, Mr Dane, who had long meditated the foundation and endowment of a law professorship at Harvard University, and had long had in his eye the preeminent qualifications of Mr Justice Story for such an office, at last matured his plan, and offered him the appointment. Though the salary was only about L.150, the duties were not incompatible with the office of a judge, and Justice Story readily accepted the office, having always felt a peculiar pleasure in imparting his own ample stores of information to others, especially to the young. He gradually increased his pupils from six to upwards of a hundred. It was part of the conditions annexed to the office, that the professor should write some legal works in four or five volumes, on subjects which were left to some extent to his own selection. These terms were probably in his eyes one of the greatest attractions of the office, and he at once applied himself to the preparation of his first work, which was entitled, *Commentaries on the Law of Bailments.* The subject was one which had not hitherto been fully developed by any legal writer, Sir William Jones's work, though elegant and able, being somewhat slight in its treatment. It also admitted of appropriate references to the civil law. His great judicial experience was also greatly in his favour. The work, when completed, displayed an elegance, ability, and copiousness of illustration, till then unknown in America, and, with the exception of Blackstone's *Commentaries*, little known in England. All his contemporaries were struck with its great merits, and these were also acknowledged in England. In a year and a half afterwards, viz., in 1833, his *Commentaries on the Constitution of the United States*, in three volumes, were published. This work, though, from its subject, not so familiar to English lawyers, was conspicuous for the same merits as the preceding. He immediately afterwards commenced his *Conflict of Laws*, one of the works by which he is best known to English lawyers. The subject had not been touched upon by any writer on the law of England, which had, indeed, always treated with contempt all other systems of jurisprudence; and it was scarcely to be wondered that a work which discussed in a liberal spirit, and with copious illustrations from the continental jurists and American reports, till then unknown even by name, was welcomed by all English lawyers. The next works followed in rapid succession, all equally able and replete with learning; his treatises on Equity Jurisprudence, on Equity Pleadings, on Principal and Agent, on Partnership, and on Bills of Exchange. While some of the latter works were in preparation, successive editions of the prior works, with large additions and improvements, were published. The rapidity with which these works were produced, while his duties, as a judge and a professor of law, were at the same time conscientiously performed, was the wonder of his contemporaries. At last, under his untiring labours, his health broke down in 1842. His physician recommended a visit to England, where his great reputation as a jurist had now made his name familiar to all the leading lawyers, and where he had acquired many friends. Lord Brougham having heard of his probable visit, had assembled the Lord Chancellor and many of the leading judges to welcome his arrival; but, in the meantime, his health had rallied, and the visit was postponed, never to be resumed. He had, however, since the time of his becoming an author, corresponded with many of the English judges, particularly Lord Stowell. It was a subject of regret that Mr Justice Story had not been appointed chief of his court on the death of Chief-Justice Marshall, a station to which his merits entitled him: his claims were ignored owing to his constitutional views being opposed to that of the then President of the United States. He died somewhat suddenly on the 10th of September 1845, at the age of sixty-six.

Justice Story has rendered a great service to the law of England, by introducing into the text-books a more philosophical spirit, and also by liberalising the minds of his readers with ample references to the foreign jurists. He was the means, also, of introducing to English lawyers what little they knew of Scotch law by his frequent references to Bell and Erskine. His treatises are now accepted as standard authorities, and stand side by side with, and in some cases superior to, the best English works. It is impossible to look upon his life without admiration for his indefatigable industry, united, as it was, with great acuteness and elegance of mind. He was universally beloved in private life, and his death left a blank in American society. He was eminent as a conversationalist; his appearance was prepossessing, intelligence and refinement being at once conspicuous in his countenance; yet withal he was mild and unassuming in manners. In every respect he is entitled to be regarded as one of the worthies of America. (J. P—N.)

STOTHARD, CHARLES ALFRED, an ingenious antiquarian draughtsman, son of Thomas Stothard the painter, noticed in the next article, was born in London on the 5th of July 1786. After studying successively at the Royal Academy, the Life Academy, and at the British Institution, Pall Mall, he began, in 1810, his first historical piece, "The Death of Richard II. in Pomfret Castle." Having taken a strong interest from an early period in the costumes of different ages and nations, he was induced to publish the first part of a valuable work on the *The Monumental Effigies of Great Britain* in 1811. It is of great value to the historical painter, as well as to the player, and the work met with entire success. He was appointed historical draughtsman to the Society of Antiquaries, and was deputed by that body to commence his visits to Bayeaux, to make drawings of the fine old remains of ancient tapestry

which had been preserved there. Stothard was made a Fellow of the Society of Antiquaries in 1819. He subsequently engaged in numerous journeyings, with the view of illustrating the works of D. Lysons. When at Beer-Ferrers, Stothard, while engaged in tracing a portrait from one of the windows of the church, fell from a height of 10 feet, and was killed on the spot. This occurred on the 27th of May 1821. Stothard's widow and her brother completed his *Monumental Effigies*, which was left unfinished at the time of his death. His biography has since been written by his widow, now Mrs Bray, known as a popular writer of novels and books of travel.

STOTHARD, *Thomas*, an English painter, was born in London on the 17th of August 1755. He was originally apprenticed to a pattern drawer of brocaded silk, but subsequently took to painting, and gained high repute by his compositions for Bell's *British Poets* and the *Novelist's Magazine*. He was made a Royal Academician in 1794; and became librarian to the Royal Academy in 1812. His more important works were his "Canterbury Pilgrims," his "Flitch of Bacon," his "Fête Champetre," and his "Wellington Shield." He besides illustrated Boydell's *Shakspeare*, Roger's *Poems* and *Italy*, and the *Complete Angler* of Isaac Walton; as well as having designed part of the ceiling of the Signet Library in Edinburgh. His compositions number in all upwards of 5000, some 3000 of which have been engraved. He followed Mortimer somewhat slavishly at the outset of his career, but when he came to his maturity as a painter he displayed simplicity and grace in a high degree. He died in London on the 27th of April 1834. His life was written in 1851 by his daughter-in-law. He had a numerous family, of whom the most noted was Charles Alfred, noticed in the previous article.

STOURBRIDGE, a market-town of England, Worcestershire, on the left bank of the Stour, 23 miles N. by E. of Worcester, and 122 N.W. by W. of London. It is pleasantly situated on the slope of a hill; and as it consists, for the most part, of well-built houses, and is somewhat irregularly laid out, it has a picturesque appearance. The river, which here divides Worcestershire from Staffordshire, is crossed by a stone-bridge, from which the town derives its name. Stourbridge contains a large market-house, of modern erection, a neat brick parish church, and several dissenting places of worship. The Free Grammar School, founded here by Edward VI. in 1551, contained 44 scholars in 1854. This is one of the schools to which Dr Johnson was sent in his youth. Stourbridge has also an endowed national school and an infant school, a theatre, and an extensive public library. Races are held here annually. The clay of this town is much esteemed for its excellence in resisting the action of fire; it is made into crucibles, glass-house pots, and fire-bricks, and is exported in large quantities. Glass, earthenware, and hardware, are the principal manufactures of the town. A considerable trade is carried on, and is facilitated by the Staffordshire and Worcestershire Canal, which has a branch to Stourbridge, and by the railways which connect this town with all the other parts of the kingdom. Pop. 7847.

STOURPORT, a market-town of England, in the county and 10 miles N. by W. of Worcester, at the confluence of the Stour and the Severn; the latter river being here crossed by an iron bridge of one arch. It is quite a modern town, and is, for the most part, well built of brick. It has several churches and schools, a savings bank, and several benevolent institutions. Carpets and leather are made here, and there are an iron-foundry and a wool-spinning mill. A considerable trade is carried on in hops, corn, apples, coal, &c. Pop. 2993.

STOVE (Saxon, *Stofa*), a mechanical contrivance for heating public buildings, private apartments, green-houses, hot-houses, fruit-walls, &c. Under HEAT, the communication and radiation have been fully explained. By the former, the caloric is given from one object to another, and communicated from particle to particle of the same object *by contact;* by the latter, it emanates in straight lines, through the air, from substance to substance, the emanations being absorbed by some bodies, and reflected by others.

The power which objects possess of receiving and communicating heat by the former of these modes, is termed their *conducting power;* by the latter, their *radiating,* their *absorbing,* and *reflecting* power. Those which receive it quickly by the former, also give it off quickly in the same way; and those which radiate powerfully also absorb powerfully; of course they reflect little: accordingly the radiating and reflecting powers are opposed to each other. Metals are good conductors; stones, bricks, and porous bodies of a similar nature, are bad conductors. The radiating, reflecting, and absorbing powers depend not so much on the nature of the substance, as on the surface. Highly polished surfaces radiate and absorb little, while dark and rough ones radiate and absorb powerfully; of course, resplendent surfaces are good reflectors.

When fuel is consumed with the view of heating apartments, the communication of heat depends entirely on the manner in which it is consumed. In an open fire-place or common grate, the heat thrown into the apartment is chiefly that emitted by radiation and reflection; the former coming directly from the fuel, and from the parts of the fire-place warmed by it; the latter being the radiated heat reflected by the polished parts of the grate. The rays thus thrown off, being absorbed by the objects in the room, then communicate warmth to the atmosphere which it contains. But part of the warmth must also be received by communication; for the walls adjoining the fire-place being heated by *contact,* will likewise communicate caloric to the air brought in contact with them; and as it is expanded it will ascend, and allow other particles to flow in, also to receive their supply. This however is small in comparison to that given to the apartment by radiation and reflection.

Much of the heat thus thrown into the room is carried off, indeed may be said to be lost; for, owing to the manner in which the fuel is consumed, a large supply of air is necessary for the combustion, which, rushing in upon the fuel, is itself, after acting on it, carried up the vent. Hence, to warm apartments in this way, a great deal of fuel is required. The quantity must depend very much on the form of the fire-place, and on the materials of which it is constructed.

The principle on which stoves operate is different. A stove, however modified in form, is merely a fire-place enclosed on all sides; the air necessary for the combustion entering from below, and carried off, as in a common grate, by a vent. Now, in this way of consuming fuel, the radiation is trifling in comparison to the communication by contact. Of course much must depend on the kind of stove employed; but it is allowed, that by far the greater part of the heat which the atmosphere of the room receives is that given directly by communication; for the air in contact with the sides of the stove is heated, is expanded, and carried upwards; and thus, by the constant flow of cool air on the stove, the whole of that in the room is warmed. No doubt, the stove being itself warm, must give off heat, not only by contact, but also by radiation; and the proportion thus emitted must depend on the temperature and surface, as already explained. But though heat is thus distributed, yet it must be borne in mind, that it is chiefly by contact that the atmosphere of the room is warmed; and as the air is thus easily heated, much less fuel is required than when it is burned in an open fire-place. The necessary supply of air is therefore not so great; and it is this which principally causes the difference in our feelings when in a room warm-

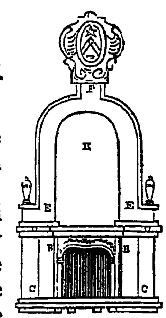
ed by a stove, and by a grate; for in the latter instance, not only have we the exhilarating influence excited by the blaze of the fuel, but there is a more rapid renewal of air through the apartment, and accordingly the atmosphere has not the close unpleasant feeling which it has when warmed by a stove.

The warming by stoves must therefore be conducted on principles different from those adopted in the employment of open fire-places. The general principle is, 1st, to employ the fuel in the most effectual manner for heating the external part of the stove, which is immediately efficient in warming the contiguous air, chiefly by contact; and, 2d, to keep within the room the air thus warmed, at least as much as is consistent with wholesomeness and cleanliness. It would occupy a volume to describe the immense variety of stoves which ingenuity has constructed. We shall content ourselves with giving a specimen of the two chief classes into which they may be distinguished.

The air of a room may be equally warmed by applying it either to the surface of a small stove made very hot, or to the surface of a much larger stove more moderately heated. The first kind is chiefly used in Holland, Flanders, and the milder climates of Germany and Poland. The last are used in the frozen climates of Russia and Sweden. The first are generally made of cast-iron, the last partly of iron and partly of brick-work.

Fig. 1 represents a small German stove, fully sufficient for warming a room of 24 feet by 18. The base is about three feet broad and fourteen inches deep, that is, from back to front, and six or seven feet high. The decoration is in the fashion of that country; but the operative structure of it will admit of any style of ornament. A is the fire-place, and the wood or charred coal is laid on the bottom, which has no bars. Bars would admit the air too freely among the fuel, and would both consume it too fast and raise too great a heat. That no heat may be uselessly expended, the sole of the fire-place and the whole bottom of the stove is raised an inch or two above the floor of the room, and the air is therefore warmed by it in succession, and rises upwards. For the same reason, the back of the stove is not in contact with the wall of the room, or of the niche in which it is placed. The fire-place is shut up by a door which fits closely to its case, and has a small wicket at the bottom, whose aperture is regulated by a sliding plate, so as to admit no more air than what suffices for slowly consuming the fuel. The flame and heated air rise to the top of the fire-place, three or four inches above the arch or mantle-piece, and get out laterally by two narrow passages B, B, immediately below the top-plate of the base. The current bends downward on each side, passes at C, C, under the partition-plates which divide the two side-chambers, and then rises upwards through the outer division of each, and passes through narrow slits D, D, in the top-plate, and from thence along the two hollow piers, E, E. The two lateral currents unite at the top of the arch, and go through the single passage F into the larger hollow behind the escutcheon G. From this place it either goes straight upwards into the vent in the wall by a pipe on the top of the stove, or it goes into the wall behind by a pipe inserted in the back of the stove. The propriety of this construction is very obvious. The current of hot air is applied to the exterior of the stove everywhere except in the two side-chambers of the base, where the partition-plates form one side of the canal. Even this might be avoided by making each of these side-chambers a detached hollow pillar. But this would greatly increase the trouble of construction and joining together, and is by no means necessary. The arch H has a graceful appearance, and affords a very warm situation for any thing that requires it, such as a drink in a sick person's bed-chamber, &c. Persons of a certain class use this place for keeping a dish warm; nay, the lower part of the arch is frequently occupied by an enclosed chamber, where the heat rises high enough even for dressing victuals, as will be easily imagined when we reflect that the sole of it is the roof of the fire-place.

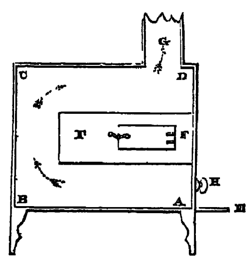
Fig. 1.



The stove now described is supplied with fuel and with air by the front door opening into the room. That there may be space for fuel, this middle part projects a few inches before the two side-chambers. These last, with the whole upper part of the stove, are not more than ten inches deep. The passages therefore from the fire-place are towards the back of it; so that if we have a mind to see the fire, which is always cheerful, the door may be thrown open, and there is no danger of the smoke coming out after the current has once warmed the upper part of the stove. When the stove is of such dimensions that the base is about two feet and a half or three feet high, the fire-place may be furnished with a small grate in the British style. If the door is so hung that it can not only be thrown back, but lifted off its hinges, we have a stove-grate of the completest kind, fully adequate, in our mild climate, to warm a handsome apartment, even with an open fire; and when we hang on the door, and shut up the fire-place, a stove of the dimensions already given is almost too much for a large drawing-room.

A very simple form of stove is that represented in the annexed cut. It consists of a square box of iron, A B C D, resting on feet, and having a projecting hearth-plate at E. FF is an inner box projecting into the outer one. G is the chimney. The fuel is burned at A; and the flame passes to the chimney around the inner box, which may be used as an oven for cooking. At H there is a large door for the introduction of the fuel, in which there is also a smaller door. Both of these are generally kept shut when the furnace is in use; but when a greater heat is required, the smaller door is opened.

Fig. 2.



The effect of stoves as now described may be greatly increased, as is frequently done, by having the mouth communicating with or joined to an opening of the same dimensions, formed in the wall; and the door is in this case on the other side of the wall, in an antechamber or lobby. In some places the apartments are disposed round a spacious lobby, in which the doors of all the stoves are situated, and through which the fuel and air necessary for the combustion are supplied. But this method, though it warms the apartment, is very unfavourable to health and cheerfulness; for the same air confined and repeatedly breathed, and adulterated with the volatile emanations of the room, loses the refreshing quality which is so desirable, and even so necessary for health.

Something of this kind, it has been already mentioned, is unavoidable in all rooms warmed by stoves; and the hotter the surface of the stove, the more and more unpleasant does the air in it become; because, in addition to the slight renewal of air consequent on their use, when the surface becomes very hot, the impurities constantly floating in the atmosphere are decomposed, and emit offensive effluvia. The stove already described is almost always made of metal, and this objection applies particularly to it; hence the necessity of being attentive when cleaning it outside, to avoid the contact of greasy or oleaginous matter, which is so easily decomposed by heat, and gives off offensive and deleterious vapours.

The objections stated to the stoves as now described, have given rise to the use of those constructed of brick-work, or other materials of a similar nature. These are much used in Flanders, Holland, and Germany, where they are made of the most elegant forms, and finely decorated; but it is evident that they cannot be so effectual, nor equally warm a room with the same expense of fuel; earthen ware being inferior to metal in its conducting power. In addition to this, they are liable to a very great objection, the difficulty of preventing their cracking when heated; for different parts of the stove being of different heats, they expand unequally; and no cement can be expected to withstand this, especially when we recollect, that the heat which causes the baked earthen ware to expand, causes a contraction of the clay or cement with which the parts of the stove are joined together. Accordingly stoves of this kind do not stand long without cracking, even when strengthened by iron hoops and cramps judiciously disposed within them; nor does hooping them externally prevent it. When a crack is thus occasioned, it is not only unsightly, but may be dangerous, from its allowing the vitiated air to escape into the apartment.

For these and other reasons, we can scarcely hope to make stoves of brick-work or pottery which shall bear the necessary heat without cracking; and their use must therefore be confined to cases where very moderate heat is sufficient. We need not describe their construction. It is evident that it should be more simple than that of iron stoves; and we imagine, that in the very few cases in which they are likely to be employed in this country, a single fire-place, and an arch over it, divided by a partition or two of thin tile to lengthen the flue, will be quite enough. If the stove is made in whole or in part of potter's ware, a base for the fire-place, with an urn, column, obelisk, or pyramid above it, for increasing the surface, will also be sufficient. The failure commonly happens at the joinings, where the different pieces of a different heat, and perhaps of a different baking, are apt to expand unequally, and by their working on each other, one of them must give way. Instead of making the joints close and using any cement, the upper piece should therefore stand in a groove formed in the undermost, having a little powdered chalk or clay sprinkled over it, which will effectually prevent the passage of any air; and room being thus given for the unequal expansion, the joint remains entire. This may be considered as a general direction for all furnace-work, where it is in vain to attempt to hinder the mutual working of the parts. When fitted up with these precautions, the brick or pottery stoves are incomparably more sweet and pleasant than the iron ones.

But in the intense colds of Russia and Sweden, or even for very large rooms in this kingdom, stoves of these small dimensions are not sufficiently powerful; and we must follow the practice of those countries where they are made of great size, and very moderately heated. It is needless to describe their external form, which may be varied at pleasure. We shall only enlarge a little on the peculiarities connected with the general principle of their construction.

The stove is intended as a sort of magazine, in which a great quantity of heat may be quickly accumulated, to be afterwards slowly communicated to the apartment. The stove is therefore built extremely massive, and is found to be more powerful when coated with clay as wet as can be made to hang together. We imagine the reason of this to be, that very wet clay, and more particularly stucco, must become exceedingly porous when dry, and therefore a very slow conductor of heat. Instead of sticking on the glazed tiles with no more clay or stucco than is sufficient to attach them, each tile has at its back a sort of box, baked in one piece, about two or three inches deep. It is represented in fig. 3. This is filled with mortar, and then stuck on the brick-work of the stove, which has a great number of iron pins or hooks driven into the joints, which may sink into this clay and keep it firmly attached when dry. This coating, with the massive brick-work, forms a great mass of matter to be heated by the fuel. The lowest chamber, which is the fire-place, is somewhat wider, and considerably thicker than the stories above, which are merely flues. When the fire-place is finished, and about to be arched over, a flat iron bar of small thickness is laid along the top of the side-wall on both sides, a set of finishing bricks being moulded on purpose, with a notch to receive the iron bar. Cross bars are laid over these, one at each end and one or two between, having a bit turned down at the ends, which takes hold of the longitudinal bars, and keeps them from being thrust outwards either by the pressure of the arch or by the swelling in consequence of the heat. In fig. 4, A is the cross section of one of the long bars, and BC is part of one of the cross bars, and CD is the clench which confines the bar A. This precaution is chiefly necessary, because the contraction of the stove upwards obliges the walls of the other stories to bear a little on the arch of the fire-place. The building above is kept together in like manner by other courses of iron bars at every second return of the flue. The top of the stove is finished by a pretty thick covering of brick-work. The last passage for the air has a ring lining its upper extremity, and projecting an inch or two above it. The flat round it is covered with sand. When we would stop this passage, a cover shaped like a basin or cover for dishes at table is whelmed over it. The rim of this, resting on the sand, effectually prevents all air from coming through and getting up the vent. Access is had to this damper by a door which can be shut tight enough to prevent the heated air of the room from wasting itself up the vent. When the room is too warm, it may be very rapidly cooled by opening this door. The warm air rushes up with great rapidity, and is replaced by cool air from without.

Fig. 3.

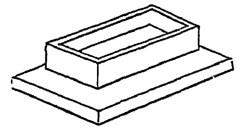
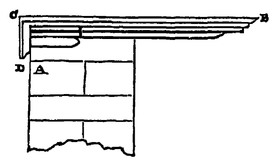


Fig. 4.



In a stove of this kind the fire is kindled early in the morning, after which the stove-door is shut, and the air-aperture below left open for some time to blow it up; but in the course of a short time, to prevent the too rapid consumption of the fuel, the fire-door is opened, by which the draught is checked. In this way the combustion is allowed to go on, and the materials of the stove become warmed, after which the air-passages are shut, so as to prevent any abstraction of heat by the current that would otherwise be occasioned. The stove thus becomes a great mass of heated matter, which is gradually pouring warmth into the apartment during the whole of the day; and as the temperature of the surface never becomes very high, the impurities in the atmosphere are not decomposed, and consequently it is free from those offensive effluvia unavoidable when metal stoves are used. One precaution, however, is necessary in the management of these stoves, which does not apply to the metal ones; we must take care that when the air-apertures are closed, there is no back-draught to carry the products of combustion into the apartment, which might be attended with fatal consequences. These being almost free from smoke, give little or no warning of their presence, and when inhaled for some time, produce giddiness and lassitude, and in some cases a dangerous state of insensibility. Hence the necessity of allowing the fire to be burned down, or nearly so, before closing the air-aper-

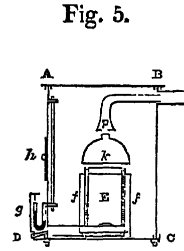
tures. Should the escape of the noxious gases into the room be suspected, the furnace-door and air-apertures must be opened, and a draught established through the stove, by kindling some wood shavings in it, the door and windows of the room being at the same time thrown open. This attention to back-draught is of course more necessary when charcoal or coke is used instead of coal, the products of combustion being then entirely free from smoke. When coal is used in stoves, the vent-tubes are apt to become choked with soot; but this may in a great measure be prevented by giving for a short time every day a brisk draught, by which the soot will be burned.

To prevent the injurious or disagreeable effects of the first kind of stoves, and at the same time to secure their advantages, numerous modifications have been proposed, not only with the view of preventing the too great heat of the external surface, but also of avoiding unnecessary expenditure of fuel. Perhaps the most important of these is *Arnott's stove;* the principle of which consists in allowing the fuel to burn very slowly, the admission of air for the combustion being regulated by an adjustment connected with the stove, and influenced by the degree of heat produced. Numerous forms and modifications of this stove are now in use, but in their general structure they are the same. The stove consists of a square or cylindrical box of iron, generally lined inside with a thick layer of fire-clay, and having a grating near the bottom, on which the fuel is burned; or the fuel may be contained in a small fire-box within the stove. Sometimes the fuel is burned within a hollow cylinder of fire-clay, in which case the stove is not lined with it. There is an ash-pit below for the reception of the ashes, and the products of the combustion are, as usual, carried off by a vent.

The principal feature of this stove is the contrivance by which the air is admitted for the combustion. When the stove-door or ash-pit door is open, the combustion is lively, and the fuel is soon consumed; but when these are shut, and they ought to be so made as to shut quite close, then air must be admitted otherwise, and this is done by the air-tube, furnished, as already stated, with a regulator.

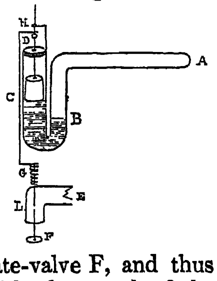
The annexed figure represents the stove of its simplest form. ABCD is the outer casing of iron, in which there is the fire-box E, with its grating. Over the fire-box there is a dome, *k*, with a funnel to carry the products of combustion into the chimney; *h* is the stove-door, and *g* is the *thermometer regulator*, or adjustment by which the air is admitted for combustion. A great variety of these regulators has been described. Perhaps the best of these is represented by the annexed cut.

Fig. 5.



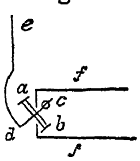
ABC is a glass tube, shut at A, containing air from A to B, and filled with mercury from B to C. On the mercury at C is placed a float, from which there proceeds an upright rod D, kept steady by passing through a support at H. From this upright wire there descends another, FGH, terminated by the plate-valve F. LE is the air-tube of the stove. When the heat within is great, the air in the shut limb of the regulator at A is expanded, and forces up the mercury at C, raising the rods and plate-valve F, and thus bringing it near to, or in contact with, the mouth of the tube, by which more or less air is admitted to the stove, according to the heat within. If the combustion is proceeding too slowly, then the air in the tube A is not much expanded, consequently air is allowed to enter the stove more freely; but when, owing to this, the combustion becomes lively, and the temperature too high, then, by the elevation of the plate-valve, air enters in smaller quantity, and the temperature is moderated. Instead of the flat plate a conical valve is sometimes used, which, passing more or less into the mouth of the tube, allows the passage of less or more air; and sometimes this contrivance is resorted to.

Fig. 6



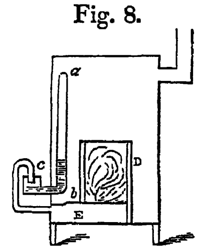
ed is the wire raised by the movement of the mercury; *ab* is a plate hung on an axis within the air-tube, and acting like a throttle-valve. When the edge of the plate is turned to the current, air is admitted freely; but when the heat becomes high, then the mercury rises and makes the plate revolve, by which more and more of the area of the tube is shut, and consequently less and less air is admitted.

Fig. 7.



Perhaps the simplest of these regulators is that here represented. *abc* is a bent tube shut at *a*, where it contains air, and open at *c*, where it is cup-shaped. The bent part at *b* is occupied by mercury. From *c* there proceeds a bent tube to supply air to the stove. When the heat within is great, the air in *a* is expanded, and forces the mercury up in *c*, and thus, bringing it in contact with the mouth, prevents the free admission of air to the stove. Numerous other contrivances of a similar nature have been recommended, all acting in the same way. Instead of these, the admission of air is sometimes regulated by a semicircular slide over the mouth of the air-tube, which may be placed so as to admit to the stove a greater or smaller quantity, as occasion requires.

Fig. 8.



The principle on which this stove operates, whatever modification of it may be used, is merely the slow combustion of the fuel, by which the stove itself is warmed; and there is thus a reservoir of heat to be communicated to the air in the apartment. As the quantity of fuel consumed is small, there is no necessity for frequent supply. When one of the ordinary dimensions for a room is in use, it will require to be supplied morning and evening, supposing that it is kept constantly burning, and the ashes removed once a day. These, instead of falling into the ash-pit, may be received in a box placed there for the purpose, which is taken out and emptied, so as to avoid dust in the apartment.

The quantity of fuel consumed must of course depend on circumstances. During the severe winter of 1836–37, Dr Arnott kept his library at a temperature varying from 60° to 63° of Fahrenheit, by about six pounds of coal a day; which, supposing the coal to be twenty shillings per ton, is at the daily expense of less than a penny.

Though the Arnott stove answers well the purpose for which it is intended, that is, economy of fuel, for most undoubtedly a room may be kept warm at a very moderate expense, yet it is liable to the objection already stated with regard to the unpleasant feeling consequent on the use of all stoves of the kind, and indeed with it more than others; for, owing to the very slight expenditure of fuel, there is little or no change in the atmosphere. It is generally allowed that a pound of coal on an average requires about 150 cubic feet of air for combustion; but as part of the air passes off without being acted on, 200 may be allowed, and this is a large allowance where the combustion is going on so slowly as in the stove. Now suppose the apartment in which the stove is placed to be fifteen feet long by twelve wide and eleven in height, its cubic contents are 1980 feet; and suppose six pounds of coal per day to be the consumption, each pound requiring about 200, that is in all 1200 feet of air for combustion. This quantity must pass through the stove and be carried off by the vent, so

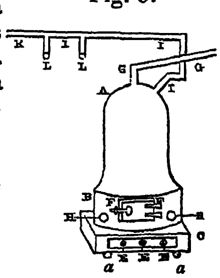
that in the course of twenty-four hours the atmosphere of the apartment is not once completely changed, and consequently renewed, by the direct influence of the fire. Hence it is that the apartment is so easily warmed; but it is this which necessarily renders it so unpleasant.

These stoves, however, fell out of use on account of another circumstance. Our readers will see the whole of the action of the self-regulator was due to the expansion and contraction of the mercury in the tube ABC, fig. 6; but mercury is a very volatile substance, and the constant heat of the stoves caused a daily loss of mercury, and consequent imperfection in the action of the regulators. This was attempted to be remedied by tightening the collar at D; but the resistance thus offered to the use of the float by the expansion of the volume of the mercury frequently caused the tube to burst, and scattered its contents about the room. The most valuable feature of the Arnott stove, the making the fire-box itself of fire-clay, however, is still in frequent use in the modern German stoves.

The stoves now described answer for small apartments. When the place to be heated is large, or when several apartments in the same building are to be warmed, a different kind is used. The heat in these cases is in general not communicated to the apartment or apartments by the direct influence of the stove, but by air heated by its external surface (of course not brought into contact with the fuel), and then conveyed by tubes or otherwise to the places to be warmed, on the principle already illustrated, that when heated it expands and ascends, and consequently rushes along the tubes, the supply being kept up by the constant flow of cold air upon the hot sides of the stove. Stoves for this purpose are made of iron or of brick-work, and sometimes of both. Fig. 9 represents a cast-metal stove of this kind. It may be considered as a double stove; an outer case, and a furnace or inner stove. The fuel is burned in the inner stove, and the smoke produced during the process of combustion is carried off by a chimney, which passes through the top of the outer stove, and is conveyed to the outside of the building. The outer case includes not only the furnace or inner stove, but also a considerable space, occupied by the air of the atmosphere, which is freely admitted through a number of openings placed around it; and when any current of air is produced, it passes off from the space between the outer case and inner stove, and is conveyed by tubes through the body of the apartment. But we shall first describe the different parts of which the stove is composed, after which we shall be better able to understand its mode of operation.

Fig. 9 exhibits a perspective view of this stove. AB is the body, which is about three feet high, and of a circular form. C is a square pedestal, on which the stove is placed, and which contains the ash-pit. The height of the pedestal is about a foot, and it is nearly insulated by resting on the spherical supports *a a*, also of cast-iron. EEE are openings in front of the ash-pit, through which the air enters to support the combustion. These openings can be enlarged or diminished, or opened and shut at pleasure. FF is the door of the furnace, through which the fuel is introduced. This door is attached to the inner furnace, and is double. It is one foot broad, and eleven inches high. GG is the chimney, which passes from the furnace within, through the outer case, and conveys the smoke out of the building. HH are openings in the outer case, and are eight in number, through which the air enters, and being heated, is greatly rarified, and passes off through the funnel or pipe III. This pipe communicates only with the outer stove, and being shut at

Fig. 9.



the end K, the air rushes out from the small tubes LL, inserted into the side of the pipe III, and thus mixes with the cold air of the apartment. The diameter of the outer case at the bottom is about two feet, and the diameter of the furnace within is about sixteen inches.

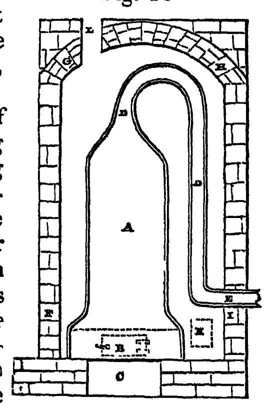
The length of the body of a church in which two stoves of the form and dimensions now described are erected, is about sixty feet, and the breadth is about forty-five feet. The tubes III are conveyed along the lower edge of the gallery, about half the length of the church. The fires are lighted about four or five o'clock on the Sunday morning during the earlier part of the cold season; but as the season advances it is usual to light them earlier. From this time till the congregation assembles for the afternoon service, the furnaces are constantly supplied with fuel. By this management the air in the church is kept comfortably warm during the coldest season of the year.

When only one apartment is to be heated by a stove of this kind, the stove ought to be placed in the apartment, because then it is supplied with air from it, which has been previously heated; whereas, when it is placed in another situation, the supply of heated air thrown into the apartment being derived from without, that within must be forced out to make way for it, and subsequently at a great expenditure of fuel. When several apartments are to be warmed, suppose those of a dwelling-house, the stove ought to be situated in some part of the lobby, from which the tubes proceed to the rooms. Of course the size of the stove, and the distribution and size of the tubes, must depend on the supply of heat required.

There is one very great objection to the stove as now described. It has been already stated, that when air is projected against a red-hot surface, the impurities constantly floating in it are burned, and emit offensive effluvia; and this is generally the case with metallic hot-air stoves. Hence the necessity of having them so placed that they shall be supplied with air as free as possible from impurities. Instead of having the whole of the stove made of metal, the inner part is sometimes metal and the outer covering brick-work; in which case the chamber between them is generally larger than in the others, consequently the temperature does not become so high, and the objection urged against the metal stoves is in a great measure removed.

The annexed figure represents a vertical section of a stove of this kind. A is the stove of metal, with the door at B and ash-pit at C. DD is the vent, making a turn downwards, and carried into the chimney at E. FGHI is the outer casing of brick-work, completely enclosing the stove, and also the descending part of the vent; K is the opening for the admission of air to the hot chamber. L is the tube for carrying off the warm air, and from this it is conveyed by other tubes to the rooms to be heated. The stove from which this figure is taken is two feet and a quarter in width, six feet in height, and the sides three-fourths of an inch in thickness. The brick casing is at the distance of six inches from the metal, and the descending vent within is six inches in diameter. It is used for warming a lecture-room thirty-five feet long, twenty-seven feet broad, and twenty high, also a large apartment thirty feet long, twenty-seven broad, and eighteen high, besides two smaller rooms and a staircase. The fire is kindled during winter at seven in the morning, and kept burning till four in the afternoon, when it is allowed to go out. The

Fig. 10



quantity of coal amounts daily, on an average, to rather less than half a hundredweight. The temperature of the air from the tubes varies from 120° to 180°, according to the state of the fire. The temperature of the different apartments is kept at about 60°. When first erected, the supply of air for the hot chamber was brought from without; but now the air for the fuel and for the hot chamber are both taken from the apartment in which the stove is placed, which is generally at the temperature of 70°.

When the place to be heated is spacious, or when there are several apartments, it is customary to have the part of the stove immediately exposed to the fire lined with fire-brick, in order to prevent the direct action of the fuel on the metal; for in these instances the stove is much larger than that described, and consequently the fire more powerful. Its size must depend on the size and number of the apartments. In its general construction it resembles the other, consisting of the inner part for the fuel, with its grating, ash-pit, and vent, and of the outer casing, with the aperture for the supply of air to the chamber, and the tube or tubes for its transmission to the apartments.

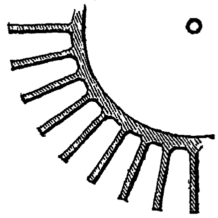
The great advantage attending the use of stoves of this kind is, that they do not become so warm as to decompose the impurities in the air flowing into the hot chamber, and consequently there are no offensive effluvia generated. As the temperature is not so high as that of metal stoves, more of the warm air is requisite, by which there is a frequent renewal of that in the apartment, and the temperature throughout is more uniform than when a smaller quantity of hotter air is admitted. It has already been mentioned that the temperature of the air from the hot chamber of the stove described is from 120° to 180°. Perhaps this is higher than it ought to be. Many prefer having the stove so constructed that the temperature of the air which it throws into the apartment shall not exceed 70°. Of course, in this case, a much larger quantity of it is necessary. By throwing in a sufficient supply, that of the apartments may be maintained at about 60°. The mouths of the hot air-tubes are made to terminate as near the floor as possible, that the air may rise, and gradually mix with the atmosphere of the apartment.

In erecting stoves for the supply of hot air in this way, there are many circumstances to be considered, to which it would here be useless to allude. Much must depend on local situation, the size and number of the apartments, and the draught through them. These considerations must be left to the skill and ingenuity of the workman, who must be guided by keeping in view the general principles which determine the supply of air to the furnace, the ascensional force of the column of warm air to be conveyed through the tubes, the manner in which the apartments to be warmed are disposed, &c.

In heating buildings by these stoves when they are not in constant use, as is the case in churches, the time for keeping them going must also depend on circumstances. If the object is merely to throw in a supply of warm air, then the stove must be kindled a few hours before the apartment is to be occupied, especially if it is not expected that there shall be much change in its atmosphere; but if the object is to keep the place warm, then the stove ought to be kept in constant use, so as to be constantly throwing in warm air. During night the fire can be banked up, and it is again made brisk when required. This is much better than allowing the fire to go out, because in again heating the stove to the requisite temperature, there must be a considerable waste of fuel. After the fire is in good condition, and the stove well heated, the combustion should be allowed to proceed slowly, which is accomplished by the proper regulation of the draught.

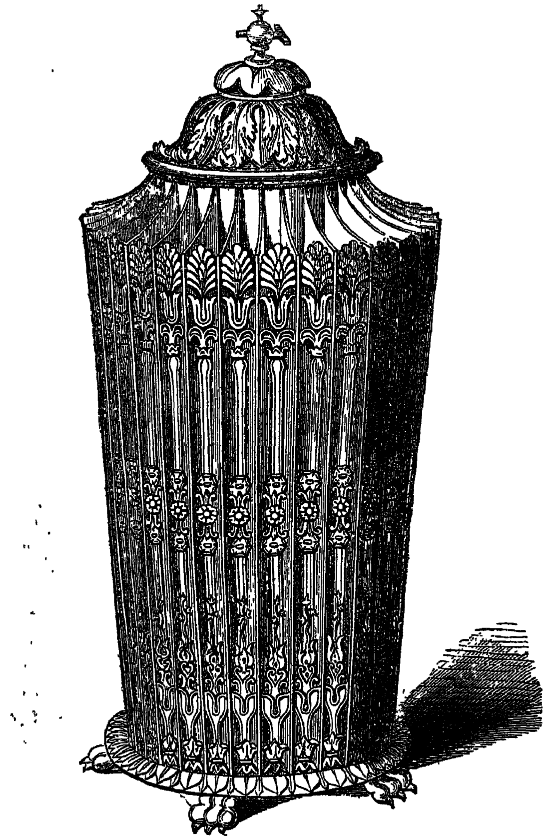
One of the most ingenious adaptations of iron, for the purposes of heating rooms, is that of the late Mr John Sylvester, although the medium conveying the heat is water. It is generally in the form of a cylinder, or part of a cone (fig. 11), from which cone radiate a number of plates (see the plan of one quarter of the stove, fig. 11), which resemble the gills of a fish, from which circumstance it is generally called the "gill stove." The whole is of iron, cast in one piece. The hot water circulates inside the cylinder. The use of the gills is to afford as large a radiating surface as possible, and to diffuse heat as soon as it is communicated, in the smallest degree, to such surface. The consequence is, the air in contact with the iron is only warmed, and never burned. Although this stove has hitherto been used with water, it seems very probable that it would succeed with coal or coke, if it had an internal fire-box of burned coke, and proper doors, vents, &c.

Fig. 11.



There can be no question, as before stated, that there is nothing so comfortable or so healthy as an ordinary open fire-place; and it is to be doubted, after all, whether by attention and management of the supply of fuel, and judicious stirring, there is such extra expense about them. But open fires require proper chimney places and flues, and will only consume fuel of good quality, while stoves will burn almost any thing. If, however, we construct our stoves so as almost to make them furnaces, we lose from two causes—the too rapid consumption of fuel, and the rapid draught of air, which carries a great quantity of heat up the chimney.

Fig. 12.



One of the best adaptations of these principles, however, is to be found in the stoves invented by Messrs Featham of Clifford Street, London. These are in the form of an ordinary register stove, with the usual grate, fire-bars,

&c., but the back and cheeks are of fire-clay. In the front of the stove there is a sort of iron shutter, sliding in a groove like a sash window, which can be drawn quite down to the front of the fire, and cause an action of the draught like that of a furnace, or it may be thrown quite up, in which case the action is that of a simple register stove. For recent continental improvements, the reader is referred to Peclet's *Traité de la Chaleur*.

STOW, JOHN, an industrious historian, son of Thomas Stow, merchant-tailor, of St Michael's, Cornhill, in London, was born about the year 1525. Of the early part of his life we know very little, except that he was bred to his father's business, which, in the year 1560, he relinquished, devoting himself entirely to the study of our ancient historians, chronicles, annals, charters, registers, and records. Of these he made a considerable collection. But this profession of an antiquary being attended with no present emolument, he was obliged for subsistence to return to his trade. It happened, however, that his talents and necessities were made known to Dr Parker, archbishop of Canterbury, who, being himself an antiquary, encouraged and enabled Stow to prosecute his darling study. In those times of persecution, though Elizabeth was then upon the throne, John Stow did not escape danger. His collection of popish records was deemed a cause of suspicion. His younger brother Thomas preferred no less than 140 articles against him before the ecclesiastical commission; but the proof being insufficient, he was acquitted. In 1565 he first published his *Summary of the Chronicles of England*. About the year 1584, he began his *Survey of London*. In 1585 he was one of the two collectors for a great muster of Limestreet ward. During the same year he petitioned the corporation of London to bestow on him the benefit of two freemen, to enable him to publish his *Survey;* and in 1589 he again petitioned for a pension. Whether he succeeded is not known. He was principally concerned in the second edition of Holinshed's *Chronicle*, published in 1587. He also corrected and twice augmented Chaucer's *Works*, published in 1561 and in 1597. His *Survey of London* was first published in 1598. To these laborious works he would have added his large Chronicle, or History of England; but he lived only to publish an abstract of it, under the title of *Flores Historiarum, or Annals of this Kingdom, from the time of the Ancient Britons to his Own.* This work was printed in 1600. The folio volume, which was printed after his death, with the title of Stow's *Chronicle*, was taken from his papers by Edmund Howes. Having thus spent his life and fortune in these laborious pursuits, he was at last obliged to solicit the charitable and well-disposed for relief. For this purpose King James I. granted him, in 1603, a brief, which was renewed in 1604, authorising him to collect in churches the benefactions of his fellow-citizens. He died in April 1605, aged eighty; and was buried in his parish church of St Andrew Undershaft, where his widow erected a monument to his memory. John Stow was a most indefatigable antiquary, a faithful historian, and an honest man.

STOWMARKET, a market-town of England, in the county of Suffolk, in a valley on the Gipping, 12 miles N.N.W. of Ipswich, and 75 N.E. of London. It has one main street, and many substantially built houses. The parish church is a fine old building of the thirteenth century, partly in the early English, and partly in the decorated style; the spire, 120 feet high, is modern. The Baptists, Methodists, and Independents have places of worship here; and education is provided for by national and other schools. Stowmarket has a handsome court-house, a large corn-exchange, a news-room, and a mechanics' institute. It is an active, bustling place, and has some important manufactories, including several malt-houses, an iron-foundry, and a rope-work. In the immediate neighbourhood there are hop-grounds and brick-fields. The river is navigable up to the town; and by its means timber, coal, and slate are conveyed up from Ipswich. The markets, which are held weekly, are well supplied with corn, cattle, and other goods; and there are at Stowmarket three annual fairs. Pop. 3161.

STRABANE, a market-town of Ireland, in the county of Tyrone, on the Mourne, 20 miles N.N.W. of Armagh, and 130 N.N.W. of Dublin. It is very irregularly built on the right side of the river; and the older part of the town consists for the most part of very mean and wretched houses; but there have been formed some new and much better streets, lined with good houses and shops. The parish church is a fine cruciform edifice in the Grecian style. Besides this, there are places of worship for Presbyterians and Methodists, several schools, a court-house, jail, dispensary, hospital, and workhouse. The manufacture of linen is carried on to a considerable extent here; and in former times Strabane was one of the chief seats of this branch of industry. There is also a large brewery, and a considerable trade is carried on in grain and provisions. A canal from Strabane to the Foyle facilitates the commercial intercourse between this town and Londonderry. Pop. 4925.

STRABO, an illustrious geographer, was born at Amasia, a city of Capadocia. The time of his birth cannot be ascertained, but he is known to have flourished during the age of Augustus and Tiberius. Some writers have fixed his birth about 66 B.C., and Clinton makes it occur not later than B.C. 54. He studied grammar and rhetoric under Aristodemus, at Nysa, in Caria; philosophy under Xenarchus, a peripatetic; and he took lessons from Tyrannis of Amisus. Influenced by the authority, probably, of Boethus of Sidon, who had been his preceptor, he adopted the tenets of the Stoics. He obtained the friendship of Cornelius Gallus, governor of Egypt. Strabo composed a history in 43 books which, unfortunately, is now lost. In order to collect materials for his great work, he travelled in many different regions, and after much toil and research completed his *Geography*, which is justly regarded as a very precious relic of antiquity. It consists of seventeen books, all of which are not, however, entire. The first two books are employed in showing that the study of geography is not only worthy of, but even necessary to, a philosopher; the third describes Spain; the fourth, Gaul and the Britannic Isles; the fifth and sixth, Italy and the adjacent isles; the seventh, which is imperfect at the end, Germany, the countries of the Getæ and Illyrii, Taurica Chersonesus, and Epirus; the eighth, ninth, and tenth, Greece with the neighbouring isles; the four following, Asia within Mount Taurus; the fifteenth and sixteenth, Asia without Taurus, India, Persia, Syria, Arabia; and the seventeenth, Egypt, Ethiopia, Carthage, and other countries of Africa. Groskurd fixes his death to the year A.D. 24.

Strabo's *Geography* first appeared in a Latin version, executed by Phavorinus and Tifernas, and printed at Rome by Sweynheym and Pannartz. It is an ample folio volume, without date, but is supposed to have been printed in or about the year 1469. The earliest edition with a date is that of Venice, 1472, fol. The *editio princeps* of the Greek text proceeded from the press of Aldus, Venet., 1516, folio. This edition, which is not distinguished by its accuracy, was succeeded by that of Hopper and Heresbach, Basil., 1549, fol. An edition, containing an elegant version, with notes and castigations, was next produced by Xylander, Basil., 1571, fol. The next edition was by Casaubon, Genev., 1597, fol. By the aid of four MSS. and of his own critical sagacity, he greatly improved the Greek text. He retained the version of Xylander. He afterwards augmented and improved his annotations, and the work was reprinted at Paris in 1620, after the death of the learned editor. This second edition of Casaubon, together with the notes of various other critics, was repub-

lished by T. Janson van Almeloveen, Amst., 1707, fol. He has subjoined the *Chrestomathiæ*, or epitome of Strabo, which, according to Dodwell, was compiled by some unknown writer, between the years 976 and 996 A.D. It had been found of some use, not only in contributing to the correction of the text, but likewise in supplying to a certain extent the defect of the seventh book. An elaborate and valuable edition of Strabo was commenced by Siebenkees, and completed by Tzschucke, Lipsiæ, 1796-1819, 7 tom. 8vo. Much was expected from the edition of Falconer, Oxon., 1807, 2 tom. fol. It was one defect of the editor that he was not sufficiently acquainted with the labours of the continental critics. Nor must we overlook an edition of the text, illustrated with Greek notes by Coraÿ, Paris, 1815, 4 tom. 8vo. Strabo was translated into German by Penzel, 4 vols. 1775. A French translation was undertaken by command of the emperor, and was executed by De la Porte du Theil, Coraÿ, and Letronne. The introduction, and the notes distinguished by the letter G, were contributed by Gosselin, Paris, 1805-19, 5 tom. 4to. Kramer has also published an edition of the *Geography* of Strabo, in three vols. 1844-52, with notes by Meineke, 3 vols., Leipsic, 1852. An excellent German translation of it is by Groskurd, 4 vols., Berlin, 1831-34. A recent English translation of the work is by Falconer and Hamilton, in 3 vols., 1854-57.

STRADA, Famiano, an ingenious and learned Jesuit, was born at Rome in the year 1572, and there taught rhetoric for fifteen years. He wrote several pieces upon the art of oratory, and published some orations with the view of illustrating by example what he had inculcated by precept. But his *Prolusiones Academicæ* and his *Historia de Bello Belgico* are the works which raised his reputation and have preserved his memory. His *History of the War of Flanders* was published at Rome, the first decade in 1640, the second in 1647, the whole extending from the death of Charles V., which happened in 1558, to the year 1590. His *Prolusiones Academicæ* show great ingenuity, and a masterly skill in classical literature; that prolusion especially in which he introduces Lucan, Lucretius, Claudian, Ovid, Statius, and Virgil, each of them versifying according to his own strain. This work has often been printed. Strada died at Rome in the Jesuits' College in the year 1649.

STRADBALLY, a market-town of Ireland, Queen's county, 44 miles S.S.W. of Dublin. It contains a handsome parish church, places of worship for Roman Catholics, Wesleyan, and Primitive Methodists, several schools, a court-house, and a dispensary. Pop. 1326.

STRAFFORD, Earl of. See Wentworth, *Thomas*.

STRAHAN, William, an eminent printer, was born at Edinburgh in the year 1715. After having passed through the tuition of a grammar-school, he served an apprenticeship to a printer, and when a very young man removed to a wider sphere in that line of business, and went to follow his trade in London. His abilities in his profession, accompanied with perfect integrity and unabating diligence, enabled him, after the first difficulties were overcome, to advance with rapid success. And he was one of the most flourishing men of the trade, when, in the year 1740, he purchased a share of the patent for king's printer, of Eyre, with whom he maintained the most cordial intimacy during the rest of his life. Never had such rewards been given to the labours of literary men as were received from him and his associates in their purchases of copyrights. Having now attained the first great object of business, wealth, Strahan looked with a very allowable ambition on the stations of political rank and eminence. Politics had long occupied his active mind, and he had for many years pursued them as his favourite amusement, by corresponding on that subject with some of the first men of the age. Strahan's queries to Dr Franklin in the year 1769, respecting the discontents of the Americans, published in the *London Chronicle* of 28th July 1778, show the just conception which he entertained of the important consequences of that dispute, and his anxiety to investigate, at that early period, the proper means by which their grievances might be removed, and a permanent harmony restored between the two countries. In the year 1775 he was elected a member of parliament for the burgh of Malmesbury, in Wiltshire, with a very illustrious colleague, Mr Fox; and in the succeeding parliament, for Wooton Basset, in the same county. In this station, applying himself with that industry which was natural to him, he was a useful member, and attended the house with a scrupulous punctuality. When parliament was dissolved in 1784, Strahan was not again returned for the borough he had previously represented, and his declining health induced him to retire from political life. He died on the 9th of July 1785, in the seventy-first year of his age.

STRAIT, a narrow passage or channel connecting two larger portions of water together.

STRALSUND, a fortified town of the Prussian monarchy, in the province of Pomerania, capital of a government of the same name, formerly of the whole of Swedish Pomerania, on the strait between the island of Rügen and the mainland, 120 miles north by west of Berlin. It is entirely surrounded by water, and only approached by three bridges, which connect it with as many suburbs on the mainland opposite to the town. It is an old-fashioned town, and somewhat gloomy in its appearance; the streets are very narrow and irregular, but for the most part clean and well paved. The principal buildings are the town-hall, a fine old building with seven pinnacles; and the churches of St Nicholas and St Mary, the former of the thirteenth and the latter of the fourteenth century, and both fine specimens of the pointed style of architecture, similar to the churches of Lübeck. Near one of the city-gates there is a stone built into the wall which marks the place where Charles XII. of Sweden used to spend the night when defending Stralsund against the kings of Prussia, Poland, and Denmark, in 1715. Besides the two already mentioned, Stralsund contains four other churches, one of which has two celebrated paintings by Tischbein. There is also a government-house, a town-hall containing a public library, a gymnasium with a museum and library, a school of navigation, a lunatic asylum, orphan hospital, and workhouse. The manufactures of the town are numerous, including ship-building, and the making of woollen and linen cloth, starch, sugar, tobacco, soap, candles, leather, &c. An active trade is carried on; and the harbour, which is good, though somewhat encumbered with shoals, is much frequented by vessels. Wheat, malt, timber, wool, and linen are the chief articles of export. Stralsund was founded in 1209 by Jaromar I., Prince of Rügen, and it soon rose to a high degree of prosperity, as a free imperial town and a member of the Hanseatic League. In the Thirty Years' War it successfully resisted the arms of Wallenstein, who besieged it in 1628, determined, as he expressed it, to take the place "though it were bound to heaven with chains." The brave defence of the citizens, supported by the Danes and Swedes, compelled the Imperial general to raise the siege, after a loss of 12,000 men. In 1678 Frederick William of Brandenburg bombarded and took the town from the Swedes, who had gained possession of it by the peace of Westphalia in 1648. It was, however, restored to Sweden in 1679. In 1715 Stralsund was besieged by the Prussian, Danish, and Saxon forces, and was compelled to surrender. Again, however, in 1720 it was given back to Sweden. In 1807 it was surrendered to the French, who destroyed its fortifications. It was in Stralsund that Schill, a German who attempted to deliver his country from the French, lost

his life in 1808. The place where he fell is still marked in one of the streets, and his body lies in one of the churchyards, without the head, which is now at Brunswick. In 1810 Stralsund was ceded to Denmark, and in 1815 to Prussia. The fortifications have been since restored. Pop. 20,333.

STRANGE, Sir Robert, an eminent line-engraver, was descended from the family of Strange or Strang, of Balcasky, in Fife, and was born in the island of Pomona, in Orkney, on the 14th of July 1721. Having early displayed a taste for drawing, he was apprenticed to Richard Cooper of Edinburgh, where he gave great satisfaction to his employer, and awakened in his friends the highest expectations of his future success.

In the year 1747 he married Isabella, only daughter of William Lumsden, son of Bishop Lumsden; and soon after his marriage he went to France, where with the most ardent application he prosecuted his studies, chiefly at Paris, under the direction of the celebrated Le Bas, who engraved many excellent prints from the Dutch painters. It was from Le Bas that he had the first hint of the use of the instrument commonly called the *dry needle*, but which he afterwards greatly improved by his own genius, and which has added such superior beauties to his engravings. In the year 1751 Strange removed with his family from Edinburgh and settled in London, where he engraved several fine historical prints. He set out for Italy in 1760. He there made many admirable drawings, several of which he afterwards engraved. He was chosen a member of the academies of Rome, Florence, and Bologna, and professor in the Royal Academy at Parma. The ceiling of the room of the Vatican library at Rome, in which the collection of engravings is kept, represents the progress of engraving; and the portraits of the most eminent artists in that line are there introduced, among which is that of Strange. Under his arm he holds a portfolio, on which his name is inscribed. In France, where he resided many years at different periods his talents were likewise appreciated. He was chosen a member of the Royal Academy of Painting at Paris. He settled in London in 1751, and soon became the first historical engraver in England. He received the honour of knighthood on the 5th of January 1787.

Such was Sir Robert Strange as an artist; nor was he less distinguished by his truly amiable moral qualities, which endeared him to all who had the happiness to know him. With regard to his works, he left fifty capital plates, which have been carefully preserved in his family. They are engraved from pictures by the most celebrated painters of the Roman, Florentine, Lombard, Venetian, and other schools. They are historical, both sacred and profane. Sir Robert carefully preserved about eighty copies of the finest and most choice impressions of each plate he engraved; which, from length of time, have acquired a great beauty, mellowness, and brilliancy. He did this with a view of presenting them to the public at a period when age should disable him from adding to their number. These he collected into as many volumes, and arranged them in the order in which they were engraved. To each volume he prefixed two portraits of himself, on the same plate, the one an etching, the other a finished proof, from a drawing by John Baptiste Greuse. This is the last plate which he engraved, and is a proof that neither his eyes nor hand were impaired by age. It likewise shows the use he made both of aquafortis and the graver. Each volume, besides a dedication to the king, contains an introduction on the progress of engraving, and critical remarks on the pictures from which his engravings are taken. These volumes were ready to be given to the public, when Sir Robert's death delayed this magnificent publication. He died at London 5th July 1792.

The following is an authentic catalogue of his works:—"Two Heads of the Author," one an etching, the other a finished proof, from a drawing by John Baptiste Greuse; "The Return from Market," by Wouvermans; "Cupid," by Vanloo; "Mary Magdalen," by Guido; "Cleopatra," by the same; "The Madonna," by the same; "The Angel Gabriel," by the same; "The Virgin holding in her hand a book, and attended by angels," by Carlo Maratt; "The Virgin with the Child asleep," by the same; "Liberality and Modesty," by Guido; "Apollo rewarding Merit and Punishing Arrogance," by Andrea Sacchi; "The finding of Romulus and Remus," by Pietro da Cortona; "Cæsar repudiating Pompeia," by the same; "Three Children of King Charles I.," by Vandyke; "Belisarius," by Salvator Rosa; "St Agnes," by Dominichino; "The Judgment of Hercules," by Nicolas Poussin; "Venus attired by the Graces," by Guido; "Justice and Meekness," by Raffaello; "The Offspring of Love," by Guido; "Cupid Sleeping," by the same; "Abraham giving up the handmaid Hagar," by Guercino; "Esther a Suppliant before Ahasuerus," by the same; "Joseph and Potiphar's Wife," by Guido; "Venus blinding Cupid," by Titian; "Venus," by the same; "Danae," by the same; "Portrait of King Charles I.," by Vandyke; "The Madonna," by Correggio; "St Cæcilia," by Raffaello; "Mary Magdalen," by Guido; "Our Saviour appearing to his Mother after his Resurrection," by Guercino; "A Mother and Child," by Parmegiano; "Cupid Meditating," by Schidoni; "Laomedon, King of Troy, detected by Neptune and Apollo," by Salvator Rosa; "The Death of Dido," by Guercino; "Venus and Adonis," by Titian; "Fortune," by Guido; Cleopatra," by the same; "Two Children at School," by Schidoni; "Mary Magdalen," by Correggio; "Portrait of King Charles I. attended by the Marquis of Hamilton," by Vandyke; "Queen Henrietta, attended by the Prince of Wales, and holding in her arms the Duke of York," by the same; "Apotheosis of the Royal Children," by West; "The Annunciation," by Guido; "Portrait of Raffaello Sancio d'Urbino," by himself; "Sappho," by Carlo Dolci; "Our Saviour asleep," by Vandyke; "St John in the Desert," by Murrillo.

STRANGFORD, a small seaport and market-town of Ireland, in the county of Down, on the south side of the mouth of Lough Strangford, 6 miles N.E. of Downpatrick. It has a chapel of ease and places of worship for Roman Catholics and Wesleyans. The people are mostly employed in fishing. There belonged to the town in 1857, 57 vessels, tonnage 3871; and there entered the port 526 vessels, tonnage 25,680; cleared, 172 vessels, tonnage 7595. Pop. 620.

STRANRAER, a royal parliamentary and municipal burgh and seaport-town of Wigtonshire, on the S. shore of Loch Ryan, 8 miles N.E. of Portpatrick, and 50 S. of Ayr. It consists principally of three main streets running parallel to the shore, and connected by several cross streets. Among the principal public buildings are an elegant parish church, a town-hall, and a jail, which was formerly one of the residences of the noble family of Stair. Besides the parish church there are a *quoad sacra* church, two Free churches, three United Presbyterian, an Original Secession, a Reformed Presbyterian church, and a Roman Catholic chapel. There is likewise a poorhouse for the Rhynns of Galloway situated here. There are also an academy and several schools, some of which are endowed. Stranraer is a thriving place, and forms the emporium for the Rhynns or western district of Wigtonshire. The number of registered shipping belonging to the port at 31st December 1858 was 30, tonnage 1196. The number of vessels that entered the port during that year was 503, tonnage 35,644; left, 368, tonnage 31,564. The harbour is protected by a high-water stone-pier, with a wooden continuation, which is at present (1860) undergoing extensive improvements. Stranraer is on the line of the Castle-Douglas and Portpatrick Railway, now approaching completion. It has a weekly market and several annual fairs. It unites with Wigton, Whithorn, and New Galloway in sending a member to Parliament. Pop. (1851) of royal burgh, 3877; of parliamentary burgh, (5738).

STRASBURG (Fr. *Strasbourg*, Germ. *Strassburg*, anc. *Argentoratum*), a fortified town in France, capital of the department of Bas-Rhin, on the Ill, an affluent of the Rhine, about a mile from its confluence with that river, 250 miles E. by S. of Paris. It stands on a flat piece of ground, and is of an irregular but somewhat triangular form, 5 or 6

miles in circuit. The defences consist of a wall with bastions, ditches, and outworks, and a citadel at the eastern extremity with five bastions, whose outworks stretch down to the Rhine. A bridge of boats leads across the river to the fortress of Kehl in Baden. Strasburg is entered by seven gates. The Ill flows through the town from south-west to north-east; at its entrance there is a sluice by means of which the surrounding country can be laid under water. Immediately below this it divides into five branches, four of which re-unite a short way further down, and form the principal channel, flowing first east and then north, and receiving the canal of the Rhine from the right. The other branch, which is much smaller, flows first north and then east, and unites with the former just before leaving the town. Strasburg is thus divided into three parts, which are joined by numerous wooden bridges. The town is very irregularly laid out; the principal streets are broad, and some of the squares spacious and regular; but in general, the streets are narrow and winding. The houses are all substantially built of stone, they rise to a great height, and have steep roofs, with two or three tiers of windows. Although Strasburg has now for a long time belonged to the French, the character of the town, and the language, manners, and customs of its inhabitants are still entirely German. The chief public squares are that of Kleber, a native of Strasburg, containing a statue in his honour; that of Gutenberg, likewise containing a statue of the inventor of printing, who carried out his first experiments here; that of Austerlitz near the gate of the same name; and that of Broglio, formerly the horse-market, one of the most busy in the town. Among the public buildings, the largest and most interesting is the Cathedral, one of the finest Gothic buildings in Europe, with the loftiest spire in the world. It is said to have been originally founded in 504; but this earlier edifice was almost entirely destroyed by lightning in 1007. The present building was begun in 1015, but not finished till 1439. Erwin of Steinbach, the architect of the tower, died in 1318, when his work was incomplete, but it was carried on by his son, and afterwards by his daughter. It stands at the northern side of the west front; and according to the original design, there should have been a similar tower to the south of this, but it has only been raised to a much lower height. This west front is exceedingly fine; it has three large portals, a rose window 48 feet in diameter, and three equestrian statues of Clovis, Dagobert, and Rudolph of Hapsburg. The height of the tower is 466 feet, 18 feet higher than St Peter's at Rome, and 16 above the great pyramid as it is at present; though the latter, in its original state, was probably considerably higher than the spire. The interior of the church consists of a nave and aisles, transepts and choir; and its principal dimensions are as follows:—entire length, 357 feet; height of the nave, 79 feet; length of the transepts, 140 feet; breadth of the nave, 35 feet; of the choir which has no aisles, 67 feet. The most remarkable objects in the interior are the rich painted glass in the windows, the carved stone pulpit, the font, and the celebrated clock, recently repaired, a most elaborate piece of machinery, indicating in addition to the hours the phenomena of the heavens. Some of the other churches in Strasburg are interesting and remarkable, such as that of St Stephen, the oldest in the town; that of St Thomas, which belongs to the Lutherans, containing a splendid monument by Pegalle to Marshal Saxe; the *Temple Neuf*, also a Lutheran church, and *St Pierre le jeune*, which is partly Roman Catholic and partly Lutheran. The Jews have also a splendid synagogue here. The whole number of churches in the town is 15. The other principal buildings are the royal palace, Episcopal palace, prefects' office, town-hall, custom-house, court-house, public library of 130,000 volumes, the Royal Academy, which was originally a Protestant school, afterwards a university, but degraded from the latter rank at the French Revolution; the Theatre with an Ionic portico; and the Picture Gallery. There are many and extensive military establishments here; including an arsenal, artillery school, cannon foundry, barracks, and military hospital. The manufactures of Strasburg are very numerous. Woollen, linen, and cotton goods, sailcloth, jewellery, metal buttons, clocks and watches, cutlery, cast-iron goods, china, porcelain, earthenware, soap, leather, straw-hats, hosiery, paper, playing-cards, &c. There are also large bleachfields, dye-works, sugar refineries, breweries, printing-offices, and other manufactories. The town is celebrated for its goose-liver pies (*pâtés de fores gras*). An extensive trade is carried on with other parts of France, as well as with Holland, Germany, Switzerland, and Italy, and it is greatly facilitated by the advantageous position of the town so near the Rhine. Strasburg is the seat of a bishop, of a prefect, of a court of law, chamber of commerce, theological, legal, and medical faculties, numerous academies and schools, hospitals, &c. It occupies the site of the ancient Argentoratum, which probably existed before the Roman conquest, but was made by them a fortress against the incursions of the Germans, who obtained possession of it at a subsequent period, but were driven back by Clovis. About the sixth century the ancient name began to be superseded by that of *Strateburguen*, whence has come its present appellation. During the middle ages it was subject to the German emperors, and was the capital of Alsace, but along with that province it was ceded to Louis XIV. in 1681. Since then its defences have been greatly improved under the direction of Vauban, so that it is now one of the strongest fortresses in Europe. Pop. (1851) 75,565, of whom 35,000 are Protestants.

STRATFORD, Stony, a market-town of England, in the county and 7 miles N.E. of Buckingham, on the Ouse, which is here crossed by a bridge. It is generally well built of freestone, and contains a parish church with an ancient tower, Wesleyan, Independent, and Baptist chapels, a national school, and several charitable institutions. Many of the people are employed in lace-making. Pop. 1757.

STRATFORD-UPON-AVON, a municipal borough and market-town of England, in Warwickshire, on the Avon, 9 miles S.W. of Warwick, and 96 N.W. of London. Its situation is very fine, on a gentle slope above the river, which has here a considerable breadth, and is crossed by an old bridge of fourteen pointed arches. The older parts of the town are irregularly laid out, and but indifferently built; but many improvements have been made of late, and new streets, with large and good houses, have been constructed. Close to the river, at the south-east corner of the town, stands the church, a fine cruciform building, illustrious as the burial-place of Shakspeare. The remains of the poet lie on the north side of the chancel, and on the wall is his monument, partly of marble, with a half-length bust, and two inscriptions, one Latin and the other English. The church, which was completely restored in 1840, is distinguished also for its architecture, and has some ancient stone seats and two modern carved pulpits. Stratford has also a chapel of ease and places of worship, belonging to Methodists, Independents, Baptists, and Roman Catholics; national and British schools, a free grammar school, and several charities. There are a theatre and a town-hall, the latter having a statue of Shakspeare on the outside, and a portrait in the interior. The house in which he was born is still preserved, but that in which he spent the later years of his life has been pulled down. The inhabitants of Stratford are chiefly employed in agriculture. Numerous fairs are held here, and an active trade is carried on. Pop. 3372.

STRATHMIGLO, a burgh of barony and parish of Scotland, Fifeshire, 10 miles W.S.W. of Cupar, on the left bank of the Miglo. It has a town-hall, a parish church,

Strato || Strength of Materials.

and others belonging to the Free Church, the United Presbyterians, and the Reformed Presbyterians, as well as several schools. The people are chiefly employed in weaving; and there are here also a bleachfield, corn-mills, malt-houses, and breweries. Pop. 1304.

STRATO, a Greek philosopher who flourished in the third century B.C., was the son of Arcesilaus, of Lampsacus. He belonged to the Aristotelian school, and in 286 B.C. was appointed by Theophrastus, the immediate successor of Aristotle, to succeed him as head of the Lyceum. This position he held for eighteen years; and he is also said to have instructed Ptolemy Philadelphus in philosophy. Strato devoted his attention chiefly to physical science, and on that account was known by the surname of Physicus, or the naturalist. A list of his works given by Diogenes shows that only a few of them were devoted to any other than physical subjects. No authentic fragments of his writings have been preserved, and we can only form some imperfect idea of his teaching from incidental notices in other authors. He seems to have introduced some modifications of the peripatetic philosophy, which were afterwards more fully developed in the epicurean system. In psychology he carried to a greater length the tendency which had been previously begun by Theophrastus; to represent the purely intellectual acts of the mind as much more closely allied to sensation than Aristotle had admitted. The mind, according to him, in pure thought no less than in sensation, makes use of the material organism; and these two operations, though distinct from each other, can never be carried on separately. Consequently, if Strato adhered to Aristotle's view as to the perishable nature of the lower or sensational part of the soul, he could not have held in any sense its immortality. The metaphysical opinions of Strato are not so certainly known as his psychological views, and they have given rise to considerable discussion in modern times. The peculiarity of his doctrine was, that the self-moving power of nature is, as it were, dormant, until it is called into action by something from without. Cudworth, Leibnitz, Bayle, and others have accused Strato of atheism; but he has not been without defenders from this charge. The few and brief notices we have on this subject from ancient writers do not perhaps warrant us in coming to any decided conclusion.

Straubing || Strength of Materials

STRAUBING, a town of Bavaria, on the right bank of the Danube, 25 miles S.E. of Regensburg. It is walled, and has a castle, a number of churches and convents, a gymnasium, Latin school, and normal seminary, an orphan and other hospitals. Brewing and weaving are extensively carried on; there are large powder and corn magazines, and an important trade in corn and horses. The castle was the residence in the fifteenth century of Albert III. of Bavaria, with his wife, Agnes Bernauer, the beautiful daughter of a citizen of Augsburg. Albert's father, the reigning duke, being displeased with his son's marriage, ordered the lady during his absence to be drowned in the river. She is now buried in the church of St Peter, where a marble tablet records her tragic fate. Pop. 9300.

STREHLEN, a town of Prussia, in the province of Silesia, government and 23 miles S. of Breslau, on the left bank of the Ohlau. It is surrounded by walls, and entered by three gates; has an old castle, a court-house, a Roman Catholic and several Protestant churches, and an hospital. Woollen and linen cloth, leather, and tobacco are manufactured here. Pop. 5114.

STRENGTH OF MATERIALS,

Importance of the subject.

In *Mechanics*, is a subject of so much importance, that in a nation so eminent as this for invention and ingenuity in every species of manufacture, and in particular so distinguished for its improvements in machinery of every kind, it is somewhat singular that no writer has treated it in the detail which its importance and difficulty demand. The man of science who visits our great manufactories is delighted with the ingenuity which he observes in every part, the innumerable inventions which come even from individual artisans, and the determined purpose of improvement and refinement which he sees in every workshop. Every cotton-mill appears an academy of mechanical science; and mechanical invention is spreading from these fountains over the whole kingdom. But the philosopher is mortified to see this ardent spirit cramped by ignorance of principle, and many of those original and brilliant thoughts obscured and clogged with needless and even hurtful additions, and a complication of machinery which checks improvement even by its appearance of ingenuity. There is nothing in which this want of scientific education, this ignorance of principle, is so frequently observed, as in the injudicious proportion of the parts of machines and other mechanical structures; proportions and forms of parts in which the strength and position are nowise regulated by the strains to which they are exposed, and where repeated failures have been the only lessons.

Strength of materials arises from cohesion.

The strength of materials arises immediately or ultimately from the cohesion of the parts of bodies. Our examination of this property of tangible matter has as yet been very partial and imperfect, and by no means enables us to apply mathematical calculations with precision and success. The various modifications of cohesion, in its different appearances of perfect softness, plasticity, ductility, elasticity, hardness, have a mighty influence on the strength of bodies, but are hardly susceptible of measurement. Their texture, whether uniform like glass and ductile metals, crystallized or granulated like other metals and freestone, or fibrous like timber, is a circumstance no less important; yet even here, although we derive some advantage from remarking to which of these forms of aggregation a substance belongs, the aid is but small. All we can do in this want of general principles is, to make experiments on every class of bodies. Accordingly philosophers have endeavoured to instruct the public in this particular. The Royal Society of London, at its very first institution, made many experiments at their meetings, as may be seen in the first registers of the society; and since then a vast multitude of experiments have been made by public bodies and private individuals. The best of these, perhaps, up to the date of the present edition, are those of Mr Barlow.

Experiments to ascertain it.

Rendered useful by generalization.

But to make use of any experiments, there must be employed some general principle by which we can generalize their results. They will otherwise be only narrations of detached facts. We must have some notion of that intermedium, by the intervention of which an external force applied to one part of a lever, joist, or pillar, occasions a strain on a distant part. This can be nothing but the cohesion between the parts. It is this connecting force which is brought into action, or, as we more shortly express it, excited. This action is modified in every part by the laws of mechanics. It is this action which we call the *strength* of that part, and its effect is the strain on the adjoining parts; and thus it is the same force, differently viewed, that constitutes both the strain and the strength. When we consider it in the light of a resistance to fracture, we call it *strength*.

Strength defined.

Causes known only from their effects.

We call every thing a *force* which we observe ever to be accompanied by a change of motion; or, more strictly speaking, we infer the presence and agency of a force wherever we observe the state of things in respect of motion different from what we know to be the result of the action of all the forces which we know to act on the body. Thus when we observe a rope prevent a body from falling, we infer a moving force inherent in the rope, with as much confidence as when we observe it drag the body along the ground. The *immediate action* of this force is undoubtedly exerted between the immediately adjoining parts of the rope. The immediate effect is the keeping the particles of the rope together. They ought to separate by any external force drawing the ends of the rope contrariwise; and we ascribe their not doing so to a mechanical force really opposing this external force. When desired to give it a name, we name it from what we conceive to be its effect, and therefore its characteristic, and we call it *cohesion*. This is merely a name for the fact; but it is the same thing in all our denominations. We know nothing of the causes but in the effects; and our name for the cause is in fact the name of the effect, which is *cohesion*. We mean nothing else by gravitation or magnetism. What do we mean when we say that Newton understood thoroughly the nature of gravitation, of the force of gravitation; or that Franklin understood the nature of the electric force? Nothing but this: Newton considered with patient sagacity the general facts of gravitation, and has described and classed them with the utmost precision. In like manner, we shall understand the nature of cohesion when we have discovered with equal generality the laws of cohesion, or general facts which are observed in the appearances, and when we have described and classed them with equal accuracy.

Let us therefore attend to the more simple and obvious phenomena of cohesion, and mark with care every circumstance of resemblance by which they may be classed. Let us receive these as the laws of cohesion, characteristic of its supposed cause, the force of cohesion. We cannot pretend to enter on this vast research. The modifications are innumerable; and it would require the penetration of more than Newton to detect the circumstance of similarity amidst millions of discriminating circumstances. Yet this is the only way of discovering which are the primary facts characteristic of the force, and which are the modifications. The study is immense, but it is by no means desperate; and we entertain great hopes that it will ere long be successfully prosecuted; but, in our particular predicament, we must content ourselves with selecting such general laws as seem to give us the most immediate information of the circumstances that must be attended to by the mechanician in his constructions, that he may unite strength with simplicity, economy, and energy.

All bodies elastic.

1. Then, it is a matter of fact that all bodies are in a certain degree perfectly elastic; that is, when their form or bulk is changed by certain moderate compressions or distractions, it requires the continuance of the changing force to continue the body in this new state; and when the force is removed, the body recovers its original form. We limit the assertion to *certain moderate* changes. For instance, take a lead wire of one fifteenth of an inch in diameter and ten feet long; fix one end firmly to the ceiling, and let the wire hang perpendicular; affix to the lower end an index like the hand of a watch; on some stand immediately below let there be a circle divided into degrees, with its centre corresponding to the lower point of the wire; now turn this index twice round, and thus twist the wire. When the index is let go, it will turn backwards again, by the wire untwisting itself, and make almost four revolutions before it stops; after which it twists and untwists many times, the index going backwards and forwards round the circle, diminishing, however, its arch of twist each time, till at last it settles precisely in its original position. This may be repeated for ever. Now, in this motion, every part of the wire partakes equally of the twist. The particles are stretched, require force to keep them in their state of extension, and recover completely their relative positions. These are all the characters of what the mechanician calls *perfect* elasticity. This is a quality quite familiar in many cases, as in glass, tempered steel, &c., but was thought incompetent to lead, which is generally considered as having little or no elasticity. But we make the assertion in the most general terms, with the limitation to moderate derangement of form. We have made the same experiment on a thread of pipe-clay, made by forcing soft clay through the small hole of a syringe by means of a screw, and we found it more elastic than the lead wire; for a thread of one twentieth of an inch diameter and seven feet long allowed the index to make two turns, and yet completely recovered its first position.

2. But if we turn the index of the lead wire four times round, and let it go again, it untwists again in the same manner, but it makes little more than four turns back again; and after many oscillations it finally stops in a position almost two revolutions removed from its original position. It has now acquired a new arrangement of parts, and this new arrangement is permanent like the former; and, what is of particular moment, it is perfectly elastic. This change is familiarly known by the denomination of a *set*. The wire is said to have *taken a set*. When we attend minutely to the procedure of nature in this phenomenon, we find that the particles have, as it were, slid on each other, still cohering, and have taken a new position, in which their connecting forces are in equilibrio; and in this change of relative situation, it appears that the connecting forces which maintained the particles in their first situation were not in equilibrio in some position intermediate between that of the first and that of the last form. The force required for changing this first form augmented with the change, but only to a certain degree; and during this process the connecting forces always tended to the recovery of this first form. But after the change of mutual position has passed a certain magnitude, the union has been partly destroyed, and the particles have been brought into new situations; such, that the forces which now connect each with its neighbour tend, not to the recovery of the first arrangement, but to push them farther from it, into a new situation, to which they now verge, and require force to prevent them from acquiring. The wire is now in fact again perfectly elastic; that is, the forces which now connect the particles with their neighbours, augment to a certain degree as the derangement from this new position augments. This is not reasoning from any theory. It is narrating facts, on which a theory is to be founded. What we have been just now saying, is evidently a description of that sensible form of tangible matter which we call *ductility*. It has every gradation of variety, from the softness of butter to the firmness of gold. All these bodies have some elasticity; but we say they are not perfectly elastic, because they do not completely recover their original form when it has been greatly damaged. The whole gradation may be most distinctly observed in a piece of glass or hard sealing-wax. In the ordinary form glass is perhaps the most completely elastic body that we know, and may be bent till just ready to snap, and yet completely recovers its first form, and takes no set whatever; but when heated to such a degree as just to be visible in the dark, it loses its brittleness, and becomes so tough that it cannot be broken by any blow; but it is no longer elastic, it takes any set, and keeps it. When more heated, it becomes as plastic as clay; but in this state is remarkably distinguished from clay by a quality which we may call *viscidity*, which is something like elasticity, of which clay and other bodies purely plastic exhibit no appearance. This

What is meant by a set.

Ductility.

Viscidity.

Strength of Materials.

is the joint operation of strong adhesion and softness. When a rod of perfectly soft glass is suddenly stretched a little, it does not at once take the shape which it acquires after some little time. It is owing to this that, in taking the impression of a seal, if we take off the seal while the wax is yet very hot, the sharpness of the impression is immediately destroyed. Each part drawing its neighbour, and each part yielding, the prominent parts are pulled down and blunted, and the sharp hollows are pulled upwards and also blunted. The seal must be kept on till the wax has become not only stiff, but hard.

Observed in all homogeneous plastic bodies.

This viscidity is to be observed in all plastic bodies which are homogeneous. It is not observed in clay, because clay is not homogeneous, but consists of hard particles of argillaceous earth sticking together by their attraction for water. Something like it might be made of finely powdered glass and a clammy fluid such as turpentine. Viscidity has all degrees of softness, till it degenerates to ropy fluidity like that of olive oil. Perhaps something of it may be found even in the most perfect fluid with which we are acquainted, as we observed in the experiments for ascertaining specific gravity.

When ductility and elasticity are combined in different proportions, an immense variety of sensible modes of aggregation may be produced. Some degree of both are probably to be observed in all bodies of complex constitution; that is, which consist of particles made up of many different kinds of atoms. Such a constitution of a body must afford many situations permanent, but easily deranged.

Particles acted on by attractions and repulsions.

In all these changes of disposition which take place among the particles of a ductile body, the particles are at such distance that they still cohere. The body may be stretched a little; and on removing the extending force, the body shrinks into its first form. It also resists moderate compressions; and when the compressing force is removed, the body again swells out. Now the corpuscular *fact* here is, that the particles are acted on by attractions and repulsions, which balance each other when no external force is acting on the body, and which augment as the particles are made, by any external cause, to recede from this situation of mutual inactivity; for since force is requisite to produce either the dilatation or the compression, and to maintain it, we are obliged, by the constitution of our minds, to infer that it is opposed by a force accompanying or inherent in every particle of dilatable or compressible matter; and as this necessity of employing force to produce a change indicates the agency of these corpuscular forces, and marks their kind, according as the tendencies of the particles appear to be toward each other in dilatation, or from each other in compression; so it also measures the degrees of their intensity. Should it require three times the force to produce a double compression, we must reckon the mutual repulsions triple when the compression is doubled; and so in other instances. We see from all this that the phenomena of cohesion indicate some relation between the centres of the particles. To discover this relation is the great problem in corpuscular mechanism, as it was in the Newtonian investigation of the force of gravitation. Could we discover this law of action between the corpuscles with the same certainty and distinctness, we might with equal confidence say what will be the result of any position which we give to the particles of bodies; but this is beyond our hopes. The law of gravitation is so simple, that the discovery or detection of it amid the variety of celestial phenomena required but one step; and in its own nature its possible combinations still do not greatly exceed the powers of human research. One is almost disposed to say that the Supreme Being has exhibited it to our reasoning powers as sufficient to employ with success our utmost efforts, but not so abstruse as to discourage us from the noble attempt. It seems to be otherwise with respect to cohesion. Mathematics informs us, that if it deviates sensibly from the law of gravitation, the simplest combinations will make the joint action of several particles an almost impenetrable mystery. We must therefore content ourselves, for a long time to come, with a careful observation of the simplest cases that we can propose, and with the discovery of secondary laws of action, in which many particles combine their influence. In pursuance of this plan, we observe,

The great problem in corpuscular mechanism.

Particles kept in their places by a balance of forces.

3. That whatever is the situation of the particles of a body with respect to each other, when in a quiescent state, they are kept in these situations by the balance of opposite forces. This cannot be refused, nor can we form to ourselves any other notion of the state of the particles of a body. Whether we suppose the ultimate particles to be of certain magnitudes and shapes, touching each other in single points of cohesion; or whether, with Boscovich, we consider them as at a distance from each other, and acting on each other by attractions and repulsions, we must acknowledge, in the first place, that the centres of the particles (by whose mutual distances we must estimate the distance of the particles) may and do vary their distances from each other. What else can we say when we observe a body increase in length, in breadth, and thickness, by heating it, or when we see it diminish in all these dimensions by an external compression? A particle, therefore, situated in the midst of many others, and remaining in that situation, must be conceived as maintained in it by the mutual balancing of all the forces which connect it with its neighbours. It is like a ball kept in its place by the opposite action of two springs. This illustration merits a more particular application. Suppose a number of balls ranged on the table in the angles of equilateral triangles, and that each ball is connected with the six which lie around it by means of an elastic wire curled like a cork-screw; suppose such another stratum of balls above this, and parallel to it, and so placed that each ball of the upper stratum is perpendicularly over the centre of the equilateral triangle below, and let these be connected with the balls of the under stratum by similar spiral wires. Let there be a third and a fourth, and any number of such strata, all connected in the same manner. It is plain that this may extend to any size, and fill any space. Now let this assemblage of balls be firmly contemplated by the imagination, and be supposed to shrink continually in all its dimensions, till the balls, and their distances from each other, and the connecting wires, all vanish from the sight as discrete individual objects. All this is very conceivable. It will now appear like a solid body, having length, breadth, and thickness; it may be compressed, and will again resume its dimensions; it may be stretched, and will again shrink; it will move away when struck; in short, it will not differ in its sensible appearance from a solid elastic body. Now when this body is in a state of compression, for instance, it is evident that any one of the balls is at rest, in consequence of the mutual balancing of the actions of all the spiral wires which connect it with those around it. It will greatly conduce to the full understanding of all that follows to recur to this illustration. The analogy or resemblance between the effects of this constitution of things and the effects of the corpuscular forces is very great; and wherever it obtains, we may safely draw conclusions from what we know would be the condition of a body of common tangible matter. We shall just give one instructive example, and then have done with this hypothetical body. We can suppose it of a long shape, resting on one point; we can suppose two weights A, B, suspended at the extremities, and the whole in equilibrio. We commonly express this state of things by saying that A and B are in equilibrio. This is very inaccurate. A is in fact in equilibrio with the united action of all the springs which connect the ball to which it is applied with the adjoining balls. These springs are brought into action, and each is in equilibrio with the joint action of

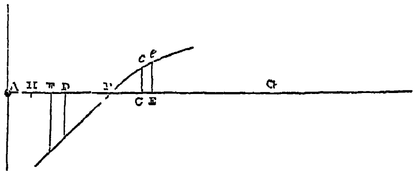
Illustration of this proposition.

By example.

all the rest. Thus through the whole extent of the hypothetical body the springs are brought into action in a way and in a degree which mathematics can easily investigate. We need not do this: it is enough for our purpose that our imagination readily discovers that some springs are stretched, others are compressed, and that a pressure is excited on the middle point of support, and the support exerts a reaction which precisely balances it; and the other weight is, in like manner, in immediate equilibrio with the equivalent of the actions of all the springs which connect the last ball with its neighbours. Now take the analogical or resembling case, an oblong piece of solid matter, resting on a fulcrum, and loaded with two weights in equilibrio; for the actions of the connecting springs substitute the corpuscular forces; and the result will resemble that of the hypothesis.

Now, as there is something that is at least analogous to a change of distance of the particles, and a concomitant change of the intensity of the connecting forces, we may express this in the same way that we are accustomed to do in similar cases. Let A and B (fig. 1) represent the centres of two particles of a coherent elastic body in their quiescent inactive state, and let us consider only the mechanical condition of B. The body may be

Fig. 1.



stretched. In this case the distance AB of the particles may become AC. In this state there is something which makes it necessary to employ a force to keep the particles at this distance. C has a tendency towards A, or we may say that A attracts C. We may represent the magnitude of this tendency of C *towards* A, or this attraction of A, by a line C*c* perpendicular to AC. Again, the body may be compressed, and the distance AB may become AD. Something obliges us to employ force to continue this compression, and D tends *from* A, or A appears to *repel* D. The intensity of this tendency or repulsion may be represented by another perpendicular D*d*; and, to represent the different directions of these tendencies, or the different nature of these actions, we may set D*d* on the opposite side of AB. It is in this manner that Boscovich has represented the actions of corpuscular forces in his celebrated Theory of Natural Philosophy. Newton had said, that as the great movements of the solar system were regulated by forces operating at a distance, and varying with the distance, so he strongly suspected (*valde suspicor*) that all the phenomena of cohesion, with all its modifications in the different sensible forms of aggregation, and in the phenomena of chemistry and physiology, resulted from the similar agency of forces varying with the distance of the particles. The learned Jesuit pursued this thought; and has shown, that if we suppose an ultimate atom of matter endowed with powers of attraction and repulsion, varying, both in kind and degree, with the distance, and if this force be the same in every atom, it may be regulated by such a relation to the distance from the neighbouring atom, that a collection of such may have all the sensible appearance of bodies in their different forms of solids, liquids, and vapours, elastic or unelastic, and endowed with all the properties which we perceive, by whose immediate operation the phenomena of motion by impulse, and all the phenomena of chemistry, and of animal and vegetable economy, may be produced. He shows, that notwithstanding a perfect sameness, and even a great simplicity, in this atomical constitution, there will result from this union all that unspeakable variety of form and property which diversifies and embellishes the face of

How Boscovich represents the action of corpuscular forces.

nature. We shall take another opportunity of giving such an account of this celebrated work as it deserves. We mention it only by the by, as far as a general notion of it will be of some service on the present occasion. For this purpose, we just observe that Boscovich conceives a particle of any individual species of matter to consist of an unknown number of particles of simpler constitution; each of which particles, in their turn, is compounded of particles still more simply constituted, and so on through an unknown number of orders, till we arrive at the simplest possible constitution of a particle of tangible matter, susceptible of length, breadth, and thickness, and necessarily consisting of four atoms of matter. And he shows that the more complex we suppose the constitution of a particle, the more must the sensible qualities of the aggregate resemble the observed qualities of tangible bodies. In particular, he shows how a particle may be so constituted, that although it act on one other particle of the same kind through a considerable interval, the interposition of a third particle of the same kind may render it totally, or almost totally, inactive; and therefore an assemblage of such particles would form such a fluid as air. All these curious inferences are made with uncontrovertible evidence; and the greatest encouragement is thus given to the mathematical philosopher to hope, that by cautious and patient proceeding in this way, we may gradually approach to a knowledge of the laws of cohesion, that will not shun a comparison even with the Principia of Newton. No step can be made in this investigation, but by observing with care, and generalizing with judgment, the phenomena, which are abundantly numerous, and much more at our command than those of the great and sensible motions of bodies. Following this plan, we observe,

Every body compressible and dilatable.

4. It is a matter of fact, that every body has some degree of compressibility and dilatability; and when the changes of dimension are so moderate that the body completely recovers its original dimensions on the cessation of the changing force, the extensions or compressions are sensibly proportional to the extending of compressing forces; and therefore *the connecting forces are proportional to the distances of the particles from their quiescent, neutral, or inactive positions.* This seems to have been first viewed as a law of nature by the penetrating eye of Dr Robert Hooke, one of the most eminent philosophers of the last century. He published a cipher, which he said contained the theory of springiness and of the motions of bodies by the action of springs. It was this, *c e i i i n o s s s t t u u*. When explained in his dissertation, published some years after, it was *ut tensio sic vis*. This is precisely the proposition now asserted as a general fact, a law of nature. This dissertation is full of curious observations of facts in support of his assertion. In his application to the motion of bodies, he gives his noble discovery of the balance-spring of a watch, which is founded on this law. The spring, as it is more and more coiled up, or unwound, by the motion of the balance, acts on it with a force proportional to the distance of the balance from its quiescent position. The balance, therefore, is acted on by an accelerating force, which varies in the same manner as the force of gravity acting on a pendulum swinging in a cycloid. Its vibrations therefore must be performed in equal time, whether they are wide or narrow. In the same dissertation Hooke mentions all the facts which John Bernoulli afterwards adduced in support of Leibnitz's whimsical doctrine of the force of bodies in motion, as the doctrine of the *vires vivæ;* a doctrine which Hooke might justly have claimed as his own, had he not seen its futility.

Law of nature discovered by Dr Hooke;

Experiments made since the time of Hooke show that this law is strictly true in the extent to which we have limited it, viz. in all the changes of form which will be completely undone by the elasticity of the body. It is nearly true to a much greater extent. James Bernoulli, in his dis-

and confirmed by the experiments of others.

sertation on the elastic curve, relates some experiments of his own, which seem to deviate considerably from it; but on close examination they do not. The finest experiments are those of Coulomb, published in some late volumes of the Memoirs of the Academy of Paris. He suspended balls by wires, and observed their motions of oscillation, which he found accurately corresponding with this law.

This we shall find to be a very important fact in the doctrine of the strength of bodies, and we desire the reader to make it familiar to his mind. If we apply to this our manner of expressing these forces by perpendicular ordinates C*c*, D*d* (fig. 1), we must take other situations E, F, of the particle B, and draw E*e*, F*f*; and we must have D*d* : F*f* = BD : BF, or C*c* : E*e* = BC : BE. In such a supposition F*d*B*ce* must be a straight line. But we shall have abundant evidence by and by that this cannot be strictly true, and that the line B*ce*, which limits the ordinates expressing the attractive forces, becomes concave towards the line ABE, and that the part B*df* is convex towards it. All that can be safely concluded from the experiments hitherto made is, that *to a certain extent* the forces, both attractive and repulsive, are *sensibly* proportional to the dilatations and compressions. For,

When a body is much dilated, a small addition of force will increase its dilatation.

5. It is universally observed, that when the dilatations have proceeded a certain length, a less addition of force is sufficient to increase the dilatation in the same degree. This is always observed when the body has been so far stretched that it takes a set, and does not completely recover its form. The like may be generally observed in compressions. Most persons will recollect, that in violently stretching an elastic cord, it becomes suddenly weaker, or more easily stretched. But these phenomena do not positively prove a diminution of the corpuscular force acting on one particle: it more probably arises from the disunion of some particles whose action contributed to the whole or sensible effect. And in compressions we may suppose something of the same kind; for when we compress a body in one direction, it commonly bulges out in another; and in cases of very violent action some particles may be disunited, whose transverse action had formerly balanced *part* of the compressing force. For the reader will see on reflection, that since the compression in one direction causes the body to bulge out in the transverse direction, and since this bulging out is in opposition to the transverse forces of attraction, it must employ some part of the compressing force. And the common appearances are in perfect uniformity with this conception of things. When we press a bit of dryish clay, it swells out and cracks transversely. When a pillar of wood is overloaded, it swells out, and small crevices appear in the direction of the fibres. After this it will not bear half of the load. This the carpenters call *crippling;* and a knowledge of the circumstances which modify it is of great importance, and enables us to understand some very paradoxical appearances, as will be shown by and by.

This partial disuniting of particles formerly cohering, is, we imagine, the chief reason why the totality of the forces which really oppose an external strain does not increase in the proportion of the extensions and compressions. But sufficient evidence will also be given that the forces which would connect one particle with one other particle do not augment in the accurate proportion of the change of distance; that in extensions they increase more slowly, and in compressions more rapidly.

Ductility another cause of deviation.

But there is another cause of this deviation perhaps equally effectual with the former. Most bodies manifest some degree of ductility. Now what is this? The fact is, that the parts have taken a new arrangement, in which they again cohere. Therefore, in the passage to this new arrangement, the sensible forces, which are the joint result of many corpuscular forces, begin to respect this new arrangement instead of the former. This must change the simple law of corpuscular force, characteristic of the particular species of matter under examination. It does not require much reflection to convince us that the possible arrangements which the particles of a body may acquire, without appearing to change their nature, must be more numerous according as the particles are of a more complex constitution; and it is reasonable to suppose that the constitution even of the most simple kind of matter that we are acquainted with is exceedingly complex. Our microscopes show us animals so minute, that a heap of them must appear to the naked eye an uniform mass with a grain finer than that of the finest marble or razor hone; and yet each of these has not only limbs, but bones, muscular fibres, blood-vessels, fibres, and a blood consisting in all probability of globules organized and complex like our own. The imagination is here lost in wonder; and nothing is left us but to adore inconceivable art and wisdom, and to exult in the thought that we are the only spectators of this beautiful scene who can derive pleasure from the view. But let us proceed to observe,

The forces which connect the particles of tangible bodies change by a change of distance.

6. That the forces which connect the particles of tangible bodies change by a change of distance, not only in degree, but also in kind. The particle B (fig. 1) is attracted by A when in the situation C or E. It is repelled by it when at D or F. It is not affected by it when in the situation B. The reader is requested carefully to remark, that this is not an inference founded on the authority of our mathematical figure. The figure is an expression (to assist the imagination) of facts in nature. It requires no force to keep the particles of a body in their quiescent situations: but if they be separated by stretching the body, they endeavour (pardon the figurative expression) to come together again. If they be brought nearer by compression, they endeavour to recede. This endeavour is manifested by the necessity of employing force to maintain the extension or condensation; and we represent this by the different position of our lines. But this is not all: the particle B, which is repelled by A when in the situation F or D, is neutral when at B, and is attracted when at C or E, may be placed at such a distance AG from A greater than AB that it shall be again repelled, or at such a distance AH that it shall be again attracted; and these alterations may be repeated again and again. This is curious and important, and requires something more than a bare assertion for its proof.

Light alternately attracted and repelled.

In the article OPTICS we mentioned the most curious and valuable observations of Sir Isaac Newton, by which it appears that light is thus alternately attracted and repelled by bodies. The rings of colour which appear between the object-glasses of long telescopes showed, that in the small interval of $\frac{1}{1000}$th of an inch, there are at least an hundred such changes observable, and that it is highly probable that these alternations extend to a much greater distance. At one of these distances the light actually converges towards the solid matter of the glass, which we express shortly by saying that it is attracted by it, and that at the next distance it declines from the glass, or is repelled by it. The same thing is more simply inferred from the phenomena of light passing by the edges of knives and other opaque bodies. We refer the reader to the experiments themselves, the detail being too long for this place; and we request him to consider them minutely and attentively, and to form distinct notions of the inferences drawn from them. And we desire it to be remarked, that although Newton, in his discussion, always considers light as a set of corpuscles moving in free space, and obeying the actions of external forces like any other matter, the particular conclusion in which we are just now interested does not at all depend on this notion of the nature of light. Should we, with Descartes or Huygens, suppose light to be the undulation of an elastic medium, the

Strength of Materials.

conclusion will be the same. The undulations at certain distances are disturbed by forces directed towards the body, and at a greater distance the disturbing forces tend *from* the body.

The same alternations of attraction and repulsion observable in the particles of other bodies, as glass.

But the same alternations of attraction and repulsion may be observed between the particles of common matter. If we take a piece of very flat and well-polished glass, such as is made for the horizon-glasses of a good Hadley's quadrant, and if we wrap round it a fibre of silk as it comes from the cocoon, taking care that the fibre shall nowhere cross another, and then press this pretty hard on such another piece of glass, it will lift it up and keep it suspended. The particles therefore of the one do most certainly attract those of the other, and this at a distance equal to the thickness of the silk fibre. This is nearly the limit; and it sometimes requires a considerable pressure to produce the effect. The pressure is effectual only by compressing the silk fibre, and thus diminishing the distance between the glass plates. This adhesion cannot be attributed to the pressure of the atmosphere, because there is nothing to hinder the air from insinuating itself between the plates, since they are separated by the silk. Besides, the experiment succeeds equally well under the receiver of an air-pump. This most valuable experiment was first made by Huygens, who reported it to the Royal Society. It is narrated in the Philosophical Transactions, No. 86.

Here, then, is an attraction acting, like gravity, at a distance. But take away the silk fibre, and try to make the glasses touch each other, and we shall find a very great force necessary. By Newton's experiments it appears, that unless the prismatic colours begin to appear between the glasses, they are at least $\frac{1}{890}$th of an inch asunder or more. Now we know that a very considerable force is necessary for producing these colours, and that the more we press the glasses together the more rings of colours appear. It also appears from Newton's measures, that the difference of distance between the glasses where each of these colours appears is about the 89,000th part of an inch. We know further, that when we have produced the last appearance of a greasy or pearly colour, and then augment the pressure, making it about 1000 pounds on the square inch, all colours vanish, and the two pieces of glass seem to make one transparent undistinguishable mass. They appear now to have no air between them, or to be in mathematical contact. But another fact shows this conclusion to be premature. The same circles of colours appear in the top of a soap-bubble; and as it grows thinner at top, there appears an unreflecting spot in the middle. We have the greatest probability therefore that the perfect transparency in the middle of the two glasses does not arise from their being in contact, but because the thickness of air between them is too small in that place for the reflection of light. Nay, Newton expressly found no reflection where the thickness was $\frac{3}{8}$ths or more of the $\frac{1}{89000}$th part of an inch.

All this while the glasses are strongly repelling each other, for great pressure is necessary for continuing the appearance of those colours, and they vanish in succession as the pressure is diminished. This vanishing of the colours is a proof that the glasses are moving off from each other, or repelling each other. But we can put an end to this repulsion by very strong pressure, and at the same time sliding the glasses on each other. We do not pretend to account for this effect of the sliding motion; but the fact is, that by so doing, the glasses will cohere with very great force, so that we shall break them by any attempt to pull them asunder. It commonly happens (at least it did so with us), that in this sliding compression of two smooth flat plates of glass, they scratch and mutually destroy each other's surface. It is also worth remarking, that different kinds of glass exhibit different properties in this respect. Flint glass will attract even though a silk fibre lies double between them, and they much more readily cohere by this sliding pressure.

Here, then, are two distances at which the plates of glass attract each other; namely, when the silk fibre is interposed, and when they are forced together with this sliding motion. And in any intermediate situation they repel each other. We see the same thing in other solid bodies.

Lead and iron.

Two pieces of lead, made perfectly clean, may be made to cohere by grinding them together in the same manner. It is in this way that pretty ornaments of silver are united to iron. The piece is scraped clean, and a small bit of silver like a fish scale is laid on. The die which is to strike it into a flower or other ornament is then set on it, and we give it a smart blow, which forces the metals into contact as firm as if they were soldered together. It sometimes happens that the die adheres to the coin so that they cannot be separated: and it is found that this frequently happens when the engraving is such that the raised figure is not completely surrounded with a smooth flat ground. The probable cause of this is curious. When the coin has a flat surface all around, this is produced by the most prominent part of the die. This applies to the metal, and completely confines the air which filled the hollow of the die.

Probable cause why the die adheres to the coin.

As the pressure goes on, the metal is squeezed up into the hollow of the die; but there is still air compressed between them, which cannot escape by any passage. It is therefore prodigiously condensed, and exerts an elasticity proportioned to the condensation. This serves to separate the die from the metal when the stroke is over. The hollow part of the die has not touched the metal all the while, and we may say that the impression was made by air. If this air escape by any engraving reaching through the border, they cohere inseparably.

We have admitted that the glass plates are in contact when they adhere thus firmly. But we are not certain of this: for if we take these cohering glasses, and touch them with water, it quickly insinuates itself between them. Yet they still cohere, but can now be pretty easily separated.

Repulsion the cause of somebodies swimming in a fluid specifically lighter than themselves.

It is owing to this repulsion, exerted through its proper sphere, that certain powders swim on the surface of water, and are wetted with great difficulty. Certain insects can run about on the surface of water. They have brushy feet, which occupy a considerable surface, and if their steps be viewed with a magnifying glass, the surface of the water is seen depressed all around, resembling the footsteps of a man walking on feather beds. This is owing to a repulsion between the brush and the water. A common fly cannot walk in this manner on water. Its feet are wetted, because they attract the water instead of repelling it. A steel needle, slightly greased, will lie on the surface of water, make an impression as a great bar would make on a feather bed; and its weight is less than that of the displaced water. A dew-drop lies on the leaves of plants without touching them mathematically, as is plain from the extreme brilliancy of the reflection at the posterior surface; nay, it may be sometimes observed that the drops of rain lie on the surface of water, and roll about on it like balls on a table. Yet all these substances can be wetted; that is, water can be applied to them at such distances that they attract it.

What we lately remarked of water insinuating itself between the glass plates without altogether destroying their cohesion, shows that this cohesion is not the same that obtains between the particles of one of the plates; that is, the two plates are not in the state of one continued mass. It is highly probable, therefore, that between these two states there is an intermediate state of repulsion, nay, perhaps, many such, alternated with attractive states.

A piece of ice is elastic, for it rebounds and rings. Its particles, therefore, when compressed, resile; and when

stretched, contract again. The particles are therefore in the state represented by B in figure 1, acted on by repulsive forces if brought nearer, and by attractive forces if drawn further asunder. Ice expands, like all other bodies, by heat. It absorbs a vast quantity of fire, which, by combining its attractions and repulsions with those of the particles of ice, changes completely the law of action, and the ice becomes water. In this new state the particles are again in limits between attractive and repulsive forces; for water has been shown, by the experiments of Canton and Zimmerman, to be elastic or compressible. It again expands by heat. It again absorbs a prodigious quantity of heat, and becomes elastic vapour; its particles repelling each other at all distances yet observed. The distance between the particles of one plate of glass and those of another which lies on it, and is carried by it, is a distance of repulsion; for the force which supports the upper piece is acting in opposition to its weight. This distance is less than that at which it would *suspend* it below it with a silk fibre interposed; for no prismatic colours appear between them when the silk fibre is interposed. But the distance at which glass attracts water is much less than this, for no colours appear when glass is wetted with water. This distance is less, and not greater, than the other; for when the glasses have water interposed between them instead of air, it is found, that when any particular colour appears, the thickness of the plate of water is to that of the plate of air which would produce the same colour, nearly as three to four. Now, if a piece of glass be wetted, and exhibit no colour, and another piece of glass be simply laid on it, no colour will appear; but if they are strongly pressed, the colours appear in the same manner as if the glasses had air between. Also, when glass is simply wetted, and the film of water is allowed to evaporate, when it is thus reduced to a proper thinness the colours show themselves in great beauty.

Particles of matter connected by forces acting at a distance.

These are a few of many thousand facts, by which it is unquestionably proved that the particles of tangible matter are connected by forces acting at a distance, varying with the distance, and alternately attractive and repulsive. If we represent these forces, as we have already done in fig. 1, by the ordinates C*c*, D*d*, E*e*, F*f*, &c. of a curve, it is evident that this curve must cross the axis at all those distances where the forces change from attractive to repulsive, and the curve must have branches alternately above and below the axis.

All these alternations of attraction and repulsion take place at small and insensible distances. At all sensible distances the particles are influenced by the attraction of gravitation; and therefore this part of the curve must be a hyperbola whose equation is $y=\frac{a^3}{x^2}$. What is the form of the curve corresponding to the smallest distance of the particles? that is, what is the mutual action between the particles just before their coming into absolute contact? Analogy should lead us to suppose it to be repulsion; for solidity is the last and simplest form of bodies with which we are acquainted. Fluids are more compounded, containing fire as an essential ingredient. We should conclude that this ultimate repulsion is insuperable, for the hardest bodies are the most elastic. We are fully entitled to say that this repelling force exceeds all that we have ever yet applied to overcome it; nay, there are good reasons for saying that this ultimate repulsion, by which the particles are kept from mathematical contact, is really insuperable in its own nature, and that it is impossible to produce mathematical contact.

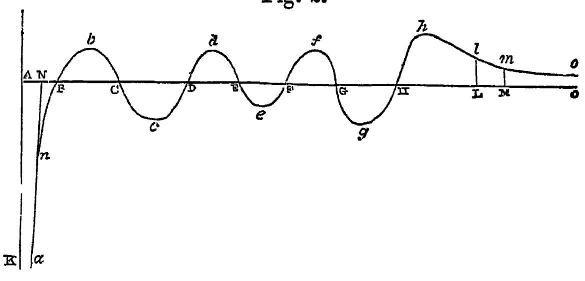
Mathematical contact impossible.

We shall just mention one of these, which we consider as unanswerable. Suppose two atoms, or ultimate particles of matter, A and B. Let A be at rest, and B move up to it with the velocity 2; and let us suppose that it comes into mathematical contact, and impels it (according to the common acceptation of the word). Both move with the velocity 1. This is granted by all to be the final result of the collision. Now the instant of time in which this communication happens is no part either of the duration of the solitary motion of A, nor of the joint motion of A and B: it is the separation or boundary between them. It is at once the end of the first and the beginning of the second, belonging equally to both. A was moving with the volocity 2. The distinguishing circumstance, therefore, of its mechanical state is, that it has a determination (however incomprehensible) by which it would move for ever with the velocity 2, if nothing changed it. This it has during the whole of its solitary motion, and therefore in the last instant of this motion. In like manner, during the whole of the joint motion, and therefore in the first instant of this motion, the atom A has a determination by which it would move for ever with the velocity 1. In one and the same instant, therefore, the atom A has two incompatible determinations. Whatever notion we can form of this state, which we call velocity, as a distinction of condition, the same impossibility of conception, or the same absurdity, occurs. Nor can it be avoided in any other way than by saying, that this change of A's motion is brought about by insensible gradations; that is, that A and B influence each other precisely as they would do if a slender spring were interposed. The reader is desired to look at what we have said in the article PHYSICS.

The two magnets there spoken of are good representatives of two atoms endowed with mutual powers of repulsion; and the communication of motion is accomplished in both cases in precisely the same manner.

If, therefore, we shall ever be so fortunate as to discover the law of variation of that force which connects one *atom* of matter with another atom, and which is therefore characteristic of matter, and the ultimate source of all its sensible qualities, the curve whose ordinates represent the kind and the intensity of this atomical force will be something like that sketched in fig. 2. The first branch *a n* B will have

Fig. 2.



AK (perpendicular to the axis AH) for its assymptote, and the last branch *lmo* will be to all sense a hyperbola, having AO for its assymptote; and the ordinates *l*L, *m*M, &c. will be proportional to $\frac{1}{AL^2}$, $\frac{1}{AM^2}$, &c. expressing the universal gravitation of matter. It will have many branches B*b*C, D*d*E, F*f*G, &c. expressing attractions, and alternate repulsive branches C*c*D, E*e*F, G*g*H, &c. All these will be contained within a distance AH, which does not exceed a very minute fraction of an inch.

The simplest extended particle consists of four atoms.

The simplest particle which can be a constituent of a body having length, breadth, and thickness, must consist of four such atoms, all of which combine their influence on each atom of another such particle. It is evident that the curve which expresses the force that connects two such particles must be totally different from this original curve, this hylarchic principle. Supposing the last known, our mathematical knowledge is quite able to discover the first; but when we proceed to compose a body of particles, each of

which consists of four such particles, we may venture to say that the compound force which connects them is almost beyond our search, and that the discovery of the primary force from an *accurate* knowledge of the corpuscular forces of *this* particular matter is absolutely out of our power.

All that we can learn is, the possibility, nay, the certainty, of an innumerable variety of external sensible forms and qualities, by which different kinds of matter will be distinguished, arising from the number, the order of composition, and the arrangement of the subordinate particles of which a particle of this or that kind of matter is composed. All these varieties will take place at those small and insensible distances which are between A and H, and may produce all that variety which we observe in the tangible or mechanical forms of bodies, such as elasticity, ductility, hardness, softness, fluidity, vapour, and all those unseen motions or actions which we observe in fusion and congelation, evaporation and condensation, solution and precipitation, crystallization, vegetable and animal assimilation and secretion, &c.; while all bodies must be, in a certain degree, elastic, all must gravitate, and all must be incompenetrable.

This general and satisfactory resemblance between the appearance of tangible matter and the legitimate consequence of this general hypothetical property of an atom of matter, affords a considerable probability that such is the origin of all the phenomena. We earnestly recommend to our readers a careful perusal of Boscovich's celebrated treatise. A careful perusal is necessary for seeing its value; and nothing will be got by a hasty inspection. The reader will be particularly pleased with the facility and evidence with which the ingenious author has deduced all the ordinary principles of mechanics, and with the explanation which he has given of fluidity, and his deduction from thence of the laws of hydrostatics. No part of the treatise is more valuable than the doctrine of the propagation of pressure through solid bodies. This, however, is but just touched on in the course of the investigation of the principles of mechanics. We shall borrow as much as will suffice for our present inquiry into the strength of materials; and we trust that our readers are not displeased with this general sketch of the doctrine (if it may be so called) of the cohesion of bodies. It is curious and important in itself, and is the foundation of all the knowledge which we can acquire of the present article. We are sorry to say that it is as yet a new subject of study; but it is a very promising one, and we by no means despair of seeing the whole of chemistry brought by its means within the pale of mechanical science. The great and distinguishing agent in chemistry is heat, or fire the cause of heat; and one of its most singular effects is the conversion of bodies into elastic vapour. We have the clearest evidence that this is brought about by mechanical forces; for it can be opposed or prevented by external pressure, a very familiar mechanical force. We may perhaps find another mechanical force which will prevent fusion.

The doctrine of cohesion yet a new subject.

Having now made our readers familiar with the mode of action in which cohesion operates in giving strength to solid bodies, we proceed to consider the strains to which this strength is opposed.

Strains to which strength is opposed.

A piece of solid matter is exposed to four kinds of strains, different in the manner of their operation.

1. It may be torn asunder, as in the case of ropes, stretchers, king-posts, tie-beams, &c.

2. It may be crushed, as in the case of pillars, posts, and truss-beams.

3. It may be broken across, as happens to a joist or lever of any kind.

4. It may be wrenched or twisted, as in the case of the axle of a wheel the nail of a press, &c.

1.—IT MAY BE PULLED ASUNDER.

Matter may be pulled asunder;

This is the simplest of all strains, and the others are indeed modifications of it. To this the force of cohesion is *directly* opposed, with very little modification of its action by any particular circumstances.

When a long cylindrical or prismatic body, such as a rod of wood or metal, or a rope, is drawn by one end, it must be resisted at the other, in order to bring its cohesion into action. When it is fastened at one end, we cannot conceive it any other way than as equally stretched in all its parts; for all our observations and experiments on natural bodies concur in showing us that the forces which connect their particles in any way whatever are equal and opposite. This is called the *third law of motion;* and we admit its universality, while we affirm that it is purely experimental. Yet we have met with dissertations by persons of eminent knowledge, where propositions are maintained inconsistent with this. During the dispute about the communication of motion, some of the ablest writers have said, that a spring compressed or stretched at the two ends was gradually less and less compressed or stretched from the extremities towards the middle: but the same writers acknowledged the universal equality of action and re-action, which is quite incompatible with this state of the spring. No such inequality of compression or dilatation has ever been observed; and a little reflection will show it to be impossible, in consistency with the equality of action and re-action.

Since all parts are thus equally stretched, it follows that the strain in any transverse section is the same, as also in every point of that section. If therefore the body be supposed of a homogeneous texture, the cohesion of the parts is equable; and since every part is equally stretched, the particles are drawn to equal distances from their quiescent positions, and the forces which are thus excited, and now exerted in opposition to the straining force, are equal. This external force may be increased by degrees, which will gradually separate the parts of the body more and more from each other, and the connecting forces increase with this increase of distance, till at last the cohesion of some particles is overcome. This must be immediately followed by a rupture, because the remaining forces are now weaker than before.

It is the united force of cohesion, immediately before the disunion of the first particles, that we call the *strength* of the section. It may also be properly called its *absolute strength*, being exerted in the simplest form, and not modified by any relation to other circumstances.

a circumstance to be attended to in every construction requiring strength.

If the external force have not produced any permanent change on the body, and it therefore recovers its former dimensions when the force is withdrawn, it is plain that this strain may be repeated as often as we please, and the body which withstands it once will always withstand it. It is evident that this should be attended to in all constructions, and that in all our investigations on this subject this should be kept strictly in view. When we treat a piece of soft clay in this manner, and with this precaution, the force employed must be very small. If we exceed this, we produce a permanent change. The rod of clay is not indeed torn asunder, but it has become somewhat more slender; the number of particles in a cross section is now smaller; and therefore, although it will again, in this new form, suffer or allow an endless repetition of a *certain* strain without any farther permanent change, this strain is smaller than the former.

Something of the same kind happens in all bodies which receive a *set* by the strain to which they are exposed. All ductile bodies are of this kind. But there are many bodies which are not ductile. Such bodies break completely whenever they are stretched beyond the limit of their perfect elasticity. Bodies of a fibrous structure exhibit very great

Great varieties in cohesion, but

varieties in their cohesion. In some the fibres have no lateral cohesion, as in the case of a rope. The only way in which all the fibres can be made to unite their strength, is to twist them together. This causes them to bind each other so fast, that any one of them will break before it can be drawn out of the bundle. In other fibrous bodies, such as timber, the fibres are held together by some cement or gluten. This is seldom as strong as the fibre. Accordingly timber is much easier pulled asunder in a direction transverse to the fibres. There is, however, every possible variety in this particular.

In stretching and breaking fibrous bodies, the visible extension is frequently very considerable. This is not solely the increasing of the distance of the particles of the cohering fibre; the greatest part chiefly arises from drawing the crooked fibre straight. In this, too, there is great diversity; and it is accompanied with important differences in their power of withstanding a strain. In some woods, such as fir, the fibres on which the strength most depends are very straight. Such woods are commonly very elastic, do not take a set, and break abruptly when overstrained: others, such as oak and birch, have their resisting fibres very undulating and crooked, and stretch very sensibly by a strain. They are very liable to take a set, and they do not break so suddenly, but give warning by *complaining*, as the carpenters call it; that is, by giving visible signs of a derangement of texture. Hard bodies of an uniform glassy structure, or granulated like stones, are elastic through the whole extent of their cohesion, and take no set, but break at once when overloaded.

Notwithstanding the immense variety which nature exhibits in the structure and cohesion of bodies, there are certain general facts of which we may now avail ourselves with advantage. In particular,

the absolute cohesion or strength proportional to the area of the section perpendicular to the extending force.

The absolute cohesion is proportional to the area of the section. This must be the case where the texture is perfectly uniform, as we have reason to think it is in glass and the ductile metals. The cohesion of each particle being alike, the whole cohesion must be proportional to their number, that is, to the area of the section. The same must be admitted with respect to bodies of a granulated texture, where the granulation is regular and uniform. The same must be admitted of fibrous bodies, if we suppose their fibres equally strong, equally dense, and similarly disposed through the whole section; and this we must either suppose, or must state the diversity, and measure the cohesion accordingly.

We may therefore assert, as a general proposition on this subject, that the absolute strength in any part of a body, by which it resists being pulled asunder, or the force which must be employed to tear it asunder *in that part*, is proportional to the area of the section perpendicular to the extending force.

Therefore all cylindrical or prismatical rods are equally strong in every part, and will break alike in any part; and bodies which have unequal sections will always break in the slenderest part. The length of the cylinder or prism has no effect on the strength. Also the absolute strengths of bodies which have similar sections are proportional to the squares of their diameters or homologous sides of the section.

The weight of the body itself may be employed to strain it and to break it. It is evident, that a rope may be so long as to break by its own weight. When the rope is hanging perpendicularly, although it is equally strong in every part, it will break towards the upper end, because the strain on

Relative strength.

any part is the weight of all that is below it. Its *relative strength* in any part, or power of withstanding the strain which is actually laid on it, is inversely as the quantity below that part.

When the rope is stretched horizontally, as in towing a ship, the strain arising from its weight often bears a very sensible proportion to its whole strength.

These are the chief general rules which can be safely deduced from our clearest notions of the cohesion of bodies. In order to make any practical use of them, it is proper to have some measures of the cohesion of such bodies as are commonly employed in our mechanics, and other structures where they are exposed to this kind of strain. These must be deduced solely from experiment; therefore they must be considered as no more than general values, or as the averages of many particular trials. The irregularities are very great, because none of the substances are constant in their texture and firmness. Metals differ by a thousand circumstances unknown to us, according to their purity, to the heat with which they were melted, to the moulds in which they were cast, and the treatment they have afterwards received, by forging, wire-drawing, tempering, &c.

The cohesion of metals depends on various circumstances.

It is a very curious and inexplicable fact, that by forging a metal, or by frequently drawing it through a smooth hole in a steel plate, its cohesion is greatly increased. This operation undoubtedly deranges the natural situation of the particles. They are squeezed closer together in one direction, but it is not in the direction in which they resist the fracture. In this direction they are rather separated to a greater distance. The general density, however, is augmented in all of them except lead, which grows rather rarer by wire-drawing; but its cohesion may be more than tripled by this operation. Gold, silver, and brass, have their cohesion nearly tripled; copper and iron have it more than doubled. In this operation they also grow much harder. It is proper to heat them to redness after drawing a little. This is called *nealing* or *annealing*. It softens the metal again, and renders it susceptible of another drawing without the risk of cracking in the operation.

We do not pretend to give any explanation of this remarkable and very important fact, which has something resembling it in woods and other fibrous bodies, as will be mentioned afterwards.

The varieties in the cohesion of stones and other minerals, and of vegetable and animal substances, are hardly susceptible of any description or classification.

Cohesion and strength of different metals.

We shall take for the measure of cohesion the number of pounds avoirdupois which are just sufficient to tear asunder a rod or bundle of one inch square. From this it will be easy to compute the strength corresponding to any other dimension.

1*st*, *Metals.*

		lbs.
Gold, cast		20,000 / 24,000
Silver, cast		40,000 / 43,000
Copper, cast,	Japan	19,000
	Barbary	22,000
	Hungary	31,000
	Anglesea	34,000
	Sweden	37,000
Iron, cast		42,000 / 59,000
Iron, bar	Ordinary	68,000
	Stirian	75,000
	Best Swedish and Russian	84,000
	Horse-nails	71,000[1]

[1] This was an experiment by Muschenbroeck, to examine the vulgar notion that iron forged from old horse-nails was stronger than all others, and shows its falsity.

Strength of Materials.

Steel, bar	Soft	120,000
	Razor temper	150,000
Tin, cast	Malacca	3,100
	Banca	3,600
	Block	3,800
	English block	5,200
	——— grain	6,500
Lead, cast		860
Regulus of antimony		1,000
Zinc		2,600
Bismuth		2,900

Tenacity of metals increased by mixtures.

It is very remarkable, that almost all the mixtures of metals are more tenacious than the metals themselves. The change of tenacity depends much on the proportion of the ingredients, and the proportion which produces the most tenacious mixture is different in the different metals. We have selected the following from the experiments of Muschenbroeck. The proportion of ingredients here selected is that which produces the greatest strength.

Two parts of gold with one of silver	28,000
Five parts of gold with one of copper	50,000
Five parts of silver with one of copper	48,500
Four parts of silver with one of tin	41,000
Six parts of copper with one of tin	41,000
Five parts of Japan copper with one of Banca tin	57,000
Six parts of Chili copper with one of Malacca tin	60,000
Six parts of Swedish copper with one of Malacca tin	64,000
Brass consists of copper and zinc in an unknown proportion; its strength is	51,000
Three parts of block-tin with one part of lead	10,200
Eight parts of block-tin with one part of zinc	10,000
Four parts of Malacca tin with one part of regulus of antimony	12,000
Eight parts of lead with one of zinc	4,500
Four parts of tin with one of lead and one of zinc	13,000

These numbers are of considerable use in the arts. The mixtures of copper and tin are particularly interesting in the fabric of great guns. We see that, by mixing copper, whose greatest strength does not exceed 37,000, with tin, which does not exceed 6000, we produce a metal whose tenacity is almost double, at the same time that it is harder and more easily wrought. It is, however, more fusible, which is a great inconvenience. We also see that a very small addition of zinc almost doubles the tenacity of tin, and increases the tenacity of lead five times; and a small addition of lead doubles the tenacity of tin. These are economical mixtures. This is very valuable information to the plumbers, for augmenting the strength of water-pipes.

By having recourse to these tables, the engineer can proportion the thickness of his pipes, of whatever metal, to the pressures to which they are exposed.

2d, *Woods.*

We may premise to this part of the table the following general observations.

Tenacity or strength of wood.

1. The wood immediately surrounding the pith or heart of the tree is the weakest, and its inferiority is so much more remarkable as the tree is older. In this assertion, however, we speak with some hesitation. Muschenbroeck's *detail* of experiments is decidedly in the affirmative. M. Buffon, on the other hand, says that his experience has taught him that the heart of a sound tree is the strongest; but he gives no instances. From many observations of our own on very *large* oaks and firs, we are certain that the heart is much weaker than the exterior parts.

2. The wood next the bark, commonly called the *white* or *blea*, is also weaker than the rest; and the wood gradually increases in strength as we recede from the centre to the blea.

3. The wood is stronger in the middle of the trunk than at the springing of the branches or at the root; and the wood of the branches is weaker than that of the trunk.

4. The wood of the north side of all trees which grow in our European climates is the weakest, and that of the south-east side is the strongest; and the difference is most remarkable in hedge-row trees, and such as grow singly. The heart of a tree is never in its centre, but always nearer to the north side, and the annual coats of wood are thinner on that side. In conformity with this, it is a general opinion of carpenters that timber is stronger whose annual plates are thicker. The trachea or air-vessels are weaker than the simple ligneous fibres. The air-vessels are the same in diameter and number of rows in trees of the same species, and they make the visible separation between the annual plates. Therefore, when these are thicker, they contain a greater proportion of the simple ligneous fibres.

5. All woods are more tenacious while green, and lose very considerably by drying after the trees are felled.

The only author who has put it in our power to judge of the propriety of his experiments is Muschenbroeck. He has described his method of trial minutely, and it seems unexceptionable. The woods were all formed into slips fit for his apparatus, and part of the slip was cut away to a parallelopiped of $\frac{1}{5}$th of an inch square, and therefore $\frac{1}{25}$th of a square inch in section. The absolute strengths of a square inch were as follow:

Absolute strength of different kinds of wood.

	lib.		lib.
Locust tree	20,100	Pomegranate	9750
Juleb	18,500	Lemon	9250
Beech, oak	17,300	Tamarind	8750
Orange	15,500	Fir	8330
Alder	13,900	Walnut	8130
Elm	13,200	Pitch-pine	7650
Mulberry	12,500	Quince	6750
Willow	12,500	Cypress	6000
Ash	12,000	Poplar	5500
Plum	11,800	Cedar	4880
Elder	10,000		

Muschenbroeck has given a very minute detail of the experiments on the ash and the walnut, stating the weights which were required to tear asunder slips taken from the four sides of the tree, and on each side, in a regular progression from the centre to the circumference. The number of this table corresponding to these two timbers may therefore be considered as the average of more than fifty trials made of each; and he says that all the others were made with the same care. We cannot therefore see any reason for not confiding in the results; yet they are considerably higher than those given by some other writers. Mr Pitot, on the authority of his own experiments, and of those of Mr Parent, avers that sixty pounds will just tear asunder a square line of sound oak, and that it will bear fifty with safety. This gives 8640 for the utmost strength of a square inch, which is much inferior to Muschenbroeck's valuation.

We may add to these,

and of other substances.

Ivory	16,270
Bone	5,250
Horn	8,750
Whalebone	7,500
Tooth of sea-calf	4,075

No substance to be strained in architecture above one half its strength.

The reader will surely observe, that these numbers express something more than the utmost cohesion; for the weights are such as will very quickly, that is, in a minute or two, tear the rods asunder. It may be said in general, that two thirds of these weights will sensibly impair the strength after a considerable while, and that one half is the utmost that can remain suspended at them without risk for ever; and it is upon this last allotment that the engineer should reckon in his constructions. There is, however, considerable difference in this respect. Woods of a very straight

fibre, such as fir, will be less impaired by any load which is not sufficient to break them immediately.

According to Mr Emerson, the load which may be safely suspended to an inch square is as follows:

Iron	76,400
Brass	35,600
Hempen rope	19,600
Ivory	15,700
Oak, box, yew, plum-tree	7,850
Elm, ash, beech,	6,070
Walnut, plum	5,360
Red fir, holly, elder, plane, crab	5,000
Cherry, hazel	4,760
Alder, asp, birch, willow	4,290
Lead	430
Freestone	914

He gives us a practical rule, that a cylinder whose diameter is 1 inch, loaded to one fourth of its absolute strength, will carry as follows:

Iron	135	cwt.
Good rope	22	cwt.
Oak	14	cwt.
Fir	9	cwt.

The rank which the different woods hold in this list of Mr Emerson's is very different from what we find in Muschenbroeck's. But precise measures must not be expected in this matter. It is wonderful, that in a matter of such unquestionable importance the public has not enabled some persons of judgment to make proper trials. They are beyond the abilities of private persons.

II.—BODIES MAY BE CRUSHED.

It is of importance to know what will crush bodies.

It is of equal, perhaps greater, importance to know the strain which may be laid on solid bodies without danger of crushing them. Pillars and posts of all kinds are exposed to this strain in its simplest form; and there are cases where the strain is enormous, viz. where it arises from the oblique position of the parts, as in the struts, braces, and trusses, which occur very frequently in our great works. It is therefore most desirable to have some general knowledge of the principle which determines the strength of bodies, in opposition to this kind of strain. But, unfortunately, we are much more at a loss in this than in the last case. The mechanism of nature is, in the present case, much more complicated. It must be in some circuitous way that compression can have any tendency to tear asunder the parts of a solid body, and it is very difficult to trace the steps.

If we suppose the particles insuperably hard and in contact, and disposed in lines which are in the direction of the external pressures, it does not appear how any pressure can disunite the particles; but this is a gratuitous supposition. There are infinite odds against this precise arrangement of the lines of particles; and the compressibility of all kinds of matter in some degree shows that the particles are in a situation equivalent to distance. This being the case, and the particles, with their intervals, or what is equivalent to intervals, being in situations that are oblique with respect to the pressures, it must follow, that by squeezing them together in one direction, they are made to bulge out or separate in other directions. This may proceed so far that some may be thus pushed laterally beyond their limits of cohesion. The moment that this happens the resistance to compression is diminished, and the body will now be crushed together. We may form some notion of this by supposing a number of spherules, like small shot, sticking together by means of a cement. Compressing this in some particular direction causes the spherules to act among each other like so many wedges, each tending to penetrate through between the three which lie below it: and this is the simplest, and perhaps the only distinct, notion we can have of the matter.

We have reason to think that the constitution of very homogeneous bodies, such as glass, is not very different from this.

Their strength or power of resistance to such a force,

If this be the constitution of bodies, it appears probable that the strength, or the resistance which they are capable of making to an attempt to crush them to pieces, is proportional to the area of the section whose plane is perpendicular to the external force; for each particle being similarly and equally acted on and resisted, the whole resistance must be as their number, that is, as the extent of the section.

Accordingly this principle is assumed by the few writers who have considered the subject; but we confess that it appears to us very doubtful. Suppose a number of brittle or friable balls lying on a table uniformly arranged, but not cohering nor in contact, and that a board is laid over them and loaded with a weight; we have no hesitation in saying that the weight necessary to crush the whole collection is proportional to their number or to the area of the section. But when they are in contact, and still more if they cohere, we imagine that the case is materially altered. Any individual ball is crushed only in consequence of its being bulged outwards in the direction perpendicular to the pressure employed. If this could be prevented by a hoop put round the ball like an equator, we cannot see how any force can crush it. Any thing therefore which makes this bulging outwards more difficult, makes a greater force necessary. Now this effect will be produced by the mere contact of the balls before the pressure is applied; for the central ball cannot swell outward laterally without pushing away the balls on all sides of it. This is prevented by the friction on the table and upper board, which is at least equal to one third of the pressure. Thus any interior ball becomes stronger by the mere vicinity of the others; and if we further suppose them to cohere laterally, we think that its strength will be still more increased.

The analogy between these balls and the cohering particles of a friable body is very perfect. We should therefore expect that the strength by which it resists being crushed will increase in a greater ratio than that of the section, or the square of the diameter of similar sections; and that a square inch of any matter will bear a greater weight in proportion as it makes a part of a greater section. Accordingly this appears in many experiments, as will afterwards be noticed. Muschenbroeck, Euler, and some others, have supposed the strength of columns to be as the biquadrates of their diameters. Euler deduced this from formulæ which occurred to him in the course of his algebraic analysis; and he boldly adopts it as a principle, without looking for its foundation in the physical assumptions which he had made in the beginning of his investigation. But some of his original assumptions were as paradoxical, or at least as gratuitous, as these results; and those, in particular, from which this proportion of the strength of columns was deduced, were almost foreign to the case; and therefore the inference was of no value. Yet it was received as a principle by Muschenbroeck and by the academicians of St Petersburg. We make these very few observations, because the subject is of great practical importance; and it is a great obstacle to improvements when deference to a great name, joined to incapacity or indolence, causes authors to adopt his careless reveries as principles from which they are afterwards to draw important consequences. It must be acknowledged that we have not as yet established, on solid mechanical principles, the relation between the dimensions and the strength of a pillar. Experience plainly contradicts the general opinion, that the strength is proportional to the area of the section; but it is still more inconsistent with the opinion, that it is in the quadruplicate ratio of the diameters of similar sections. It would seem that the ratio depends much on the internal structure of the body; and experiment seems the only method for ascertaining its general laws.

Strength of Materials.

to be ascertained only by experiment.

If we suppose the body to be of a fibrous texture, having the fibres situated in the direction of the pressure, and slightly adhering to each other by some kind of cement, such a body will fail only by the bending of the fibres, by which they will break the cement and be detached from each other. Something like this may be supposed in wooden pillars. In such cases, too, it would appear that the resistance must be as the number of equally resisting fibres, and as their mutual support, jointly; and, therefore, as some function of the area of the section. The same thing must happen if the fibres be naturally crooked or undulated, as is observed in many woods, provided we suppose some similarity in their form. Similarity of some kind must always be supposed, otherwise we need never aim at any general inferences.

In all cases therefore we can hardly refuse admitting that the strength in opposition to compression is proportional to a function of the area of the section.

As the whole length of a cylinder or prism is equally pressed, it does not appear that the strength of a pillar is at all affected by its length. If indeed it be supposed to bend under the pressure, the case is greatly changed, because it is then exposed to a transverse strain; and this increases with the length of the pillar. But this will be considered with due attention under the next class of strains.

Few experiments have been made on this species of strength and strain. Mr Pitot says that his experiments and those of Mr Parent show that the force necessary for crushing a body is nearly equal to that which will tear it asunder. He says that it requires something more than sixty pounds on every square line to crush a piece of sound oak. But the rule is by no means general: glass, for instance, will carry a hundred times as much as oak in this way, that is, resting on it; but will not *suspend* four or five times as much. Oak will suspend a great deal more than fir; but fir, as a pillar, will carry twice as much. Woods of a soft texture, although consisting of very tenacious fibres, are more easily crushed by their load. This softness of texture is chiefly owing to their fibres not being straight but undulated, and there being considerable vacuities between them, so that they are easily bent laterally and crushed. When a post is overstrained by its load, it is observed to swell sensibly in diameter. Increasing the load causes longitudinal cracks or shivers to appear, and it presently after gives way. This is called *crippling.*

In all cases where the fibres lie oblique to the strain, the strength is greatly diminished, because the parts can then be made to slide on each other when the cohesion of the cementing matter is overcome.

Muschenbroeck has given some experiments on this subject; but they are cases of long pillars, and therefore do not belong to this place. They will be considered afterwards.

The only experiments of which we have seen any detail (and it is useless to insert mere assertions) are those of Mr Gauthey, in the fourth volume of Rozier's *Journal de Physique.* This engineer exposed to great pressures small rectangular parallelopipeds, cut from a great variety of stones, and noted the weights which crushed them. The following table exhibits the medium results of many trials on two very uniform kinds of freestone, one of them among the hardest and the other among the softest used in building.

Column first expresses the length AB of the section, in French lines or 12ths of an inch; column second expresses the breadth BC; column third is the area of the section, in square lines; column fourth is the number of ounces required to crush the piece; column fifth is the weight which was then borne by each square line of the section; and column sixth is the round numbers to which Mr Gauthey imagines that those in column fifth approximate.

Experiments for this purpose made on freestone

	AB.	BC.	AB×BC.	Weight.	Force.	
			Hard Stone.			
1	8	8	64	736	11·5	12
2	8	12	96	2625	27·3	24
3	8	16	128	4496	35·1	36
			Soft Stone.			
4	9	16	144	560	3·9	4·
5	9	18	162	848	5·3	4·5
6	18	18	324	2928	9·	9·
7	18	24	432	5296	12·2	12·

Little can be deduced from these experiments: the first and third, compared with the fifth and sixth, should furnish similar results; for the first and fifth are respectively half of the third and sixth; but the third is three times stronger (that is, a line of the third) than the first, whereas the sixth is only twice as strong as the fifth.

It is evident, however, that the strength increases much faster than the area of the section, and that a square line can carry more and more weight, according as it makes a part of a larger and larger section. In this series of experiments on the soft stone, the individual strength of a square line seems to increase nearly in the proportion of the section of which it makes a part.

Mr Gauthey deduces, from the whole of his numerous experiments, that a pillar of hard stone of Givry, whose section is a square foot, will bear with perfect safety 664,000 pounds, and that its extreme strength is 871,000; and the smallest strength observed in any of his experiments was 460,000. The soft bed of Givry stone had for its smallest strength 187,000, for its greatest 311,000, and for its safe load 249,000. Good brick will carry with safety 320,000; chalk will carry only 9000. The boldest piece of architecture in this respect which he has seen is a pillar in the church of All-Saints at Angers. It is twenty-four feet long and eleven inches square, and is loaded with 60,000, which is not one seventh of what is necessary for crushing it.

We may observe here by the way, that Mr Gauthey's measure of the suspending strength of stone is vastly small in proportion to its power of supporting a load laid above it. He finds that a prism of the hard bed of Givry, of a foot section, is torn asunder by 4600 pounds; and if it be firmly fixed horizontally in a wall, it will be broken by a weight of 56,000 suspended a foot from the wall. If it rest on two props at a foot distance, it will be broken by 206,000 laid on its middle. These experiments agree so ill with each other, that little use can be made of them. The subject is of great importance, and well deserves the attention of the patriotic philosopher.

not satisfactory.

A set of good experiments would be very valuable, because it is against this kind of strain that we must guard by judicious construction in the most delicate and difficult problems which come through the hands of the civil and military engineer. The construction of stone arches, and the construction of great wooden bridges, and particularly the construction of the frames of carpentry called *centres* in the erection of stone bridges, are the most difficult jobs that occur. In the centres on which the arches of the bridge of Orleans were built, some of the pieces of oak were carrying upwards of two tons on every square inch of their scantling. All who saw it said that it was not able to carry the fourth part of the intended load. But the engineer understood the principles of his art, and ran the risk, and the result completely justified his confidence; for the centre did not complain in any part, only it was found too supple; so that it went out of shape while the haunches only of the arch were laid on it. The engineer corrected this by loading it at the crown, and thus kept it completely in shape during the progress of the work.

Good experiments much wanted.

In the Memoirs of the Academy of St Petersburg for

1778, there is a dissertation by Euler on this subject, but particularly limited to the strain on columns, in which the bending is taken into the account. Mr Fuss has treated the same subject with relation to carpentry in a subsequent volume. But there is little in these papers besides a dry mathematical disquisition, proceeding on assumptions which (to speak favourably) are extremely gratuitous. The most important consequence of the compression is wholly overlooked, as we shall presently see. Our knowledge of the mechanism of cohesion is as yet far too imperfect to entitle us to a confident application of mathematics. Experiments should be multiplied.

How they are to be made useful.

The only way in which we can hope to make these experiments useful, is to pay a careful attention to the *manner* in which the fracture is produced. By discovering the general resemblances in this particular, we advance a step in our power of introducing mathematical measurement. Thus, when a cubical piece of chalk is slowly crushed between the chaps of a vice, we see it uniformly split in a surface oblique to the pressure, and the two parts then slide along the surface of fracture. This should lead us to examine mathematically what relation there is between this surface of fracture and the necessary force; then we should endeavour to determine experimentally the position of this surface. Having discovered some general law or resemblance in this circumstance, we should try what mathematical hypothesis will agree with this. Having found one, we may then apply our simplest notions of cohesion, and compare the result of our computations with experiment.

III.—A BODY MAY BE BROKEN ACROSS.

It is of importance to know what strain will break a body transversely.

The most usual, and the greatest strain, to which materials are exposed, is that which tends to break them transversely. It is seldom, however, that this is done in a manner perfectly simple; for when a beam projects horizontally from a wall, and a weight is suspended from its extremity, the beam is commonly broken near the wall, and the intermediate part has performed the functions of a lever. It sometimes, though rarely, happens that the pin in the joint of a pair of pincers or scissors is cut through by the strain; and this is almost the only case of a simple transverse fracture. Being so rare, we may content ourselves with saying, that in this case the strength of the piece is proportional to the area of the section.

Experiments made to ascertain it.

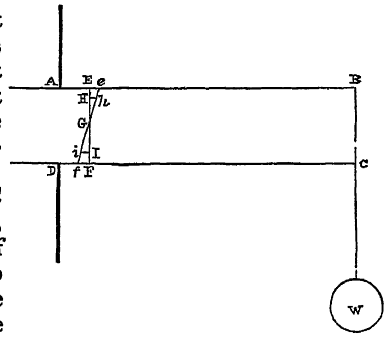
Experiments were made for discovering the resistances made by bodies to this kind of strain in the following manner. Two iron bars were disposed horizontally at an inch distance; a third hung perpendicularly between them, being supported by a pin made of the substance to be examined. This pin was made of a prismatic form, so as to fit exactly the holes in the three bars, which were made very exact, and of the same size and shape. A scale was suspended at the lower end of the perpendicular bar, and loaded till it tore out that part of the pin which filled the middle hole. This weight was evidently the measure of the lateral cohesion of two sections. The side-bars were made to grasp the middle bar pretty strongly between them, that there might be no distance interposed between the opposite pressures. This would have combined the energy of a lever with the purely transverse pressure. For the same reason it was necessary that the internal parts of the holes should be no smaller than the edges. Great irregularities occurred in our first experiments from this cause, because the pins were somewhat tighter within than at the edges; but when this was corrected they were extremely regular. We employed three sets of holes, viz. a circle, a square (which was occasionally made a rectangle whose length was twice its breadth), and an equilateral triangle. We found in all our experiments the strength exactly proportional to the area of the section, and quite independent of its figure or position, and we found it considerably above the direct cohesion; that is, it took considerably more than twice the force to tear out this middle piece that it did to tear the pin asunder by a direct pull. A piece of fine freestone required 205 pounds to pull it directly asunder, and 575 to break it in this way. The difference was very constant in any one substance, but varied from four thirds to six thirds in different kinds of matter, being smallest in bodies of a fibrous texture. But indeed we could not make the trial on any bodies of considerable cohesion, because they required such forces as our apparatus could not support. Chalk, clay baked in the sun, baked sugar, brick, and freestone, were the strongest that we could examine.

Their result.

But the more common case, where the energy of a lever intervenes, demands a minute examination.

Let ABCD (fig. 3) be the longitudinal section of a beam inserted into a wall at the end AD, and supporting a weight at the free end BC: it is required to find what tendency the weight will have to break the beam over at the section EF.

Fig. 3.



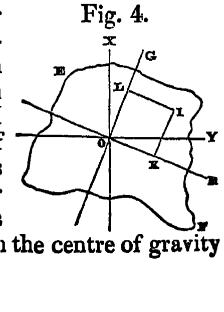
The weight at C will, in the first place, cause a tendency of the part EBCF to slide down on the surface EF, but the strength of the beam in resisting this kind of dislocation is much greater than its power of resisting common fracture: it is therefore unnecessary to examine this case.

The weight at C will cause the beam to bend; that is, it will distend the upper and compress the under part of the beam, and, acting at the extremity of the lever FC, its power of causing such compression and distention will be W × FC. Since the weight at C acts in a vertical direction, it cannot tend either to lengthen or to shorten the beam, and thus the repulsion of the compressed part must be exactly equal to the attraction of the distended parts.

Let G be the neutral point, and draw through it the line *f* G *e*, contiguous to FGE; draw also H*h* and I*i* parallel to CD. The lines I*i*, in the under side of the cross section, will represent the degrees of compression, and also (since within the limits of security the repulsion is proportional to the degree of compression) the force of repulsion, while the lines H*h* on the upper side will serve to represent the attractions. The sum of all the lines on the upper side, that is, the wedge EG*e*, will thus represent the entire amount of attraction, while the wedge FG*f* will represent the total amount of repulsion. These two wedges, then, must be equal to each other; and this equality determines the position of the axis of flexure represented by the point G. In the case of a rectangular beam, G must clearly be in the middle of the line EF; but when the cross section of the beam is irregular, the position of the axis of flexure is not quite so easily found.

Let EF be the cross section of an irregular beam, and OH the axis of flexure, or the place where the beam is neither compressed nor distended. Then the wedges generated by turning the section EF upon OH as an axis must be equal to each other. This is always the case when OH passes through the centre of gravity of the cross section, and thus it follows that those points which are neither compressed nor distended are always ranged in a straight line drawn through the centre of gravity of the cross section.

Fig. 4.



The position of the fulcrum of the lever being now known, we can proceed to ascertain the effects of the various forces.

Returning, for the sake of simplicity, to the rectangular beam; the sum of the repulsions iI will be represented by the triangle GfF: but the rectangle under GF and Ff would measure the entire strength of the under half of the beam, and therefore the force actually exerted when the beam is about to be broken across, is just half of the absolute strength of the beam; one quarter being exhibited as attraction, another quarter as repulsion. These forces act at different distances from the fulcrum G, and it is well known that the influence of a number of weights in turning a lever round is the same as if all these weights were to act at their common centre of gravity; so that to find the entire action in this case, we have to suppose one fourth of the whole strength of the beam to act at the distance $\frac{2}{3}$ of GF or $\frac{1}{3}$ of EF from the fulcrum G, and another quarter of the strength at $\frac{2}{3}$ of GE. Now, if s be the strength of one square inch of the beam, and if D, B, and L be its depth, breadth, and length, measured in inches, DBs will be the absolute strength of the whole beam; and therefore the tendencies of the above forces to straighten the beam will be

$$\tfrac{1}{4}\,DBs \times \tfrac{1}{3}\,D + \tfrac{1}{4}\,DBs \times \tfrac{1}{3}\,D;$$

that is, $\frac{1}{6}\,D^2 \cdot B \cdot s$. And again, the tendency of the weight W to bend the beam is WL; so that

$$\tfrac{1}{6}\,D^2 \cdot B \cdot s = WL,$$

$$\text{or } 6L : D :: DBs : W;$$

that is, *as six times the length of the beam is to its depth, so is the absolute strength of the beam to the weight which it can carry at the free end.*

Throughout this investigation we have supposed that the force needed to extend or compress a fibre is exactly proportional to the quantity of extension or compression. This hypothesis, though not perhaps strictly true, and though it certainly errs when we approach to dislocation or fracture, is yet confirmed by all experiments when the extensions have been kept within the limits of safety: the results of this hypothesis therefore are what must guide us in forming any structure.

It may now be interesting to inquire into the strength of a beam when bent in different directions.

EF being, as before, the cross section of an irregular beam, let that beam be bent in the direction OG, the axis of flexure being OH perpendicular to OG; and let us consider the action of a small portion ds of the surface situated at I. Having drawn the perpendiculars IK and IL, it is clear that the compression of the fibre I must be proportional to KI; and therefore the force exerted by it may be denoted by $C \cdot IK \cdot ds$, C being some constant depending on the nature of the material and the degree of flexure. This force, conceived to act at the extremity of the lever KI, will tend to bend the beam round the axis OH; but again acting at the end of the lever LI, it will tend to bend the beam on OG as an axis. Putting Σ to denote the integral for the entire surface, $C \cdot \Sigma \cdot IK^2 ds$ will be the entire tendency to rectify the form of the beam, and $C\Sigma IK \cdot IL \cdot ds$ will be the entire tendency to take a flexure in a plane at right angles to that which it actually has. A beam therefore will not bend in the direction in which the pressure is applied to it unless $\Sigma \cdot IK \cdot IL ds = 0$. This is a circumstance overlooked in all treatises on flexure; but it is one that must be carefully attended to in practice. It may easily be illustrated thus: Take a thin slip of wood, such perhaps as is used for Venetian blinds, and fix it in a vice so that while its length is horizontal its flat sides may be inclined at a considerable angle. Attach now a weight to the free end, and it will be found that that end does not descend vertically, but that it moves obliquely, the flexure not happening in that direction in which the force is applied. The force necessary to bend the beam in the plane of OG is not a force in that direction, but is the resultant of two forces, $\Sigma\, IK^2 \cdot ds$ in the direction OG, and $\Sigma \cdot IK \cdot IL \cdot ds$ in the direction OH. For the present we shall call $\Sigma IK^2 ds$ the *stiffness in the direction* OG, and $\Sigma \cdot IL^2 ds$ of course the stiffness in the direction OH. The sum of these two stiffnesses is manifestly $\Sigma \cdot OI^2 ds$, which is a constant quantity, depending not at all upon the directions of OG, OH, but only on the form of the cross section: hence follows the remarkable law, that the sum of the stiffnesses of a beam in two directions perpendicular to each other is constant; and that therefore, whatever may be the form of the beam, its directions of greatest and least stiffness are always perpendicular to each other.

For the purpose of discovering in what directions the greatest and least stiffness lie, let us refer all the points in the cross section to the axes OX and OY, putting the angle $XOG = \varphi$. We have then $IK = x \cos.\varphi + y \sin.\varphi$, $IL = -x \sin.\varphi + y \cos.\varphi$; and thus the tendency of the beam to redress itself in the direction GO is $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)^2\, ds$, while the deflecting tendency in the direction HO is $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)(-x \sin.\varphi + y \cos.\varphi)\, ds$. Regarding φ as the variable quantity, and differentiating the former for the purpose of discovering its maximum, we obtain $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)(-x \sin.\varphi + y \cos.\varphi)\, ds = 0$; now it will be observed that this expression is just that for the deflecting tendency, and hence this law,

That when a beam is bent in the direction of greatest or of least stiffness, the pressure to be applied is exactly in the direction of the bending.

The value of φ may easily be found from the above equation; the result is

$$\tan.\, 2\,\varphi = \frac{2\,\Sigma \cdot xy\, ds}{\Sigma x^2 ds - \Sigma y^2 ds}.$$

The lines OX and OY will coincide with the directions of greatest and least stiffness when $\varphi = 0$, or when $\tan.\, 2\,\varphi = 0$, that is, when $\Sigma \cdot xy\, ds = 0$.

If, then, the directions of greatest and least stiffness be taken for the axes of x and of y, we shall have $\Sigma \cdot xy\, ds = 0$, $\Sigma\, x^2 ds =$ greatest stiffness $= A$, $\Sigma\, y^2 ds =$ least stiffness $= B$. These being once known, the stiffness in any other direction, as well as the deflecting tendency, can readily be obtained. Putting P and Q respectively for these quantities, we have

$$P = A \cos.\varphi^2 + B \sin.\varphi^2,$$

$$Q = \tfrac{1}{2}\,(B - A) \sin.\, 2\,\varphi.$$

The deflecting tendency is thus greatest when $\varphi = 45°$, that is, when the actual direction of flexure is equally inclined to the directions of greatest and least stiffness. In this case

$$P^1 = \tfrac{1}{2}\,(A + B),\ Q = \tfrac{1}{2}\,(B - A).$$

Galileo, who was the first to investigate the law of transverse strain, conceived the lower edge of the beam to be the fulcrum, and each fibre to be exerting its whole strength; Professor Robison, in the former editions of this work, corrected the supposition in the case of rectangular beams: the above investigation extends it to beams of all forms.

We must now remark, that this correction of the Galilean hypothesis of equal forces was suggested by the bending which is observed in all bodies which are strained transversely. Because they are bent, the fibres on the convex side have been extended. We cannot say in what proportion this obtains in the different fibres. Our most distinct notions of the internal equilibrium between the particles render it highly probable that their extension is proportional to their distance from that fibre which retains its former dimensions. But by whatever law this is regulated, we see plainly that the actions of the stretched fibres must follow the proportions of some function of this distance, and that therefore the relative strength of a beam is in all cases susceptible of mathematical determination.

Bernoulli's problem of the elastic curve.

We also see an intimate connection between the strain and the curvature. This suggested to the celebrated James Bernoulli the problem of the *elastic curve, i. e.* the curve into which an extensible rigid body will be bent by a transverse strain. His solution in the *Acta Eruditorum* 1694 and 1695, is a very beautiful specimen of mathematical discussion, and we recommend it to the perusal of the curious reader. He will find it very perspicuously treated in the first volume of his works, published after his death, where the wide steps which he had taken in his investigation are explained so as to be easily comprehended. His nephew, Daniel Bernoulli, has given an elegant abridgement in the Petersburg Memoirs for 1729. The problem is too intricate to be fully discussed in a work like ours, but it is also too intimately connected with our present subject to be entirely omitted. We must content ourselves with showing the leading mechanical properties of this curve, from which the mathematician may deduce all its geometrical properties.

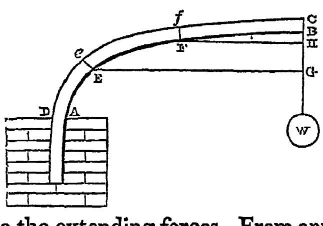
Its leading mechanical property described.

When a bar of uniform depth and breadth, and of a given length, is bent into an arch of a circle, the extension of the outer fibres is proportional to the curvature; for, because the curves formed by the inner and outer sides of the beam are similar, the circumferences are as the radii, and the radius of the inner circle is to the difference of the radii as the length of the inner circumference is to the difference of the circumferences. The difference of the radii is the depth of the beam, the difference of the circumferences is the extension of the outer fibres, and the inner circumference is supposed to be the primitive length of the beam. Now the second and third quantities of the above analogy, viz. the depth and length of the beam, are constant quantities, as is also their product. Therefore the product of the inner radius and the extension of the outer fibre is also a constant quantity, and the whole extension of the outer fibre is inversely as the radius of curvature, or is directly as the curvature of the beam.

The mathematical reader will readily see, that into whatever curve the elastic bar is bent, the whole extension of the outer fibre is equal to the length of a similar curve having the same proportion to the thickness of the beam that the length of the beam has to the radius of curvature.

Now let ADCB (fig. 5) be such a rod of uniform breadth and thickness, firmly fixed in a vertical position, and bent into a curve AEFB by a weight W suspended at B, and of such magnitude that the extremity B has its tangent perpendicular to the action of the weight, or parallel to the horizon. Suppose, too, that the extensions are proportional to the extending forces. From any two points E and F draw the horizontal ordinates EG, FH. It is evident that the exterior fibres of the sections E*e* and F*f* are stretched by forces which are in the proportion of EG to FH (these being the long arms of the levers, and the equal thicknesses E*e*, F*f* being the short arms). Therefore (by the hypothesis) their extensions are in the same proportion. But because the extensions are proportional to some similar functions of the distance from the axes of fracture E and F, the extension of any fibre in the section E*e* is to the contemporaneous extension of the similarly situated fibre in the section F*f*, as the extension of the exterior fibre in the section E*e* is to the extension of the exterior fibre in the section F*f*: therefore the whole extension of E*e* is to the whole extension of F*f* as EG to FH, and EG is to FH as the curvature in E to the curvature in F.

Fig. 5.



Here let it be remarked, that this proportionality of the curvature to the extension of the fibres is not limited to the hypothesis of the proportionality of the extensions to the extending forces: it follows from the extension in the different sections being as some similar function of the distance from the axis of fracture; an assumption which cannot be refused.

This, then, is the fundamental property of the elastic curve, from which its equation, or relation between the abscissa and ordinate, may be deduced in the usual forms, and all its other geometrical properties. These are foreign to our purpose; and we shall notice only such properties as have an immediate relation to the strain and strength of the different parts of a flexible body, and which in particular serve to explain some difficulties in the valuable experiments of Buffon on the Strength of Beams.

It is not a circle.

We observe, in the first place, that the elastic curve cannot be a circle, but is gradually more incurvated as it recedes from the point of application B of the straining forces. At B it has no curvature; and if the bar were extended beyond B there would be no curvature there. In like manner, when a beam is supported at the ends and loaded in the middle, the curvature is greatest in the middle; but at the props, or beyond them, if the beam extend farther, there is no curvature. Therefore, when a beam projecting twenty feet from a wall is bent to a certain curvature at the wall by a weight suspended at the end, and a beam of the same size projecting twenty feet is bent to the very same curvature at the wall by a greater weight at ten feet distance, the figure and the mechanical state of the beam in the vicinity of the wall is different in these two cases, though the curvature at the very wall is the same in both. In the first case every part of the beam is incurvated; in the second, all beyond the ten feet is without curvature. In the first experiment the curvature at the distance of five feet from the wall is three fourths of the curvature at the wall; in the second, the curvature at the same place is but one half of that at the wall. This must weaken the long beam in this whole interval of five feet, because the greater curvature is the result of a greater extension of the fibres.

Every beam has a certain determinate curvature.

In the next place we may remark, that there is a certain determinate curvature for every beam, which cannot be exceeded without breaking it; for there is a certain separation of two adjoining particles that puts an end to their cohesion. A fibre can therefore be extended only a certain proportion of its length. The ultimate extension of the outer fibres must bear a certain determinate proportion to its length, and this proportion is the same with that of the thickness (or what we have hitherto called the depth) to the radius of ultimate curvature, which is therefore determinate.

And when of uniform breadth and depth, is most incurvated where the strain is greatest.

A beam of uniform breadth and depth is therefore most incurvated where the strain is greatest, and will break in the most incurvated part. But by changing its form, so as to make the strength of its different sections in the ratio of the strain, it is evident that the curvature may be the same throughout, or may be made to vary according to any law. This is a remark worthy of the attention of the watchmaker. The most delicate problem in practical mechanics is so to taper the balance-spring of a watch that its wide and narrow vibrations may be isochronous. Hooke's principle *ut tensio sic vis* is not sufficient when we take the *inertia* and motion of the spring itself into the account. The figure into which it bends and unbends has also an influence. Our readers will take notice that the artist aims at an accuracy which will not admit an error of $\frac{1}{86400}$th, and that Harrison and Arnold have actually attained it in several instances. The taper of a spring is at present a nostrum in the hands of each artist, and he is careful not to impart its secret.

Again, since the depth of the beam is thus proportional to the radius of ultimate curvature, this ultimate or breaking curvature is inversely as the depth. It may be expressed by $\frac{1}{d}$.

To what the curvature is proportional.

When a weight is hung on the end of a prismatic beam, the curvature is nearly as the weight and the length directly, and as the breadth and the cube of the depth inversely; for the strength is $=f\frac{bd^2}{6l}$. Let us suppose that this produces the ultimate curvature $\frac{1}{d}$. Now let the beam be loaded with a smaller weight w, and let the curvature produced be C; we have this analogy, $f\frac{bd^2}{6l}:w=\frac{1}{d}:\mathrm{C}$, and $\mathrm{C}=\frac{6lw}{fbd^3}$. It is evident that this is also true of a beam supported at the ends and loaded between the props; and we see how to determine the curvature in its different parts, whether arising from the load, or from its own weight, or from both.

Deflection.

When a beam is thus loaded at the end or middle, the loaded point is pulled down, and the space through which it is drawn may be called the *deflection*. This may be considered as the subtense of the angle of contact, or as the versed sine of the arch into which the beam is bent, and is therefore as the curvature when the length of the arches is given (the flexure being moderate), and as the square of the length of the arch when the curvature is given. The deflection therefore is as the curvature and as the square of the length of the arch jointly; that is, as $\frac{6lw}{fbd^3}\times l^2$, or as $\frac{6l^3w}{fbd^3}$. The deflection from the primitive shape is therefore as the bending weight and the cube of the length directly, and as the breadth and cube of the depth inversely.

In beams just ready to break, the curvature is as the depth inversely, and the deflection is as the square of the length divided by the depth; for the ultimate curvature at the breaking part is the same whatever is the length; and in this case the deflection is as the square of the length.

The theorems resulting from this subject afford the finest methods of examining the laws of corpuscular action.

We have been the more particular in our consideration of this subject, because the resulting theorems afford us the finest methods of examining the laws of corpuscular action, that is, for discovering the variation of the force of cohesion by a change of distance. It is true it is not the atomical law, or *hylarchic principle* as it may justly be called, which is thus made accessible, but the specific law of the particles of the substance or kind of matter under examination. But even this is a very great point; and coincidences in this respect among the different kinds of matter are of great moment. We may thus learn the nature of the corpuscular action of different substances, and perhaps approach to a discovery of the *mechanism* of chemical affinities. For that chemical actions are insensible cases of local motion is undeniable, and local motion is the province of mechanical discussion; nay, we see that these hidden changes are produced by mechanical forces in many important cases, for we see them promoted or prevented by means purely mechanical. The conversion of bodies into elastic vapour by heat can at all times be prevented by a *sufficient* external pressure. A strong solution of Glauber's salts will congeal in an instant by agitation, giving out its latent heat; and it will remain fluid for ever, and retain its latent heat in a close vessel which it completely fills. Even water will by such treatment freeze in an instant by agitation, or remain fluid for ever by confinement. We know that heat is produced or extricated by friction, that certain compounds of gold or silver with saline matters explode with irresistible violence by the smallest pressure or agitation. Such facts should rouse the mathematical philosopher, and excite him to follow out the conjectures of the illustrious Newton, encouraged by the ingenious attempts of Boscovich; and the proper beginning of this study is to attend to the laws of attraction and repulsion exerted by the particles of cohering bodies, discoverable by experiments made on their actual extensions and compressions. The experiments of simple extensions and compressions are quite insufficient, because the total stretching of a wire is so small a quantity, that the mistake of the 1000th part of an inch occasions an irregularity which deranges any progression so as to make it useless. But by the bending of bodies a distention of $\frac{1}{100}$th of an inch may be easily magnified in the deflection of the spring ten thousand times. We know that the investigation is intricate and difficult, but not beyond the reach of our present mathematical attainments; and it will give very fine opportunities of employing all the address of analysis. In the 17th century and the beginning of the 18th this was a sufficient excitement to the first geniuses of Europe. The cycloid, the catenaria, the elastic curve, the velaria, the caustics, were reckoned an abundant recompense for much study; and James Bernoulli requested, as an honourable monument, that the logarithmic spiral might be inscribed on his tombstone. The reward for the study to which we now presume to incite the mathematicians is the almost unlimited extension of natural science, important in every particular branch. To go no further than our present subject, a great deal of important practical knowledge respecting the strength of bodies is derived from the single observation, that in the moderate extensions which happen before the parts are overstrained, the forces are nearly in the proportion of the extensions or separations of the particles. To return to our subject.

Bernoulli calls in question this law,

James Bernoulli, in his second dissertation on the elastic curve, calls in question this law, and accommodates his investigation to any hypothesis concerning the relation of the forces and extensions. He relates some experiments of lutestrings where the relation was considerably different. Strings of three feet long,

stretched by	2,	4,	6,	8,	10 pounds,
were lengthened	9,	17,	23,	27,	30 lines.

But this is a most exceptionable form of the experiment. The strings were twisted, and the mechanism of the extensions is here exceedingly complicated, combined with compressions and with transverse twists, &c. We made experiments on fine slips of the gum caoutchouc, and on the juice of the berries of the white bryony, of which a single grain will draw to a thread of two feet long, and again return into a perfectly round sphere. We measured the diameter of the thread by a microscope with a micrometer, and thus could tell in every state of extension the proportional number of particles in the sections. We found, that through the whole range in which the distance of the particles was changed in the proportion of thirteen to one, the extensions did not *sensibly* deviate from the proportion of the forces. The same thing was observed in the caoutchouc as long as it perfectly recovered its first dimensions. And it is on the authority of these experiments that we presume to announce this as a law of nature.

which was first assumed by Dr Hooke.

Dr Robert Hooke was undoubtedly the first who attended to this subject, and assumed this as a law of nature. Mariotte indeed was the first who expressly used it for determining the strength of beams: this he did about the year 1679, correcting the simple theory of Galileo. Leibnitz, indeed, in his dissertation in the *Acta Eruditorum* 1684, *De Resistentia Solidorum*, introduces this consideration, and wishes to be considered as the discoverer; and he is always acknowledged as such by the Bernoullis, and others who adhered to his peculiar doctrines. But Mariotte had published the doctrine in the most express terms long before; and Bulfinger, in the *Comment. Petropol.* 1729, completely vindicates his claim. But Hooke was unquestionably the discoverer of this law. It made the foundation of his theory of springs, announced to the Royal Society about the year 1661, and read in 1666. On this occasion he mentions

many things on the strength of bodies as quite familiar to his thoughts, which are immediate deductions from this principle; and among these *all* the facts which John Bernoulli so vauntingly adduces in support of Leibnitz's finical dogmas about the force of bodies in motion; a doctrine which Hooke might have claimed as his own, had he not perceived its frivolous inanity.

Though corrected by Mariotte, it does not properly explain the mechanism of transverse strain.

But even with this first correction of Mariotte, the mechanism of transverse strain is not fully nor justly explained. The force acting in the direction BW (fig 3), and bending the body ABCD, not only stretches the fibres on the side opposite to the axis of fracture, but compresses the side CD, which becomes concave by the strain. Indeed it cannot do the one without doing the other; for, in order to stretch the fibres at D, there must be some fulcrum, some support, on which the virtual lever BAD may press, that it may tear asunder the stretched fibres. This fulcrum must sustain both the pressure arising from the cohesion of the distended fibres, and also the action of the external force, which immediately tends to cause the prominent part of the beam to slide along the section EF.

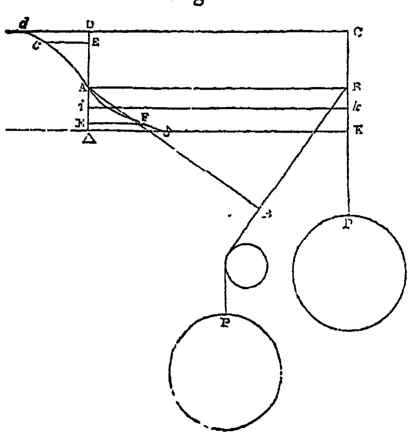
as is fully verified by experiment.

This is fully verified by experiment. If we attempt to break a long slip of cork, or any such very compressible body, we always observe it to bulge out on the concave side before it cracks on the other side. If it is a body of fibrous or foliated texture, it seldom fails splintering off on the concave side; and in many cases this splintering is very deep, even reaching half way through the piece. In hard and granulated bodies, such as a piece of freestone, chalk, dry clay, sugar, and the like, we generally see a considerable splinter or shiver fly off from the hollow side. If the fracture be slowly made by a force at B gradually augmented, the formation of the splinter is very distinctly seen. It forms a triangular piece, which generally breaks in the middle.

Consequences resulting from the state of the case.

Let us see what consequences result from this state of the case respecting the strength of bodies. Let DΔKC (fig. 6) represent a vertical section of a prism of compres-

Fig. 6.



sible materials, such as a piece of timber. Suppose it loaded with a weight P hung at its extremity. Suppose it of such a constitution that all the fibres in AD are in a state of dilatation, while those in AΔ are in a state of compression. In the instant of fracture the particles at D and E are withheld by forces Dd, Ee, and the particles at Δ and F repel, resist, or support, with forces Δδ, Fε.

Some line, such as deA$\varepsilon\delta$, will limit all these ordinates, which represent the forces actually exerted in the instant of fracture. If the forces be as the extensions and compressions, as we have great reason to believe, deA and A$\varepsilon\delta$ will be two straight lines. They will form *one* straight line dAδ, if the forces which resist a certain dilatation are equal to the forces which resist an equal compression. But this is quite accidental, and is not strictly true in any body. In most bodies which have any considerable firmness, the compressions made by any external force are not so great as the dilatations which the same force would produce; that is, the repulsions which are excited by any supposed degree of compression are greater than the attractions excited by the same degree of dilatation. Hence it will generally follow, that the angle dAD is less than the angle δAΔ, and the ordinates Dd, Ee, &c. are less than the corresponding ordinates Δδ, Eε, &c.

An important consequence of the compressibility of body fully proved.

But whatever be the nature of the line dAδ, we are certain of this, that the whole area ADd is equal to the whole area AΔδ; for as the force at B is gradually increased, and the parts between A and D are more extended, and greater cohesive forces are excited, there is always such a degree of repulsive forces excited in the particles between A and Δ that the one set precisely balances the other. The force at B, acting perpendicularly to AB, has no tendency to push the whole piece closer on the part next the wall, or to pull it away. The sum of the attractive and repulsive forces actually excited must therefore be equal. These sums are represented by the two triangular areas, which are therefore equal.

The greater we suppose the repulsive forces corresponding to any degree of compression, in comparison with the attractive forces corresponding to the same degree of extension, the smaller will AΔ be in comparison of AD. In a piece of cork or sponge, AΔ may chance to be equal to AD, or even to exceed it; but in a piece of marble, AΔ will perhaps be very small in comparison of AD.

Now it is evident that the repulsive forces excited between A and Δ have no share in preventing the fracture. They rather contribute to it, by furnishing a fulcrum to the lever by whose energy the cohesion of the particles in AD is overcome. Hence we see an important consequence of the compressibility of the body. Its power of resisting this transverse strain is diminished by it, and so much the more diminished as the stuff is more compressible.

This is fully verified by some very curious experiments made by Duhamel. He took sixteen bars of willow two feet long and half an inch square, and supporting them by props under the ends, he broke them by weights hung on the middle. He broke four of them by weights of 40, 41, 47, and 52 pounds: the mean is 45. He then cut four of them one third through on the upper side, and filled up the cut with a thin piece of harder wood stuck in pretty tight. These were broken by 48, 54, 50, and 52 pounds; the mean of which is 51. He cut other four half through, and they were broken by 47, 49, 50, 46; the mean of which is 48. The remaining four were cut two thirds, and their mean strength was 42.

Another set of his experiments is still more remarkable.

Six battens of willow thirty-six inches long and one and a half square were broken by 525 pounds at a medium.

Six bars were cut one third through, and the cut filled with a wedge of hard wood stuck in with a little force: these broke with 551.

Six bars were cut half through, and the cut was filled in the same manner: they broke with 542.

Six bars were cut three fourths through: these broke with 530.

A batten cut three fourths through, and loaded till nearly broken, was unloaded, and the wedge taken out of the cut. A thicker wedge was put in tight, so as to make the batten straight again by filling up the space left by the compression of the wood: this batten broke with 577 pounds.

From this it is plain that more than two thirds of the thickness (perhaps nearly three fourths) contributed nothing to the strength.

The point A is the centre of fracture in this case; and in order to estimate the strength of the piece, we may sup-

pose that the crooked lever virtually concerned in the strain is DAB. We must find the point I, which is the centre of effort of all the attractive forces, or that point where the full cohesion of AD must be applied, so as to have a momentum equal to the accumulated momenta of all the variable forces. We must in like manner find the centre of effort i of the repulsive or supporting forces exerted by the fibres lying between A and Δ.

It is plain, and the remark is important, that this last centre of effort is the real fulcrum of the lever, although A is the point where there is neither extension nor contraction; for the lever is supported in the same manner as if the repulsions of the whole line AΔ were exerted at that point. Therefore let S represent the surface of fracture from A to D, and f represent the absolute cohesion of a fibre at D in the instant of fracture. We shall have $f\mathrm{S} \times \overline{\mathrm{I}+i} = pl$, or $l : \mathrm{I}+i = f\mathrm{S} : p$; that is, the length AB is to the distance between the two centres of effort I and i, as the absolute cohesion of the section between A and D is to the relative strength of the section.

It would be perhaps more accurate to make AI and Ai equal to the distances of A from the horizontal lines passing through the centres of gravity of the triangles of dAD and δAΔ. It is only in this construction that the points I and i are the centres of real effort of the accumulated attractions and repulsions. But I and i, determined as we have done, are the points where the full equal actions may be all applied, so as to produce the same momenta. The final results are the same in both cases. The attentive and duly informed reader will see that Mr Bulfinger, in a very elaborate dissertation on the strength of beams, in the *Comment. Petropolitan.* 1729, has committed several mistakes in his estimation of the actions of the fibres. We mention this because his reasonings are quoted and appealed to as authorities by Muschenbroeck and other authors of note. The subject has been considered by many authors on the continent. We recommend to the reader's perusal the very minute discussions in the Memoirs of the Academy of Paris for 1702 by Varignon, the Memoirs for 1708 by Parent, and particularly that of Coulomb in the *Mém. par les Sçavans Etrangers*, tom. vii.

It is evident from what has been said above, that if S and s represent the surfaces of the sections above and below A, and if G and g are the distances of their centres of gravity from A, and O and o the distances of their centres of oscillation, and D and d their whole depths, the momentum of cohesion will be $\frac{f\mathrm{S}\cdot\mathrm{G}\cdot\mathrm{O}}{\mathrm{D}} = \frac{fs\cdot g\cdot o}{d} = pl$.

If, as is most likely, the forces are proportional to the extensions and compressions, the distances AI and Ai, which are respectively $= \frac{\mathrm{G}\cdot\mathrm{O}}{\mathrm{D}}$ and $\frac{g\cdot o}{d}$, are respectively $= \frac{1}{3}$DA and $\frac{1}{3}\,\Delta$A, and when taken together are $= \frac{1}{3}$DΔ. If, moreover, the extensions are equal to the compressions in the instant of fracture, and the body is a rectangular prism like a common joist or beam, then DA and ΔA are also equal; and therefore the momentum of cohesion is $fb \times \frac{1}{2}d \times \frac{1}{3}d = \frac{fbd^2}{6} = fb\,d \times \frac{1}{6}d = pl$. Hence we obtain this analogy: "six times the length is to the depth as the absolute cohesion of the section is to its relative strength."

This consequence farther explained. Thus we see that the compressibility of bodies has a very great influence on their power of withstanding a transverse strain. We see that in this most favourable supposition of equal dilatations and compressions, the strength is reduced to one half of the value of what it would have been had the body been incompressible. This is by no means obvious; for it does not readily appear how compressibility, which does not diminish the cohesion of a single fibre, should impair the strength of the whole. The reason, however, is sufficiently convincing when pointed out. In the instant of fracture, a smaller portion of the section is actually exerting cohesive forces, while a part of it is only serving as a fulcrum to the lever by whose means the strain on the section is produced. We see, too, that this diminution of strength does not so much depend on the sensible compressibility, as on its proportion to the dilatability by equal forces. When this proportion is small, AΔ is small in comparison of AD, and a greater portion of the whole fibre is exerting attractive forces. The experiments already mentioned, of Duhamel de Monceau, on battens of willow, show that its compressibility is nearly equal to its dilatability. But the case is not very different in tempered steel. The famous Harrison, in the delicate experiments which he made while occupied in making his longitude watch, discovered that a rod of tempered steel was nearly as much diminished in its length as it was augmented by the same external force. But it is not by any means certain that this is the proportion of dilatation and compression which obtains in the very instant of fracture. We rather imagine that it is not. The forces are nearly as the dilatations till very near breaking; but we think that they diminish when the body is just going to break. But it seems certain that the forces which resist compression increase faster than the compressions, even before fracture. We know incontestably that the ultimate resistances to compression are insuperable by any force which we can employ. The repulsive forces, therefore, in their whole extent, increase faster than the compressions, and are expressed by an assymptotic branch of the Boscovician curve formerly explained. It is therefore probable, especially in the more simple substances, that they increase faster, even in such compressions as frequently obtain in the breaking of hard bodies. We are disposed to think that this is always the case in such bodies as do not fly off in splinters on the concave side; but this must be understood with the exception of the permanent changes which may be made by compression when the bodies are crippled by it. This always increases the compression itself, and causes the neutral point to shift still more towards D. The effect of this is sometimes very great and fatal.

Experiment alone can help us to discover the proportion between the dilatability and compressibility of bodies. The strain now under consideration seems the best calculated for this research. Thus if we find that a piece of wood an inch square requires 12,000 pounds to tear it asunder by a direct pull, and that 200 pounds will break it transversely by acting 10 inches from the section of fracture, we must conclude that the neutral point A is in the middle of the depth, and that the attractive and repulsive forces are equal. Any notions that we can form of the constitution of such fibrous bodies as timber, make us imagine that the *sensible* compressions, including what arises from the bending up of the compressed fibres, is much greater than the real corpuscular extensions. One may get a general conviction of this unexpected proposition by reflecting on what must happen during the fracture. An undulated fibre can only be drawn straight, and then the corpuscular extension begins; but it may be bent up by compression to any degree, the corpuscular compression being little affected all the while. This observation is very important; and though the forces of corpuscular repulsion may be almost insuperable by any compression that we can employ, a *sensible* compression may be produced by forces not enormous, sufficient to cripple the beam. Of this we shall see very important instances afterwards.

It deserves to be noticed, that although the relative strength of a prismatic solid is extremely different in the three hypotheses now considered, yet the proportional

The proportional strengths of different pieces follow the same ratio.

strengths of different pieces follow the same ratio, namely, the direct ratio of the breadth, the direct ratio of the square of the depth, and the inverse ratio of the length. In the first hypothesis (of equal forces) the strength of a rectangular beam was $\frac{fbd^2}{2l}$; in the second (of attractive forces proportioned to the extensions) it was $\frac{fbd^2}{3l}$; and in the third (equal attractions and repulsions proportional to the extensions and compressions) it was $\frac{fbd^2}{6l}$, or more generally $\frac{fbd^2}{ml}$, where m expresses the unknown proportion between the attractions and repulsions corresponding to an equal extension and compression.

The strength of a piece depends chiefly on its depth;

Hence we derive a piece of useful information, which is confirmed by unexceptionable experience, that the strength of a piece depends chiefly on its depth, that is, on that dimension which is in the direction of the strain. A bar of timber of one inch in breadth and two inches in depth is four times as strong as a bar only one inch deep, and it is twice as strong as a bar two inches broad and one deep; that is, a joist or lever is always strongest when laid on its edge.

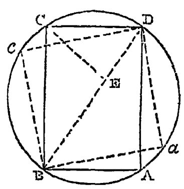
and therefore a choice in the manner in which the cohesion is opposed to the strain.

There is therefore a choice in the manner in which the cohesion is opposed to the strain. The general aim must be to put the centre of effort I as far from the fulcrum or the neutral point A as possible, so as to give the greatest energy or momentum to the cohesion. Thus if a triangular bar projecting from a wall is loaded with a weight at its extremity, it will bear thrice as much when one of the sides is uppermost as when it is undermost.

The strongest joist has not the greatest quantity of timber.

Hence it follows that the strongest joist that can be cut out of a round tree is not the one which has the greatest quantity of timber in it, but such that the product of its breadth by the square of its depth shall be the greatest possible. Let ABCD (fig. 7) be the section of this joist inscribed in the circle, AB being the breadth and AD the depth. Since it is a rectangular section, the diagonal BD is a diameter of the circle, and BAD is a right-angled triangle. Let BD be called a, and BA be called x; then $AD = \sqrt{a^2 - x^2}$. Now we must have $AB \cdot AD^2$, or $x\,(a^2 - x^2)$, or $a^2 x - x^3$, a minimum; its differential $(a^2 - 3x^2)\,dx$ must be 0, or $a^2 = 3x^2$, or $x^2 = \frac{a^2}{3}$. If therefore we make $DE = \frac{1}{3}$ DB, and draw EC perpendicular to BD, it will cut the circumference in the point C, which determines the depth BC and the breadth CD.

Fig. 7.



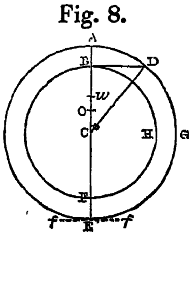
Because $BD : BC = CD : CE$, we have the area of the section $BC \cdot CD = BD \cdot CE$. Therefore the different sections having the same diagonal BD, are proportional to their heights CE. Therefore the section BCDA is less than the section B*c* D*a*, whose four sides are equal. The joist so shaped, therefore, is stronger, lighter, and cheaper.

A hollow tube stronger than a solid rod containing the same quantity of matter,

The strength of ABCD is to that of *a* B *c* D as 10,000 to 9186, and the weight and expense as 10,000 to 10,607; so that ABCD is preferable to *a* B *c* D, in the proportion of 10,607 to 9186, or nearly 115 to 100.

From the same principles it follows that a hollow tube is stronger than a solid rod containing the same quantity of matter. Let fig. 8 represent the section of a cylindric tube, of which AF and BE are the exterior and interior diameters, and C the centre. Draw BD perpendicular to BC, and join DC. Then, because $BD^2 = CD^2 - CB^2$, BD is the radius of a circle containing the same quantity of matter with the ring. If we estimate the strength by the first hypothesis, it is evident that the strength of the tube will be to that of the solid cylinder, whose radius is BD, as $BD^2 \times AC$ to $BD^2 \times BD$; that is, as AC to BD; for BD^2 expresses the cohesion of the ring of the circle, and AC and BD are equal to distances of the centres of effort (the same with the centres of gravity) of the ring and circle from the axis of the fracture.

Fig. 8.



The proportion of these strengths will be different in the other hypothesis, and is not easily expressed by a general formula; but in both it is still more in favour of the ring or hollow tube.

The following very simple solution will be readily understood by the intelligent reader. Let O be the centre of oscillation of the exterior circle, *o* the centre of oscillation of the inner circle, and *w* the centre of oscillation of the ring included between them. Let M be the quantity of surface of the exterior circle, *m* that of the inner circle, and μ that of the ring.

We have $Fw = \frac{M \cdot FO - m \cdot Fo}{\mu} = \frac{5}{4}\,\frac{FC^2 + EC^2}{FC}$, and the strength of the ring $= \frac{f\mu \times Fw}{2}$, and the strength of the same quantity of matter in the form of a solid cylinder is $f\mu \times \frac{5}{8}$ BD; so that the strength of the ring is to that of the solid rod of equal weight as F w to $\frac{5}{4}$ BD, or nearly as FC to BD. This will easily appear by recollecting that FO is $= \frac{\text{sum of } p \cdot r^2}{m \cdot FC}$ (see ROTATION), and that the momentum of cohesion is $\frac{fm \cdot FC \cdot Ca}{2\,FC} = \frac{fm \cdot Fo}{2}$ for the inner circle, &c.

Emerson has given a very inaccurate approximation to this value in his Mechanics, 4to.

and more stiff.

This property of hollow tubes is accompanied also with greater stiffness; and the superiority in strength and stiffness is so much the greater as the surrounding shell is thinner in proportion to its diameter.

Hence the wisdom of God in forming the bones, &c. hollow.

Here we see the admirable wisdom of the Author of nature in forming the bones of animal limbs hollow. The bones of the arms and legs have to perform the office of levers, and are thus opposed to very great transverse strains. By this form they become incomparably stronger and stiffer, and give more room for the insertion of muscles, while they are lighter and therefore more agile; and the same wisdom has made use of this hollow for other valuable purposes of the animal economy. In like manner the quills in the wings of birds acquire by their thinness the very great strength which is necessary, while they are so light as to give sufficient buoyancy to the animal in the rare medium in which it must live and fly about. The stalks of many plants, such as all the grasses, and many reeds, are in like manner hollow, and thus possess an extraordinary strength. Our best engineers now begin to imitate nature by making many parts of their machines hollow, such as their axles of cast iron, &c.; and the ingenious Mr Ramsden made the axes and framings of his great astronomical instruments in the same manner.

In the supposition of homogeneous texture, it is plain that the fracture happens as soon as the particles at D are separated beyond their utmost limit of cohesion. This is a determined quantity, and the piece bends till this degree of extension is produced in the uttermost fibre. It follows, that the smaller we suppose the distance between A and D, the greater will be the curvature which the beam will acquire before it breaks. Greater depth therefore makes a beam not only stronger, but also stiffer. But if the parallel fibres can slide on each other, both the strength and the stiffness will be diminished. Therefore, if, instead of one beam DAKC (fig. 6), we suppose two, DABC and

AΔKB, not cohering, each of them will bend, and the extension of the fibres AB of the under beam will not hinder the compression of the adjoining fibres AB of the upper beam. The two together therefore will not be more than twice as strong as one of them (supposing DA = AΔ), instead of being four times as strong; and they will bend as much as either of them alone would bend by half the load. This may be prevented, if it were possible to unite the two beams all along the seam AB, so that the one shall not slide on the other. This may be done in small works by gluing them together with a cement as strong as the natural lateral cohesion of the fibres. If this cannot be done (as it cannot in large works), the sliding is prevented by *joggling* the beams together, that is, by cutting down several rectangular notches in the upper side of the lower beam, and making similar notches in the under side of the upper beam, and filling up the square spaces with pieces of very hard wood firmly driven in, as represented in fig. 9. Some employ iron bolts by way of joggles. But when the joggle is much harder than the wood into which it is driven, it is very apt to work loose, by widening the hole into which it is lodged. The same thing is sometimes done by scarphing the one upon the other, as represented in fig. 10; but this wastes more timber, and is not so strong, because the mutual hooks which this method form on each beam are very apt to tear each other up. By one or other of these methods, or something similar, may a compound beam be formed, of any depth, which will be almost as stiff and strong as an entire piece.

How a strong compound beam may be formed.

Fig. 9.

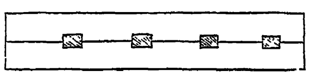
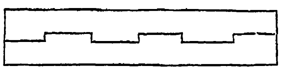


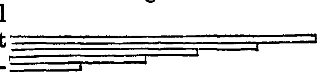
Fig. 10.



How strength may be combined with pliableness.

On the other hand, we may combine strength with pliableness, by composing our beam of several thin planks laid on each other, till they make a proper depth, and leaving them at full liberty to slide on each other. It is in this manner that coach-springs are formed, as is represented in fig. 11. In this assemblage there must be no joggles nor bolts of any kind put through the planks or plates, for this would hinder their mutual sliding. They must be kept together by straps which surround them, or by something equivalent.

Fig. 11.



Maxims of construction.

The preceding observations show the propriety of some maxims of construction, which the artists have derived from long experience.

Thus, if a mortise is to be cut out of a piece which is exposed to a cross strain, it should be cut out from that side which becomes concave by the strain.

If a piece is to be strengthened by the addition of another, the added piece must be joined to the side which grows convex by the strain.

Before we proceed any farther, it will be convenient to recall the reader's attention to the analogy between the strain on a beam projecting from a wall and loaded at the extremity, and a beam supported at both ends and loaded in some intermediate point. It is sufficient on this occasion to read attentively what is delivered in the article ROOF. We learn there that the strain on the middle point C (fig. 16 of the present article) of a rectangular beam AB, supported on props at A and B, is the same as if the part CA projected from a wall, and were loaded with the half of the weight W suspended at A. The momentum of the strain is therefore $\frac{1}{2}W \times \frac{1}{2}AB = W \times \frac{1}{4}AB = p\frac{1}{4}l$, or $\frac{pl}{4}$. The momentum of cohesion must be equal to this in every hypothesis.

Having now considered in sufficient detail the circumstances which affect the strength of any section of a solid body that is strained transversely, it is necessary to take notice of some of the chief modifications of the strain itself. We shall consider only those that occur most frequently in our constructions.

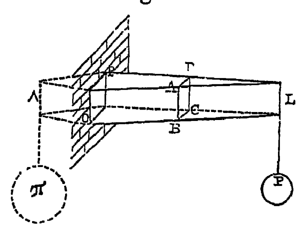
The strain depends on the external force, and also on the lever by which it acts.

The strain depends on the external force,

It is evidently of importance, that since the strain is exerted in any section by means of the cohesion of the parts intervening between the section under consideration and the point of application of the external force, the body must be able in all these intervening parts to propagate or excite the strain in the remote section. In every part it must be able to resist the strain excited in that part. It should therefore be equally strong; and it is useless to have any part stronger, because the piece will nevertheless break where it is not stronger throughout; and it is useless to make it stronger (relatively to its strain) in any part, for it will nevertheless equally fail in the part that is too weak.

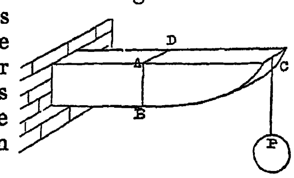
Suppose, then, in the first place, that the strain arises from a weight suspended at one extremity, while the other end is firmly fixed in a wall. Supposing also the cross sections to be all rectangular, there are several ways of shaping the beam so that it shall be equally strong throughout. Thus it may be equally deep in every part, the upper and under surfaces being horizontal planes. The condition will be fulfilled by making all the horizontal sections triangles, as in fig. 12. The two sides are vertical planes, meeting in an edge at the extremity L. For the equation expressing the balance of strain and strength is $pl = fbd^2$. Therefore, since d^2 is the same throughout, and also p, we must have $fb = l$, and b (the breadth AD of any section ABCD) must be proportional to l (or AL), which it evidently is.

Fig. 12.



Or, if the beam be of uniform breadth, we must have d^2 everywhere proportional to l. This will be obtained by making the depths the ordinates of a common parabola, of which L is the vertex and the length is the axis. The upper or under side may be a straight line, as in fig. 13, or the middle line may be straight, and then both upper and under surfaces will be curved. It is almost indifferent what is the shape of the upper and under surfaces, provided the distances between them in every part be at the ordinates of a common parabola.

Fig. 13.



Or, if the sections are all similar, such as circles, squares, or any other similar polygons, we must have d^3 or b^3 proportional to l, and the depths or breadths must be as the ordinates of a cubical parabola.

and on the form of the levers by which it acts.

It is evident that these are also the proper forms for a lever moveable round a fulcrum, and acted on by a force at the extremity. The force comes in the place of the weight suspended in the cases already considered; and as such levers always are connected with another arm, we readily see that both arms should be fashioned in the same manner. Thus in fig. 12 the piece of timber may be supposed a kind of steelyard, moveable round a horizontal axis in the front of the wall, and having the two weights P and ϖ in equilibrio. The strain occasioned by each at the section in which the axis OP is placed must be the same, and each

arm OL and Oλ must be equally strong in all its parts. The longitudinal sections of each arm must be a triangle, a common parabola, or a cubic parabola, according to the conditions previously given.

And, moreover, all these forms are equally strong; for any one of them is equally strong in all its parts, and they are all supposed to have the same section at the front of the wall or at the fulcrum. They are not, however, equally stiff. The first, represented in fig. 12, will bend least upon the whole, and the one formed by the cubic parabola will bend most. But their curvature at the very fulcrum will be the same in all.

It is also plain, that if the lever is of the second or third kind, that is, having the fulcrum at one extremity, it must still be of the same shape; for in abstract mechanics it is indifferent which of the three points is considered as the axis of motion. In every lever the two forces at the extremities act in one direction, and the force in the middle acts in the opposite direction, and the great strain is always at that point. Therefore a lever such as fig. 12, moveable round an axis passing horizontally through λ, and acting against an obstacle at OP, is equally able in all its parts to resist the strains excited in those parts.

The same principles and the same construction will apply to beams, such as joists, supported at the ends L and λ (fig. 12), and loaded at some intermediate part OP. This will appear evident by merely inverting the directions of the forces at these three points, or by recurring to the article ROOF, p. 444.

The external straining force may be distributed over the beam.

Hitherto we have supposed the external straining force as acting only in one point of the beam. But it may be uniformly distributed all over the beam. To make a beam in such circumstances equally strong in all its parts, the shape must be considerably different from the former.

To make a beam strong which projects from a wall.

Thus suppose the beam to project from a wall. If it be of equal breadth throughout, its sides being vertical planes parallel to each other and to the length, the vertical section in the direction of its length must be a triangle instead of a common parabola; for the weight uniformly distributed over the part lying beyond any section, is as the length beyond that section: and since it may all be conceived as collected at its centre of gravity, which is the middle of that length, the lever by which this load acts or strains the section is also proportioned to the same length. The strain on the section (or momentum of the load) is as the square of that length. The section must have strength in the same proportion. Its strength being as the breadth and the square of the depth, and the breadth being constant, the square of the depth of any section must be as the square of its distance from the end, and the depth must be as that distance; and therefore the longitudinal vertical section must be a triangle.

But if all the transverse sections are circles, squares, or any other similar figures, the strength of every section, or the cube of the diameter, must be as the square of the lengths beyond that section, or the square of its distance from the end; and the sides of the beam must be a semicubical parabola.

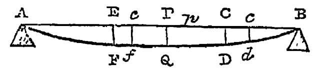
If the upper and under surfaces are horizontal planes, it is evident that the breadth must be as the square of the distance from the end, and the horizontal sections may be formed by arches of the common parabola, having the length for their tangent at the vertex.

By recurring to the analogy so often quoted between a projecting beam and a joist, we may determine the proper form of joists which are uniformly loaded through their whole length.

The strain upon a beam supported at both ends.

This is a frequent and important case, being the office of joists, rafters, &c.; and there are some circumstances which must be particularly noticed, because they are not so obvious, and have been misunderstood. When a beam AB (fig. 14) is supported at the ends, and a weight is laid on any point P, a strain is excited in every part of the beam. The load on P causes the beam to press on A and B, and the props re-act with forces equal and opposite to these pressures. The load at P is to the pressures at A and B as AB to PB and PA, and the pressure at A is to that at B as BP to PA; the beam therefore is in the same state, with respect to strain in every part of it, as if it were resting on a prop at P, and were loaded at the ends with weights equal to the two pressures on the props: and observe, these pressures are such as will balance each other, being inversely as their distances from P. Let P represent the weight or load at P. The pressure on the prop P must be $P \times \frac{PA}{AB}$. This is therefore the re-action of the prop B, and is the weight which we may suppose suspended at B, when we conceive the beam resting on a prop at P, and carrying the balancing weights at A and B.

Fig. 14.



The strain occasioned at any other point C, by the load P at P, is the same with the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, when the beam rests on P, in the manner now supposed; and it is the same if the beam, instead of being balanced on a prop at P, had its part AP fixed in a wall. This is evident. Now we have shown at length that the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, is $P \times \frac{PA}{AB} \times BC$. We desire it to be particularly remarked, that the pressure at A has no influence on the strain at C, arising from the action of any load between A and C; for it is indifferent how the part AP of the projecting beam PB is supported. The weight at A just performs the same office with the wall in which we suppose the beam to be fixed. We are thus particular, because we have seen even persons not unaccustomed to discussions of this kind puzzled in their conceptions of this strain.

Now let the load P be laid on some point p between C and B. The same reasoning shows us that the point is, with respect to strain, in the same state as if the beam were fixed in a wall, embracing the part pB, and a weight $= P \times \frac{pB}{AB}$ were hung on at A, and the strain at C is $P \times \frac{pB}{AB} \times AC$.

A general proposition.

In general, therefore, the strain on any point C, arising from a load P laid on another point P, is proportional to the rectangle of the distances of P and C from the ends nearest to each. It is $P \times \frac{PA \times CB}{AB}$, or $P \times \frac{pB \times CA}{AB}$, according as the load lies between C and A or between C and B.

Cor. 1. The strains which a load on any point P occasions on the points C, c, lying on the same side of P, are as the distances of these points from the end B. In like manner the strains on E and e are as EA and eA.

Cor. 2. The strain which a load occasions in the part on which it rests is as the rectangle of the parts on each side. Thus the strain occasioned at C by a load is to that at D by the same load as AC × CB to AD × DB. It is therefore greatest in the middle.

The strain arising from a load distributed along the beam.

Let us now consider the strain on any point C arising from a load uniformly distributed along the beam. Let AP be represented by x, and Pp by dx, and the whole weight on the beam by a. Then

Strength of Materials.

The weight on Pp is.....................$= a\dfrac{dx}{AB}$.

Pressure on B by the weight on $Pp = a\dfrac{dx}{AB} \times \dfrac{AP}{AB}$,

Or..$= a\dfrac{xdx}{AB^2}$.

Pressure on B by whole wt. on $AC = a\dfrac{\frac{1}{2}AC^2}{AB^2} = a\dfrac{AC^2}{2AB^2}$.

Strain at C by the weight on $AC = a\dfrac{AC^2 \times BC}{2AB^2}$.

Strain at C by the weight on $BC = a\dfrac{BC^2 \times AC}{2AB^2}$.

Do. by whole weight on $AB = a\dfrac{AC^2 \times BC + BC^2 \times AC}{2AB^2}$

$$= a\frac{AC \times BC \times \overline{AC + CB}}{2AB^2} = a\frac{AC \times BC}{2AB}.$$

Thus we see that the strain is proportional to the rectangle of the parts, in the same manner as if the load a had been laid directly on the point C, and is indeed equal to one half of the strain which would be produced at C by the load a laid on there.

Mistakes on this subject committed by authors of reputation.

It was necessary to be thus particular, because we see in some elementary treatises on mechanics, published by authors of reputation, mistakes which are very plausible, and mislead the learner. It is there said that the pressure at B from a weight uniformly diffused along AB, is the same as if it were collected at its centre of gravity, which would be the middle of AB; and then the strain at C is said to be this pressure at B multiplied by BC. But surely it is not difficult to see the difference of these strains. It is plain that the pressure of gravity downwards on any point between the end A and the point C has no tendency to diminish the strain at C, arising from the upward re-action of the prop B; whereas the pressure of gravity between C and B is almost in direct opposition to it, and must diminish it. We may however avoid the fluxionary calculus with safety by the consideration of the centre of gravity, by supposing the weights of AC and BC to be collected at their respective centres of gravity; and the result of this computation will be the same as above: and we may use either method, although the weight be not uniformly distributed, provided only that we know in what manner it is distributed.

This investigation is evidently of importance in the practice of the engineer and architect, informing them what support is necessary in the different parts of their constructions. We considered some cases of this kind in the article Roof.

To form a joist which may have the same relative strength in all its parts.

It is now easy to form a joist so that it shall have the same relative strength in all its parts.

I. To make it equally able in all its parts to carry a given weight laid on any point C taken at random, or uniformly diffused over the whole length, the strength of the section at the point C must be as $AC \times CB$. Therefore,

1. If the sides be parallel vertical planes, the square of the depth (which is the only variable dimension), or CD^2, must be as $AC \times CB$, and the depths must be ordinates of an ellipse.

2. If the transverse sections be similar, we must make CD^3 as $AC \times CB$.

3. If the upper and under surfaces be parallel, the breadth must be as $AC \times CB$.

II. If the beam be necessarily loaded at some given point C, and we would have the beam equally able in all its parts to resist the strain arising from the weight at C, we must make the strength of every transverse section between C and either end as its distance from that end. Therefore,

1. If the sides be parallel vertical planes, we must make $CD^2 : EF^2 = AC : AE$.

2. If the sections be similar, then $CD^3 : EF^3 = AC : AE$.

3. If the upper and under surfaces be parallel, then breadth at C : breadth at E $= AC : AE$.

The strain and strength of square or circular plates of different extent but of equal thickness may be determined from the same principles.

The same principles enable us to determine the strain and strength of square or circular plates of different extent but equal thickness. This may be comprehended in this general proposition.

Similar plates of equal thickness supported all round will carry the same absolute weight, uniformly distributed, or resting on similar points, whatever be their extent.

Suppose two similar oblong plates of equal thickness, and let their lengths and breadths be L, l, and B, b. Let their strength or momentum of cohesion be C, c, and the strains from the weights W, w, be S, s.

Suppose the plates supported at the ends only, and resisting fracture transversely. The strains, being as the weights and lengths, are as WL and wl, but their cohesions are as the breadths; and since they are of equal relative strength, we have $WL : wl = B : b$, and $WLb = wlB$, and $L : l = wB : Wb$; but since they are of similar shapes, $L : l = B : b$, and therefore $w = W$.

The same reasoning holds again when they are also supported along the sides, and therefore holds when they are supported all round (in which case the strength is doubled).

And if the plates be of any other figure, such as circles or ellipses, we need only conceive similar rectangles inscribed in them. These are supported all around by the continuity of the plates, and therefore will sustain equal weights; and the same may be said of the segments which lie without them, because the strengths of any similar segments are equal, their lengths being as their breadths.

Therefore the thickness of the bottoms of vessels holding heavy liquors or grains should be as their diameters and as the square root of their depths jointly.

Also the weight which a square plate will bear is to that which a bar of the same matter and thickness will bear as twice the length of the bar to its breadth.

The strain of a beam arising from its own weight.

There is yet another modification of the strain which tends to break a body transversely, which is of very frequent occurrence, and in some cases must be very carefully attended to, viz. the strain arising from its own weight.

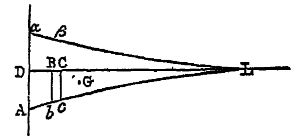
When a beam projects from a wall, every section is strained by the weight of all that projects beyond it. This may be considered as all collected at its centre of gravity. Therefore the strain on any section is in the joint ratio of the weight of what projects beyond it, and the distance of its centre of gravity from the section.

General principle respecting it.

The determination of this strain, and of the strength necessary for withstanding it, must be more complicated than the former, because the form of the piece which results from this adjustment of strain and strength influences the strain. The general principle must evidently be, that the strength or momentum of cohesion of every section must be as the product of the weight beyond it, multiplied by the distance of its centre of gravity. For example:

Suppose the beam DLA (fig. 15) to project from the wall, and that its sides are parallel vertical planes, so that the depth is the only variable dimension. Let $LB = x$ and $Bb = y$. The element $BbcC$ is $= ydx$. Let G be the centre of gravity of the part lying without Bb, and g be its distance from the extremity L. Then $x - g$ is the arm of the lever by which the strain is excited in the section Bb.

Fig. 15.



Let Bb or y be as some power m of LB; that is, let $y=x^m$. Then the contents of LBb is $\frac{x^{m+1}}{m+1}$. The momentum of gravity round a horizontal axis at L is $yxdx=x^{m+1}dx$, and the whole momentum round the axis is $\frac{x^{m+2}}{m+2}$. The distance of the centre of gravity from L is had by dividing this momentum by the whole weight, which is $\frac{x^{m+1}}{m+1}$. The quotient or g is $\frac{x\times\overline{m+1}}{m+2}$, and the distance of the centre of gravity from the section Bb is $x-\frac{x\times m+1}{m+2}=\frac{x\times\overline{m+2}-x\times\overline{m+1}}{m+2}=\frac{x}{m+2}$. Therefore the strain on the section Bb is had by multiplying $\frac{x^{m+1}}{m+1}$ by $\frac{x}{m+2}$. The product is $\frac{x^{m+2}}{\overline{m+2}\times\overline{m+1}}$. This must be as the square of the depth, or as y^2. But y is as x^m, and y^2 as x^{2m}. Therefore we have $m+2=2m$, and $m=2$; that is, the depth must be as the square of the distance from the extremity, and the curve LbA is a parabola touching the horizontal line in L.

A conoid equally able in every section to bear its own weight.

It is easy to see that a conoid formed by the rotation of this figure round DL will also be equally able in every section to bear its own weight.

We need not prosecute this farther. When the figure of the piece is given, there is no difficulty in finding the strain; and the circumstance of equal strength to resist this strain is chiefly a matter of curiosity.

The more a beam projects, the less able it is to bear its own weight.

It is evident, from what has been already said, that a projecting beam becomes less able to bear its own weight as it projects farther. Whatever may be the strength of the section DA, the length may be such that it will break by its own weight. If we suppose two beams A and B of the same substance and similar shapes, that is, having their lengths and diameters in the same proportion; and further suppose that the shorter can just bear its own weight; then the longer beam will not be able to do the same; for the strengths of the sections are as the cubes of the diameters, while the strains are as the biquadrates of the diameters; because the weights are as the cubes, and the levers by which these weights act in producing the strain are as the lengths or as the diameters.

Small bodies more able to withstand the strain produced by the weight of the machine than great bodies.

These considerations show us, that in all cases where strain is affected by the weight of the parts of the machine or structure of any kind, the smaller bodies are more able to withstand it than the greater; and there seem to be bounds set by nature to the size of machines constructed of any given materials. Even when the weight of the parts of the machine is not taken into the account, we cannot enlarge them in the same proportion in all their parts. Thus a steam-engine cannot be doubled in all its parts, so as to be still efficient. The pressure on the piston is quadrupled. If the lift of the pump be also doubled in height while it is doubled in diameter, the load will be increased eight times, and will therefore exceed the power. The depth of lift, therefore, must remain unchanged; and in this case the machine will be of the same relative strength as before, independent of its own weight. For the beam being doubled in all its dimensions, its momentum of cohesion is eight times greater, which is again a balance for a quadruple load acting by a double lever. But if we now consider the increase of the weight of the machine itself, which must be supported, and which must be put in motion by the intervention of its cohesion, we see that the large machine is weaker and less efficient than the small one.

There is a similar limit set by nature to the size of plants and animals formed of the same matter. The cohesion of an herb could not support it if it were increased to the size of a tree, nor could an oak support itself if forty or fifty times bigger; nor could an animal of the make of a long-legged spider be increased to the size of a man; the articulations of its legs could not support it.

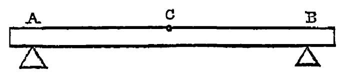
Even small animals are remarkable for strength and agility.

Hence may be understood the prodigious superiority of the small animals both in strength and agility. A man by falling twice his own height may break his firmest bones. A mouse may fall twenty times its height without risk; and even the tender mite or wood-louse may fall unhurt from the top of a steeple. But their greatest superiority is in respect of nimbleness and agility. A flea can leap above 500 times its own length, while the strength of the human muscles could not raise the trunk from the ground on limbs of the same construction.

The angular motions of small animals (in which consists their nimbleness or agility) must be greater than those of large animals, supposing the force of the muscular fibre to be the same in both. For supposing them similar, the number of equal fibres will be as the square of their linear dimensions; and the levers by which they act are as their linear dimensions. The energy therefore of the moving force is as the cube of these dimensions. But the momentum of inertia, or $\int p\cdot r^2$, is as the fourth power; therefore the angular velocity of the greater animals is smaller. The number of strokes which a fly makes with its wings in a second is astonishingly great; yet, being voluntary, they are the effects of its agility.

We have hitherto confined our attention to the simplest form in which this transverse strain can be produced. This was quite sufficient for showing us the mechanism of nature by which the strain is resisted; and a very slight attention is sufficient for enabling us to reduce to this every other way in which the strain can be produced. We shall not take up the reader's time with the application of the same principles to other cases of this strain, but refer him to what has been said in the article Roof. In that article we have shown the analogy between the strain on the section of a beam projecting from a wall and loaded at the extremity, and the strain on the same section of a beam simply resting on supports at the ends, and loaded at some intermediate point or points. The strain on the middle C of a beam AB (fig. 16) so supported, arising from a weight laid on there, is the same with the strain which half that weight hanging at B would produce on the same section C, if the other end of the beam were fixed in a wall.

Fig. 16.



If therefore 1000 pounds hung on the end of a beam projecting ten feet from a wall will just break it at the wall, it will require 4000 pounds on its middle to break the same beam resting on two props ten feet asunder. We have also shown in that article the additional strength which will be given to this beam by extending both ends beyond the props, and there framing it firmly into other pillars or supports.

Effects of obliquity of the external force.

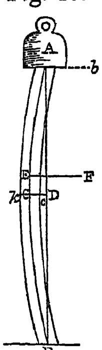
We can hardly add any thing to what has been said in that article, except a few observations on the effects of the obliquity of the external force. We have hitherto supposed it to act in the direction BP (fig. 6) perpendicular to the length of the beam. Suppose it to act in the direction BP′, oblique to BA. In the article Roof we supposed the strain to be the same as if the force p acted at the distance AB′, but still perpendicular to AB: so it is. But the strength of the section AΔ is not the same in both cases; for by the obliquity of the action the piece DCKΔ is pressed to the other. We are not sufficiently acquainted with the corpuscular forces to say precisely what will be the effect of the pressure arising from this obliquity; but we can clearly see in general, that the point A, which in the instant of fracture

is neither stretched nor compressed, must now be farther up, or nearer to D; and therefore the number of particles which are exerting cohesive forces is smaller, and therefore the strength is diminished. Therefore, when we endeavour to proportion the strength of a beam to the strain arising from an external force acting obliquely, we make too liberal allowance by increasing this external force in the ratio of AB to AB′. We acknowledge our inability to assign the proper correction. But this circumstance is of very great influence. In many machines, and many framings of carpentry, this oblique action of the straining force is unavoidable; and the most enormous strains to which materials are exposed are generally of this kind. In the frames set up for carrying the ringstones of arches, it is hardly possible to avoid them; for although the judicious engineer dispose his beams so as to sustain only pressures in the direction of their lengths, tending either to crush them or to tear them asunder, it frequently happens that, by the settling of the work, the pieces come to check and bear on each other transversely, tending to break each other across. This we have remarked upon in the article Roof, with respect to a truss by Mr Price (see Roof, p. 452–54). Now when a cross strain is thus combined with an enormous pressure in the direction of the length of the beam, it is in the utmost danger of snapping suddenly across. This is one great cause of the carrying away of masts. They are compressed in the direction of their length by the united force of the shrouds, and in this state the transverse action of the wind soon completes the fracture.

The strain on columns.

When considering the compressing strains to which materials are exposed, we deferred the discussion of the strain on columns, observing that it was not, in the cases which usually occur, a simple compression, but was combined with a transverse strain, arising from the bending of the column. When the column ACB (fig. 17), resting on the ground at B, and loaded at top with a weight A, acting in the vertical direction AB, is bent into a curve ACB, so that the tangent at C is perpendicular to the horizon, its condition somewhat resembles that of a beam firmly fixed between B and C, and strongly pulled by the end A, so as to bend it between C and A. Although we cannot conceive how a force acting on a straight column AB in the direction AB can bend it, we may suppose that the force acted first in the horizontal direction Ab till it was bent to this degree, and that the rope was then gradually removed from the direction Ab to the direction AB, increasing the force as much as is necessary for preserving the same quantity of flexure.

Fig. 17.



Observations on Euler's theory of the strength of columns.

The first author, we believe, who considered this important subject with scrupulous attention was the celebrated Euler, who published in the Berlin Memoirs for 1757 his Theory of the Strength of Columns. The general proposition established by this theory is, that the strength of prismatical columns is in the direct quadruplicate ratio of their diameters, and the inverse duplicate ratio of their lengths. He prosecuted this subject in the Petersburg Commentaries for 1778, confirming his former theory. We do not find that any other author has bestowed much attention on it, all seeming to acquiesce in the determinations of Euler, and to consider the subject as of very great difficulty, requiring the application of the most refined mathematics. Muschenbroeck has compared the theory with experiment; but the comparison has been very unsatisfactory, the difference from the theory being so enormous as to afford no argument for its justness. But the experiments do not contradict it, for they are so anomalous as to afford no conclusion or general rule whatever.

To say the truth, the theory can be considered in no other light than as a specimen of ingenious and very artful algebraic analysis. Euler was unquestionably the first analyst in Europe for resource and address. He knew this, and enjoyed his superiority, and without scruple admitted any physical assumptions which gave him an opportunity of displaying his skill. The inconsistency of his assumptions with the known laws of mechanism gave him no concern; and when his algebraic processes led him to any conclusion which would make his readers stare, being contrary to all our usual notions, he frankly owned the paradox, but went on in his analysis, saying, *Sed analysi magis fidendum*. Mr Robins has given some very risible instances of this confidence in his analysis, or rather of his confidence in the indolent submission of his readers. Nay, so fond was he of this kind of amusement, that after having published an untenable Theory of Light and Colours, he published several Memoirs, explaining the aberration of the heavenly bodies, deducing some very wonderful consequences, fully confirmed by experience, from the Newtonian principles, which were opposite and totally inconsistent with his own theory, merely because the Newtonian theory gave him *occasionem analyseos promovendæ*. We are thus severe in our observations, because his Theory of the Strength of Columns is one of the strongest instances of this wanton kind of proceeding, and because his followers in the Academy of St Petersburg, such as Fuss, Lexill, and others, adopt his conclusions, and merely echo his words. Since the death of Daniel Bernoulli, no member of that academy has controverted any thing advanced by their *Professor sublimis Geometriæ*, to whom they had been indebted for their places and for all their knowledge, having been (most of them) his amanuenses, employed by this wonderful man during his blindness, to make his computations and carry on his algebraic investigations. We are not a little surprised to see Mr Emerson, a considerable mathematician, and a man of very independent spirit, hastily adopting the same theory, of which we doubt not but our readers will easily see the falsity.

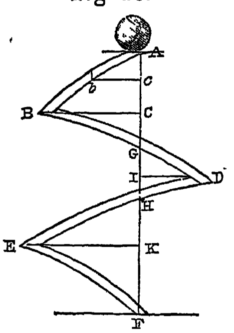
Euler considers the column ACB as in a condition precisely similar to that of an elastic rod bent into the curve by a cord AB connecting its extremities. In this he is not mistaken. But he then draws CD perpendicular to AB, and considers the strain on the section C as equal to the momentum or mechanical energy of the weight A, acting in the direction DE, upon the lever $k$$c$D, moveable round the fulcrum c, and tending to tear asunder the particles which cohere along the section cCk. This is the same principle (as Euler admits) employed by James Bernoulli in his investigation of the elastic curve ACB. Euler considers the strain on the section ck as the same with what it would sustain if the same power acted in the horizontal direction EF on a point E, as far removed from C as the point D is. We reasoned in the same manner (as has been observed) in the article Roof, where the obliquity of action was inconsiderable. But in the present case this substitution leads to the greatest mistakes, and has rendered the whole of this theory false and useless. It would be just if the column were of materials which are incompressible. But it is evident, by what has been said above, that by the compression of the parts the real fulcrum of the lever shifts away from the point c, so much the more as the compression is greater. In the great compressions of loaded columns, and the almost unmeasurable compressions of the truss-beams in the centres of bridges, and other cases of chief importance, the fulcrum is shifted far over towards k, so that very few fibres resist the fracture by their cohesion, and these few have a very feeble energy or momentum, on account of the short arm of the lever by which they act. This is a most important consideration in carpentry, yet makes no element of Euler's theory. The consequence of this is, that a very small degree of curvature is sufficient

to cause the column or strut to snap in an instant, as is well known to every experienced carpenter. The experiment by Muschenbroeck, which Euler makes use of in order to obtain a measure of strength in a particular instance, from which he might deduce all others by his theorem, is an incontestable proof of this. The force which broke the column is not the twentieth part of what is necessary for breaking it by acting at E in the direction EF. Euler takes no notice of this immense discrepancy, because it must have caused him to abandon the speculation with which he was then amusing himself.

This theory false and useless.

The limits of this work do not afford room to enter minutely upon the refutation of this theory; but we can easily show its uselessness, by its total inconsistency with common observation. It results legitimately from this theory, that if CD have no magnitude, the weight A can have no momentum, and the column cannot be broken. True, it cannot be broken in this way, snapped by a transverse fracture, if it do not bend; but we know very well that it can be crushed or crippled, and we see this frequently happen. This circumstance or event does not enter into Euler's investigation, and therefore the theory is at least imperfect and useless. Had this crippling been introduced in the form of a physical assumption, every topic of reasoning employed in the process must have been laid aside, as the intelligent reader will easily see. But the theory is not only imperfect, but false. The ordinary reader will be convinced of this by another legitimate consequence of it. Fig. 18 is the same with fig. 106 of Emerson's Mechanics, where this subject is treated on Euler's principles, and represents a crooked piece of matter resting on the ground at F, and loaded at A with a weight acting in the vertical direction AF. It results from Euler's theory that the strains at *b*, B, D, E, &c. are as *bc*, BC, DI, EK, &c. Therefore the strains at G and H are nothing; and this is asserted by Emerson and Euler as a serious truth; and the piece may be thinned *ad infinitum* in these two places, or even cut through, without any diminution of its strength. The absurdity of this assertion strikes at first hearing. Euler asserts the same thing with respect to a point of contrary flexure. Farther discussion is, we apprehend, needless.

Fig. 18.



Yet Euler's dissertations deserve a perusal.

This theory must therefore be given up. Yet these dissertations of Euler in the Petersburg Commentaries deserve a perusal, both as very ingenious specimens of analysis, and because they contain maxims of practice which are important. Although they give an erroneous measure of the comparative strength of columns, they show the immense importance of preventing all bendings, and point out with accuracy where the tendencies to bend are greatest, and how this may be prevented by very small forces, and what a prodigious accession of force this gives the column. There is a valuable paper in the same volume by Fuss on the Strains on framed Carpentry, which may also be read with advantage.

A new theory cannot be substituted in place of Euler's till many experiments be made.

It will now be asked, what shall be substituted in place of this erroneous theory? what is the true proportion of the strength of columns? We acknowledge our inability to give a satisfactory answer. This can only be obtained by a previous knowledge of the proportion between the extensions and compressions produced by equal forces, by the knowledge of the absolute compressions producible by a given force; and by a knowledge of the degree of that derangement of parts which is termed crippling. These circumstances are but imperfectly known to us, and there lies before us a wide field of experimental inquiry. Fortunately the force requisite for crippling a beam is prodigious, and a very small lateral support is sufficient to prevent that bending which puts the beam in imminent danger. A judicious engineer will always employ transverse bridles, as they are called, to stay the middle of long beams which are employed as pillars, struts, or truss-beams, and are exposed, by their position, to enormous pressures in the direction of their lengths. Such stays may be observed, disposed with great judgment and economy, in the centres employed by Mr Perronet in the erection of his great stone arches. He was obliged to correct this omission made by his ingenious predecessor in the beautiful centres of the bridge of Orleans, which we have no hesitation in affirming to be the finest piece of carpentry in the world.

It only remains on this head to compare these theoretical deductions with experiment.

Experiments on the transverse strength of bodies are easily made, and accordingly are very numerous, especially those made on timber, which is the case most common and most interesting. But in this great number of experiments there are very few from which we can draw much practical information. The experiments have in general been made on such small scantlings, that the unavoidable natural inequalities bear too great a proportion to the strength of the whole piece. Accordingly, when we compare the experiments of different authors, we find them differ enormously, and even the experiments by the same author are very anomalous. The completest series that we have yet seen is that detailed by Belidor in his *Science des Ingenieurs.* They are contained in the following table. The pieces were sound, even-grained oak. The column *b* contains the breadths of the pieces in inches; the column *d* contains their depths; the column *l* contains their lengths; column *p* contains the weights (in pounds) which broke them when hung on their middles; and *m* is the column of averages or mediums.

Table of experiments made by Belidor.

No.	*b*	*d*	*l*	*p*	*m*	
1	1	1	18	400 415 405	406	The ends lying loose.
2	1	1	18	600 600 624	608	The ends firmly fixed.
3	2	1	18	810 795 812	805	Loose.
4	1	2	18	1570 1580 1590	1580	Loose.
5	1	1	36	185 195 180	187	Loose.
6	1	1	36	285 280 285	283	Fixed.
7	2	2	36	1550 1620 1585	1585	Loose.
8	$2\frac{1}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660	Loose.

Corollaries derived from them.

By comparing Experiments 1st and 3d, the strength appears proportional to the breadth.

Experiments 3d and 4th show the strength proportional to the square of the depth.

Experiments 1st and 5th show the strength nearly in the inverse proportion of the lengths, but with a sensible deficiency in the longer pieces.

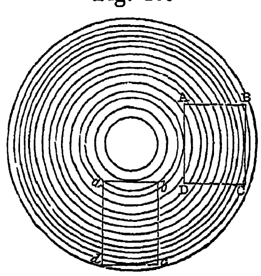
Experiments 5th and 7th show the strengths proportional to the breadths and the square of the depth.

Experiments 1st and 7th show the same thing, compounded with the inverse proportion of the length: here the deficiency relative to the length is not so remarkable.

Experiments 1st and 2d, and experiments 5th and 6th, show the increase of strength, by fastening the ends, to be in the proportion of two to three. The theory gives the proportion of two to four. But a difference in the manner of fixing may produce this deviation from the theory, which only supposed them to be held down at places beyond the props, as when a joist is held in the walls, and also rests on two pillars between the walls.

The chief source of irregularity in such experiments is the fibrous, or rather plated texture of timber. It consists of annual additions, whose cohesion with each other is vastly weaker than that of their own fibres. Let fig. 19 represent the section of a tree, and ABCD, *abcd* the section of two battens that are to be cut out of it for experiment, and let AD and *ad* be the depths, and DC, *dc* the breadths. The batten ABCD will be the stronger, for the same reason that an assemblage of planks set edgewise will form a stronger joist than planks laid above each other like the plates of a coach-spring. M. Buffon found by many trials that the strength of ABCD was to that of *abcd* (in oak) nearly as eight to seven. The authors of the different experiments were not careful that their battens had their plates all disposed similarly with respect to the strain. But even with this precaution they would not have afforded sure grounds of computation for large works; for great beams occupy much, if not the whole, of the section of the tree; and from this it has happened that their strength is less than in proportion to that of a small lath or batten. In short, we can trust no experiments but such as have been made on large beams. These must be very rare, for they are most expensive and laborious, and exceed the abilities of most of those who are disposed to study this subject.

Fig. 19.



But we are not wholly without such authority. M. Buffon and M. Duhamel, two of the first philosophers and mechanicians of the age, were directed by government to make experiments on this subject, and were supplied with ample funds and apparatus. The relation of their experiments is to be found in the Memoirs of the French Academy for 1740, 1741, 1742, 1768; as also in Duhamel's valuable performances *Sur l'Exploitation des Arbres, et sur la Conservation et le Transport de Bois.* We earnestly recommend these dissertations to the perusal of our readers, as containing much useful information relative to the strength of timber, and the best methods of employing it. We shall here give an abstract of M. Buffon's experiments.

M. Buffon's experiments on bars of sound oak.

He relates a great number which, during two years, he had prosecuted on small battens. He found that the odds of a single layer, or part of a layer, more or less, or even a different disposition of them, had such influence that he was obliged to abandon this method, and to have recourse to the largest beams that he was able to break. The following table exhibits one series of experiments on bars of sound oak, clear of knots, and four inches square. This is a specimen of all the rest.

Column 1st is the length of the bar in clear feet between the supports.

Column 2d is the weight of the bar (the second day after it was felled) in pounds. Two bars were tried of each length. Each of the first three pairs consisted of two cuts of the same tree. The one next the root was always found the heaviest, stiffest, and strongest. Indeed M. Buffon says that this was invariably true, that the heaviest was always the strongest; and he recommends it as a certain (or sure) rule for the choice of timber. He finds that this is always the case when the timber has grown vigorously, forming very thick annual layers. But he also observes that this is only during the advances of the tree to maturity; for the strength of the different circles approaches gradually to equality during the tree's healthy growth, and then it decays in these parts in a contrary order. Our tool-makers assert the same thing with respect to beech: yet a contrary opinion is very prevalent; and wood with a fine, that is, a small grain, is frequently preferred. Perhaps no person has ever made the trial with such minuteness as M. Buffon, and we think that much deference is due to his opinion.

Column 3d is the number of pounds necessary for breaking the tree in the course of a few minutes.

Column 4th is the number of inches which it bent down before breaking.

Column 5th is the time at which it broke.

1	2	3	4	5
7	60 56	5350 5275	3·5 4·5	29 22
8	68 63	4600 4500	3·75 4·7	15 13
9	77 71	4100 3950	4·85 5·5	14 12
10	84 82	3625 3600	5·83 6·5	15 15
12	100 98	3050 2925	7· 8·	... ...

The experiments on other sizes were made in the same way. A pair at least of each length and size was taken. The mean results are contained in the following table. The beams were all square, and their sizes in inches are placed at the head of the columns, and their lengths in feet are in the first column.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14	...	5300	7475	13225	19775	5763
16	...	4350	6362	11000	16375	5042
18	...	3700	5562	9245	13200	4482
20	...	3225	4950	8375	11487	4034
22	...	2975	...	...	...	3667
24	...	2162	...	...	...	3362
28	...	1775	...	...	...	2881

M. Buffon had found, by numerous trials, that oak-timber lost much of its strength in the course of drying or season-

Strength of Materials.

ing; and therefore, in order to secure uniformity, his trees were all felled in the same season of the year, were squared the day after, and tried the third day. Trying them in this green state gave him an opportunity of observing a very curious and unaccountable phenomenon. When the weights were laid briskly on, nearly sufficient to break the log, a very sensible smoke was observed to issue from the two ends with a sharp hissing noise. This continued all the while the tree was bending and cracking. This shows that the log is affected or strained through its whole length. Indeed this must be inferred from its bending through its whole length. It also shows us the great effects of the compression. It is a pity M. Buffon did not take notice whether this smoke issued from the upper or compressed half of the section only, or whether it came from the whole.

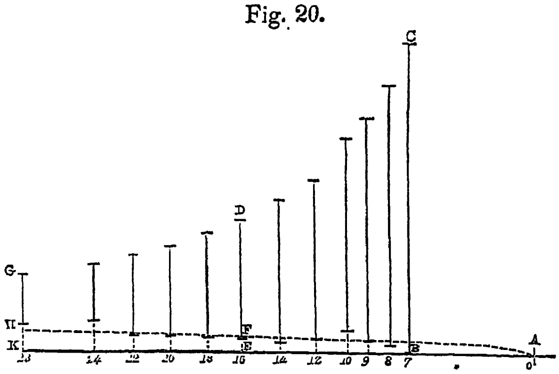
Observations on M. Buffon's experiments.

We must now make some observations on these experiments, in order to compare them with the theory which we have endeavoured to establish.

M. Buffon considers the experiments with the five-inch bars as the standard of comparison, having both extended these to greater lengths, and having tried more pieces of each length.

Our theory determines the relative strength of bars of the same section to be inversely as their lengths. But, if we except the five experiments in the first column, we find a very great deviation from this rule. Thus the five-inch bar of twenty-eight feet long should have half the strength of that of fourteen feet, or 2650; whereas it is but 1775. The bar of fourteen feet should have half the strength of that of seven feet, or 5762; whereas it is but 5300. In like manner, the fourth of 11,525 is 2881; but the real strength of the twenty-eight feet bar is 1775. We have added a column A, which exhibits the strength which each of the five-inch bars ought to have by the theory. This deviation is most distinctly seen in fig. 20, where BK is the scale

Fig. 20.



of lengths, B being at the point seven of the scale, and K at twenty-eight. The ordinate CB is $= 11,525$, and the other ordinates DE, GK, &c. are respectively $= \frac{7CB}{\text{length}}$. The lines DF, GH, &c. are made $= 4350$, 1775, &c., expressing the strengths given by experiment. The ten-feet bar and the twenty-four feet bar are remarkably anomalous. But all are deficient, and the defect has an evident progression from the first to the last. The same thing may be shown of the other columns, and even of the first, though it is very small in that column. It may also be observed in the experiments of Belidor, and in all that we have seen. We cannot doubt therefore of its being a law of nature, depending on the true principles of cohesion and the laws of mechanics.

But it is very puzzling, and we cannot pretend to give a satisfactory explanation of the difficulty. The only effect which we can conceive the length of a beam to have, is to increase the strain at the section of fracture, by employing the intervening beam as a lever. But we do not distinctly see what change this can produce in the mode of action of the fibres in this section, so as either to change their cohesion or the place of its centre of effort: yet something of this kind must happen.

We see indeed some circumstances which must contribute to make a smaller weight sufficient, in M. Buffon's experiments, to break a long beam, than in the exact inverse proportion of its length.

In the first place, the weight of the beam itself augments the strain as much as if half of it were added in the form of a weight. M. Buffon has given the weights of every beam on which he made experiments, which is very nearly seventy-four pounds per cubic foot. But they are much too small to account for the deviation from the theory. The half weights of the five-inch beams of seven, fourteen, and twenty-eight feet length, are only forty-five, ninety-two, and 182 pounds; which makes the real strains in the experiments 11,560, 5390, and 1956; which are far from having the proportions of four, two, and one.

Buffon says that healthy trees are universally strongest at the root end; therefore, when we use a longer beam, its middle point, where it is broken in the experiment, is in a weaker part of the tree. But the trials of the four-inch beams show that the difference from this cause is almost insensible.

The length must have some mechanical influence which the theory we have adopted has not yet explained. It may not however be inadequate to the task. The very ingenious investigation of the elastic curve by James Bernoulli and other celebrated mathematicians is perhaps as refined an application of mathematical analysis as we know. Yet in this investigation it was necessary, in order to avoid almost insuperable difficulties, to take the simplest possible case, viz. where the thickness is exceedingly small in comparison with the length. If the thickness be considerable, the quantities neglected in the calculus are too great to permit the conclusion to be accurate, or very nearly so. Without being able to define the form into which an elastic body of considerable thickness will be bent, we can say with confidence, that in an extreme case, where the compression in the concave side is very great, the curvature differs considerably from the Bernoullian curve. But as our investigation is incomplete and very long, we do not offer it to the reader. The following more familiar considerations will, we apprehend, render it highly probable that the relative strength of beams decreases faster than in the inverse ratio of their length. The curious observation by M. Buffon, of the vapour which issued with the hissing noise from the ends of a beam of green oak, while it was breaking by the load on its middle, shows that the whole length of the piece was affected: indeed it must be, since it is bent throughout. We have shown above, that a certain definite curvature of a beam of a given form is always accompanied by rupture. Now suppose the beam A of ten feet long, and the beam B of twenty feet long, bent to the same degree, at the place of their fixture in the wall; the weight which hangs on A is nearly double of that which must hang on B. The form of any portion, suppose five feet, of these two beams, immediately adjoining to the wall, is considerably different. At the distance of five feet the curvature of A is half of its curvature at the wall. The curvature of B in the corresponding point is three fourths of the same curvature at the wall. Through the whole of the intermediate five feet, therefore, the curvature of B is greater than that of A. This must make it weaker throughout. It must occasion the fibres to slide more on each other (that it may acquire *this* greater curvature), and thus affect their lateral union; and therefore those which are stronger will not assist their weaker neighbours. To this we must add, that in the shorter beams the force with which the fibres are pressed laterally on each other is double. This must impede the

Probable that the relative strength of beams decreases faster than in the inverse ratio of their length.

mutual sliding of the fibres which we mentioned a little ago; nay, this lateral compression may change the law of longitudinal cohesion (as will readily appear to the reader who is acquainted with Boscovich's doctrines), and increase the strength of the very surface of fracture, in the same way (however inexplicable) as it does in metals when they are hammered or drawn into wire.

The reader must judge how far these remarks are worthy of his attention. The engineer will carefully keep in mind the important fact, that a beam of quadruple length, instead of having one fourth of the strength, has only about one sixth; and the philosopher should endeavour to discover the cause of this diminution, that he may give the artist a more accurate rule of computation.

We cannot discover the precise relation between the curvature and the momentum of cohesion.

Our ignorance of the law by which the cohesion of the particles changes by a change of distance, hinders us from discovering the precise relation between the curvature and the momentum of cohesion; and all we can do is to multiply experiments, upon which we may establish some *empirical* rules for calculating the strength of solids. Those from which we must reason at present are too few and too anomalous to be the foundation of such an empirical formula. We may however observe, that M. Buffon's experiments gave us considerable assistance in this particular; for if to each of the numbers of the column for the five-inch beams, corrected by adding half the weight of the beam, we add the constant number 1245, we shall have a set of numbers which are very nearly reciprocals of the lengths. Let 1245 be called c, and let the weight which is known by experiment to be necessary for breaking the five-inch beam of the length a be called P. We shall have $\frac{\overline{P+c}\times a}{l}-c=p$.

Thus the weight necessary for breaking the seven-feet bar is 11,560. This added to 1245, and the sum multiplied by 7, gives $\overline{P+c}\times a=89{,}635$. Let l be 18; then $\frac{89{,}635}{18}-1245$ $=3725=p$, which differs not more than $\frac{1}{40}$th from what experiment gives us. This rule holds equally well in all the other lengths except the 10 and 24 feet beams, which are very anomalous. Such a formula is abundantly exact for practice, and will answer through a much greater variety of length, though it cannot be admitted as a true one; because, in a certain very great length, the strength will be nothing. For other sizes the constant number must change in the proportion of d^3, or perhaps of p.

Relation between the strength and the square of the depth of the section.

The next comparison which we have to make with the theory is the relation between the strength and the square of the depth of the section. This is made by comparing with each other the numbers in any horizontal line of the table. In making this comparison we find the numbers of the five-inch bars uniformly greater than the rest. We imagine that there is something peculiar to these bars; they are in general heavier than in the proportion of their section, but not so much so as to account for all their superiority. We imagine that this set of experiments, intended as a standard for the rest, has been made at one time, and that the season has had a considerable influence. The fact however is, that if this column be kept out, or uniformly diminished about one sixteenth in their strength, the different sizes will deviate very little from the ratio of the square of the depth, as determined by theory. There is however a small deficiency in the bigger beams.

We have been thus anxious in the examination of these experiments, because they are the only ones which have been related in sufficient detail, and made on a proper scale for giving us data from which we can deduce confidential maxims for practice. They are so troublesome and expensive that we have little hopes of seeing their number greatly increased; yet surely our navy board would do an unspeakable service to the public by appropriating a fund for such experiments under the management of some man of science.

Proportion between the absolute cohesion and the relative strength.

There remains another comparison which is of chief importance, namely, the proportion between the *absolute cohesion* and the *relative strength*. It may be guessed, from the very nature of the thing, that this must be very uncertain. Experiments on the absolute strength must be confined to very small pieces, by reason of the very great forces which are required for tearing them asunder. The values therefore deduced from them must be subject to great inequalities. Unfortunately we possess no detail of any experiments; all that we have to depend on are two passages of Muschenbroeck's *Essais de Physique;* in one of which he says, that a piece of sound oak $\frac{27}{100}$ths of an inch square is torn asunder by 1150 pounds; and in the other, that an oak plank twelve inches broad and one thick will just suspend 189,163 pounds. These give for the cohesion of an inch square 15,755 and 15,763 pounds. Bouguer, in his *Traité du Navire*, says that it is very well known that a rod of sound oak one fourth of an inch square will be torn asunder by 1000 pounds. This gives 16,000 for the cohesion of a square inch. We shall take this as a round number, easily used in our computations. Let us compare this with M. Buffon's trials of beams four inches square.

The absolute cohesion of this section is $16{,}000\times16=256{,}000$. Did every fibre exert its whole force in the instant of fracture, the momentum of cohesion would be the same as if it had all acted at the centre of gravity of the section at two inches from the axis of fracture, and is therefore 512,000. The four-inch beam, seven feet long, was broken by 5312 pounds hung on its middle. The half of this, or 2656 pounds, would have broken it, if suspended at its extremity, projecting $3\frac{1}{2}$ feet, or 42 inches, from a wall. The momentum of this strain is therefore $2656\times42=111{,}552$. Now this is in equilibrio with the actual momentum of cohesion, which is therefore 111,552 instead of 512,000. The strength is therefore diminished in the proportion of 512,000 to 111,552, or very nearly of 4·59 to 1.

As we are quite uncertain as to the place of the centre of effort, it is needless to consider the full cohesion as acting at the centre of gravity, and producing the momentum 512,000; and we may convert the whole into a simple multiplier m of the length, and say, *as* m *times the length is to the depth, so is the absolute cohesion of the section to the relative strength.* Therefore let the absolute cohesion of a square inch be called f, the breadth b, the depth d, and the length l (all in inches), the relative strength, or the external force, p, which balances it, is $\frac{fbd^2}{9\cdot18l}$, or, in round numbers, $\frac{fbd^2}{9l}$; for $m=2\times4\cdot59$.

This great diminution of strength cannot be wholly accounted for by the inequality of the cohesive forces exerted in the instant of fracture; for in this case we know that the centre of effort is at one third of the height in a rectangular section (because the forces really exerted are as the extensions of the fibres). The relative strength would be $\frac{fbd^2}{3l}$, and p would have been 8127 instead of 2656.

We must ascribe this diminution (which is three times greater than that produced by the inequality of the cohesive forces) to the compression of the under part of the beam; and we must endeavour to explain in what manner this compression produces an effect which seems so little explicable by such means.

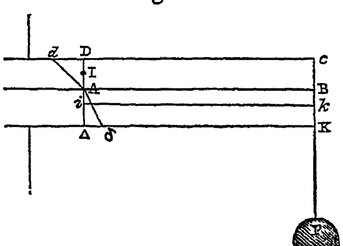
As we have repeatedly observed, it is a matter of nearly universal experience that the forces *actually* exerted by the

particles of bodies, when stretched or compressed, are very nearly in the proportion of the distances to which the particles are drawn from their natural positions. Now, although we are certain that, in enormous compressions, the forces increase faster than in this proportion, this makes no sensible change in the present question, because the body is broken before the compressions have gone so far; nay, we imagine that the compressed parts are crippled in most cases even before the extended parts are torn asunder Muschenbroeck asserts this with great confidence with respect to oak, on the authority of his own experiments. He says, that although oak will suspend half as much again as fir, it will not support, as a pillar, two thirds of the load which fir will support in that form.

We imagine therefore that the mechanism in the *present* case is nearly as follows:

Let the beam DCKΔ (fig. 21) be loaded at its extremity with the weight P, acting in the direction KP perpendicular to DC. Let DΔ be the section of fracture. Let DA be about one third of DΔ. A will be the particle or fibre which is neither extended nor compressed. Make $\Delta\delta : Dd = DA : A\Delta$. The triangles DAd, $\Delta A\delta$, will represent the accumulated attracting and repelling forces. Make AI and $Ai = \frac{1}{3}$ DA and $\frac{1}{3}$ ΔA. The point I will be that to which the full cohesion Dd or f of the particles in AD must be applied, so as to produce the same momentum which the variable forces at I, D, &c. really produce at their several points of application. In like manner, i is the circle of similar effort of the repulsive forces excited by the compression between A and Δ, and it is the real fulcrum of a bended lever IiK, by which the whole effect is produced. The effect is the same as if the full cohesion of the stretched fibres in AD were accumulated in I, and the full repulsion of all the compressed fibres in AΔ were accumulated in i. The forces which are balanced in the operation are the weight P, acting by the arm ki, and the full cohesion of AD acting by the arm Ii. The forces exerted by the compressed fibres between A and Δ only serve to give support to the lever, that it may exert its strain.

Fig. 21.



We imagine that this does not differ much from the real procedure of nature. The position of the point A may be different from what we have deduced from Buffon's experiments, compared with Muschenbroeck's value of the absolute cohesion of a square inch. If this last should be only 12,000, DA must be greater than we have here made it, in the proportion of 12,000 to 16,000. For Ii must still be made $= \frac{1}{3}$ AΔ, supposing the forces to be proportional to the extensions and compressions. There can be no doubt that a part only of the cohesion of DΔ operates in resisting the fracture in all substances which have any compressibility; and it is confirmed by the experiments of M. Duhamel on willow, and the inferences are by no means confined to that species of timber. We say, therefore, that when the beam is broken, the cohesion of AD alone is exerted, and that each fibre exerts a force proportional to its extension; and the accumulated momentum is the same as if the full cohesion of AD were acting by the lever Ii = $\frac{1}{3}$d of DΔ.

It may be said, that if only one third of the cohesion of oak be exerted, it may be cut two thirds through without weakening it. But this cannot be, because the cohesion of the whole is employed in preventing the lateral slide so often mentioned. We have no experiments to determine that it *may not* be cut through one third without loss of its strength.

This must not be considered as a subject of mere speculative curiosity. It is intimately connected with all the practical uses which we can make of this knowledge; for it is almost the only way that we can learn the compressibility of timber. Experiments on the direct cohesion are indeed difficult, and exceedingly expensive if we attempt them in large pieces. But experiments on compression are almost impracticable. The most instructive experiments would be, first to establish, by a great number of trials, the transverse force of a moderate batten; and then to make a great number of trials of the diminution of its strength, by cutting it through on the concave side. This would very nearly give us the proportion of the cohesion which really operates in resisting fractures. Thus if it be found that one half of the beam may be cut on the under side without diminution of its strength (taking care to drive in a slice of harder wood), we may conclude that the point A is at the middle, or somewhat above it.

Much lies before the curious mechanician, and we are as yet very far from a scientific knowledge of the strength of timber.

A useful practical rule may be deduced from M. Buffon's experiments.

In the mean time, we may derive from these experiments of Buffon a very useful practical rule, without relying on any value of the absolute cohesion of oak. We see that the strength is nearly as the breadth, as the square of the depth, and as the inverse of the length. It is most convenient to measure the breadth and depth of the beam in inches, and its length in feet. Since, then, a beam four inches square and seven feet between the supports is broken by 5312 pounds, we must conclude that a batten one inch square and one foot between the supports will be broken by 581 pounds. Then the strength of any other beam of oak, or the weight which will just break it when hung on its middle, is $581 \frac{bd^2}{l}$.

But we have seen that there is a very considerable deviation from the inverse proportion of the lengths, and we must endeavour to accommodate our rule to this deviation. We found, that by adding 1245 to each of the ordinates or numbers in the column of the five-inch bars, we had a set of numbers very nearly reciprocal of the lengths; and if we make a similar addition to the other columns in the proportion of the cubes of the sixes, we have nearly the same result. The greatest error (except in the case of experiments which are very irregular) does not exceed $\frac{1}{15}$th of the whole. Therefore, for a radical number, add to the 5312 the number 640, which is to 1245 very nearly as 4^3 to 5^3. This gives 5952. The 64th of this is 93, which corresponds to a bar of one inch square and seven feet long. Therefore 93×7 will be the reciprocal corresponding to a bar of one foot. This is 651. Take from this the present empirical correction, which is $\frac{b\,40}{b\,4}$, or 10, and there remains 641 for the strength of the bar. This gives us for a general rule $p = 651 \frac{bd^2}{l} - 10\,bd^2$.

Example. Required the weight necessary to break an oak beam eight inches square and twenty feet between the props, $p = 651 \times \frac{8 \times 8^2}{20}\ 10 \times 8 \times 8^2$. This is 11,545, whereas the experiment gives 11,487. The error is very small indeed. The rule is most deficient in comparison with the five-inch bars, which, we have already said, appear stronger than the rest.

The following process is easily remembered by such as are not algebraists.

Multiply the breadth in inches twice by the depth, and

call this product f. Multiply f by 651, and divide by the length in feet. From the quotient take 10 times f. The remainder is the number of pounds which will break the beam.

We are not sufficiently sensible of our principles to be confident that the correction $10f$ should be in the proportion of the section, although we think it most probable. It is quite empirical, founded on Buffon's experiments. Therefore the safe way of using this rule is to suppose the beam square, by increasing or diminishing its breadth till equal to the depth. Then find the strength by this rule, and diminish or increase it for the change which has been made in its breadth. Thus, there can be no doubt that the strength of the beam given as an example is double of that of a beam of the same depth and half the breadth.

The reader cannot but observe that all this calculation relates to the very greatest weight which a beam will bear for a very few minutes. M. Buffon uniformly found that two thirds of this weight sensibly impaired its strength, and frequently broke at the end of two or three months. One half of this weight brought the beam to a certain bend, which did not increase after the first minute or two, and may be borne by the beam for any length of time. But the beam contracted a bend, of which it did not recover any considerable portion. One third seemed to have no permanent effect on the beam; but it recovered its rectilineal shape completely, even after having been loaded several months, provided that the timber was seasoned when first loaded; that is to say, one third of the weight which would quickly break a seasoned beam, or one fourth of what would break one just felled, may lie on it for ever without giving the beam a set.

We have no detail of experiments on the strength of other kinds of timber: only M. Buffon says, that fir has about $\frac{6}{10}$ths of the strength of oak; Mr Parent makes it $\frac{10}{12}$ths; Emerson, $\frac{2}{3}$ds, &c.

We have been thus minute in our examination of the mechanism of this transverse strain, because it is the greatest to which the parts of our machines are exposed. We wish to impress on the minds of artists the necessity of avoiding this as much as possible. They are improving in this respect, as may be seen by comparing the centres on which stone arches of great span are now turned with those of former times. They were formerly a load of mere joists resting on a multitude of posts, which obstructed the navigation, and were frequently losing their shape by some of the posts sinking into the ground. Now they are more generally trusses, where the beams abut on each other, and are relieved from transverse strains. But many performances of eminent artists are still very injudiciously exposed to cross strains. We may instance one which is considered as a fine work, viz. the bridge at Walton on Thames. Here every beam of the great arch is a joist, and it hangs together by framing. The finest piece of carpentry that we have seen is the centre employed in turning the arches of the bridge at Orleans, described by Perronet. In the whole there is not one cross strain. The beam, too, of Hornblower's steam-engine is very scientifically constructed.

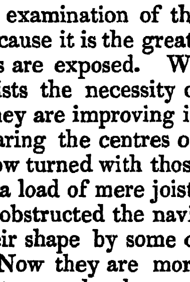
Strain produced by twisting.

IV. The last species of strain which we are to examine is that produced by twisting. This takes place in all axles which connect the working parts of machines.

The resistance must be proportional to the number of particles.

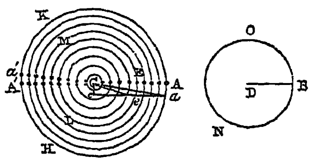
Although we cannot pretend to have a very distinct conception of that modification of the cohesion of a body by which it resists this kind of strain, we can have no doubt that, when all the particles act alike, the resistance must be proportional to the number. Therefore if we suppose the two parts ABCD, ABFE (fig. 22), of the body EFCD to be of insuperable strength, but cohering more weakly in the common surface AB, and that one part ABCD is pushed laterally in the direction AB, there can be no doubt that it will yield only there, and that the resistance will be proportional to the surface.

Fig. 22.



In like manner, we can conceive a thin cylindrical tube, of which KAH (fig. 23) is the section, as cohering more weakly in that section than anywhere else. Suppose it to be grasped in both hands, and the two parts twisted round the axis in opposite directions, as we would twist the joints of a flute; it is plain that it will first fail in this section, which is the circumference of a circle, and the particles of the two parts which are contiguous to this circumference will be drawn from each other laterally. The total resistance will be as the number of equally resisting particles, that is, as the circumference (for the tube being supposed very thin, there can be no sensible difference between the dilatation of the external and internal particles). We can now suppose another tube within this, and a third within the second, and so on till we reach the centre. If the particles of each ring exerted the same force (by suffering the same dilatation in the direction of the circumference), the resistance of each ring of the section would be as its circumference and its breadth (supposed indefinitely small), and the whole resistance would be as the surface; and this would represent the resistance of a solid cylinder. But when a cylinder is twisted in this manner by an external force applied to its circumference, the external parts will suffer a greater circular extension than the internal; and it appears that this extension (like the extension of a beam strained transversely) will be proportional to the distance of the particles from the axis. We cannot say that this is demonstrable, but we can assign no proportion that is more probable. This being the case, the forces simultaneously exerted by each particle will be as its distance from the axis. Therefore the whole force exerted by each ring will be as the square of its radius, and the accumulated force actually exerted will be as the cube of the radius; that is, the accumulated force exerted by the whole cylinder, whose radius is CA, is to the accumulated force exerted *at the same time* by the part whose radius is CE, as CA^3 to CE^3.

Fig. 23.



The whole cohesion now exerted is just two thirds of what it would be if all the particles were exerting the same attractive forces which are just now exerted by the particles in the external circumference. This is plain to any person in the least familiar with the fluxionary calculus. But such as are not may easily see it in this way.

Let the rectangle AC*ca* be set upright on the surface of the circle along the line CA, and revolve round the axis C*c*. It will generate a cylinder whose height is C*c* or A*a*, and having the circle KAH for its base. If the diagonal C*a* be supposed also to revolve, it is plain that the triangle *c*C*a* will generate a cone of the same height, and having for its base the circle described by the revolution of *ca*, and the point C for its apex. The cylindrical surface generated by A*a* will express the whole cohesion exerted by the circumference AHK, and the cylindrical surface generated by E*e* will represent the cohesion exerted by the circumference ELM, and the solid generated by the triangle CA*a* will represent the cohesion exerted by the whole circle AHK, and the cylinder generated by the rectangle AC*ca* will represent the cohesion exerted by the same surface if each particle had suffered the extension A*a*.

Now it is plain, in the first place, that the solid generated by the triangle *e*EC is to that generated by *a*AC as EC^3 to

Strength of Materials.

AC^3. In the next place, the solid generated by aAC is two thirds of the cylinder, because the cone generated by cCa is one third of it.

We may now suppose the cylinder twisted till the particles in the external circumference lose their cohesion. There can be no doubt that it will now be wrenched asunder, all the inner circles yielding in succession. Thus we obtain one useful information, viz. that a body of homogeneous texture resists a *simple twist* with two thirds of the force with which it resists an attempt to force one part laterally from the other, or with one-third part of the force which will cut it asunder by a square-edged tool; for to drive a square-edged tool through a piece of lead, for instance, is the same as forcing a piece of the lead as thick as the tool laterally away from the two pieces on each side of the tool. Experiments of this kind do not seem difficult, and they would give us very useful information.

With what force a body of a homogeneous texture resists a simple twist.

When two cylinders AHK and BNO are wrenched asunder, we must conclude that the external particles of each are just put beyond their limits of cohesion, are equally extended, and are exerting equal forces. Hence it follows, that in the instant of fracture the sum-total of the forces actually exerted are as the squares of the diameters.

The forces exerted in breaking two cylinders are as the squares of the diameters.

For drawing the diagonal Ce, it is plain that $Ee = Aa$ expresses the distension of the circumference ELM, and that the solid generated by the triangle CEe expresses the cohesion exerted by the surface of the circle ELM, when the particles in the circumference suffer the extension Ee equal to Aa. Now the solids generated by CAa and CEe being respectively two thirds of the corresponding cylinders, are as the squares of the diameters.

Relative strength of the section to the external force employed to break it.

Having thus ascertained the real strength of the section, and its relation to its absolute lateral strength, let us examine its strength relative to the external force employed to break it. This examination is very simple in the case under consideration. The straining force must act by some lever, and the cohesion must oppose it by acting on some other lever. The centre of the section may be the neutral point, whose position is not disturbed.

Let F be the force exerted laterally by an exterior particle. Let a be the radius of the cylinder, and x the indeterminate distance of any circumference, and dx the indefinitely small interval between the concentric arches; that is, let dx be the breadth of a ring and x its radius. The forces being as the extensions, and the extensions as the distances from the axis, the cohesion actually exerted at any part of any ring will be $f\frac{xdx}{a}$. The force exerted by the whole ring (being as the circumference or as the radius) will be $f\frac{x^2dx}{a}$. The momentum of cohesion of a ring, being as the force multiplied by its lever, will be $f\frac{x^3dx}{a}$. The accumulated momentum will be the sum or fluent of $f\frac{x^3dx}{a}$; that is, when $x = a$, it will be $\frac{1}{4}f\frac{a^4}{a} = \frac{1}{4}fa^3$.

The resistance of the axle is as the cube of its diameter.

Hence we learn that the strength of an axle, by which it resists being wrenched asunder by a force acting at a given distance from the axis, is as the cube of its diameter.

But, further, $\frac{1}{4}fa^3$ is $= fa^2 \times \frac{1}{4}a$. Now fa^2 represents the full lateral cohesion of the section. The momentum therefore is the same as if the full lateral cohesion were accumulated at a point distant from the axis by one fourth of the radius, or one eighth of the diameter of the cylinder.

Therefore let F be the number of pounds which measure the lateral cohesion of a circular inch, d the diameter of the cylinder in inches, and l the length of the lever by which the straining force p is supposed to act; we shall have $F \times \frac{1}{8}d^3 = pl$, and $F\frac{d^3}{8l} = p$.

We see in general that the strength of an axle, by which it resists being wrenched asunder by twisting, is as the cube of its diameter.

We see also that the internal parts are not acting so powerfully as the external. If a hole be bored out of the axle of half its diameter, the strength is diminished only one eighth, while the quantity of matter is diminished one fourth. Therefore hollow axles are stronger than solid ones containing the same quantity of matter. Thus let the diameter be 5, and that of the hollow 4; then the diameter of another solid cylinder having the same quantity of matter with the tube is 3. The strength of the solid cylinder of the diameter 5 may be expressed by 5^3, or 125. Of this the internal part (of the diameter 4) exerts 64; therefore the strength of the tube is $125 - 64 = 61$. But the strength of the solid axle of the same quantity of matter and diameter 3 is 3^3, or 27, which is not half of that of the tube.

Hollow axles more proper than solid ones.

Engineers, therefore, have of late introduced this improvement in their machines, and the axles of cast iron are all made hollow when their size will admit of it. They have the additional advantage of being much stiffer, and of affording much better fixture for the flanches which are used for connecting them with the wheels or levers by which they are turned and strained. The superiority of strength of hollow tubes over solid cylinders is much greater in this kind of strain than in the former or transverse. In this last case the strength of this tube would be to that of the solid cylinder of equal weight as 61 to 32 and a half nearly.

and now generally used.

The apparatus which we mentioned on a former occasion for trying the lateral strength of a square inch of solid matter, enabled us to try this theory of twist with all desirable accuracy. The bar which hung down from the pin in the former trials was now placed in a horizontal position, and loaded with a weight at the extremity. Thus it acted as a powerful lever, and enabled us to wrench asunder specimens of the strongest materials. We found the results perfectly conformable to the theory, in as far as it determined the proportional strength of different sizes and forms; but we found the ratio of the resistance to twisting to the simple lateral resistance considerably different, and it was some time before we discovered the cause.

The ratio of resistance to twisting to the simple lateral resistence appears different.

We had here taken the simplest view that is possible of the action of cohesion in resisting a twist. It is frequently exerted in a very different way. When, for instance, an iron axle is joined to a wooden one by being driven into one end of it, the extensions of the different circles of particles are in a very different proportion. A little consideration will show that the particles in immediate contact with the iron axle are in a state of violent extension; so are the particles of the exterior surface of the wooden part, and the intermediate parts are less strained. It is almost impossible to assign the exact proportion of the cohesive forces exerted in the different parts. Numberless cases can be pointed out where parts of the axle are in a state of compression, and where it is still more difficult to determine the state of the other particles. We must content ourselves with the deductions made from this simple case, which is fortunately the most common. In the experiments just now mentioned, the centre of the circle is by no means the neutral point, and it is very difficult to ascertain its place; but when this consideration occurred to us, we easily freed the experiments from this uncertainty, by extending the lever to both sides, and by means of a pulley applied equal force to each arm, acting in opposite directions. Thus the centre became the neutral point, and the resistance to twist was found to be two thirds of the simple lateral strength.

But when the experiment was altered, it was exactly the same.

We beg leave to mention here, that our success in these

Experiments on chalk, clay, and wax, satisfactory; but those on timber irregular.

experiments encouraged us to extend them much farther. We hoped by these means to discover the absolute cohesion of many substances, which would have required an enormous apparatus and a most unmanageable force to tear them asunder directly. But we could reason with confidence from the resistance to twist (which we could easily measure), provided that we could ascertain the proportion of the direct and the lateral strengths. Our experiments on chalk, finely prepared clay, and white bee's wax (of one melting and one temperature), were very consistent and satisfactory. But we have hitherto found great irregularities in this proportion in bodies of a fibrous texture like timber. These are the most important cases, and we still hope to be able to accomplish our project, and to give the public some valuable information. This being our sole object, it was our duty to mention the method which promises success, and thus excite others to the task; and it will be no mortification to us to be deprived of the honour of being the first who thus adds to the stock of experimental knowledge.

When the matter of the axle is of the most simple texture, such as that of metals, we do not conceive that the length of the axle has any influence on the fracture. It is otherwise if it be of a fibrous texture like timber; the fibres are bent before breaking, being twisted into spirals like a corkscrew. The length of the axle has somewhat of the influence of a lever in this case, and it is more easily wrenched asunder if long. Accordingly we have found it so; but we have not been able to reduce this influence to calculation.

Many useful deductions might be made from these premises respecting the manner of disposing and combining the strength of materials in our structures. The best form of joints, mortises, tenons, scarphs, the rules for joggling, tabling, faying, fishing, &c., practised in the delicate art of mast-making, are all founded on this doctrine; but the discussion of these would be equivalent to writing a complete treatise of carpentry.

The most recent experiments on the strength and elasticity of material give the results entered in the following tables:—

I.—*Distensions of Rods for a Strain of one Pound per Square Inch, computed from the results given in Tredgold, edition of* 1840, *as deduced from observations on transverse strain.*

British timber	Oak	$\frac{1}{92000}$
	Larch	$\frac{1}{36000}$
	Scotch fir	$\frac{1}{80000}$
	Ash	$\frac{1}{120000}$
Foreign timber	Memel fir	$\frac{1}{76000}$
	Norway fir	$\frac{1}{109000}$
	American pine	$\frac{1}{60000}$
	White spruce	$\frac{1}{92000}$
	Riga oak	$\frac{1}{100000}$
	American oak	$\frac{1}{98000}$
English malleable iron		$\frac{1}{24200000}$

II.—*Cohesive Strengths of Bars per Square Inch.*

		lb.		lb.
Oak	from	14,000	to	19,000
Beech	„	11,000	„	22,000
Ash	„	12,000	„	17,000
Elm	„	13,000	„	14,000
Mahogany	„	8,000	„	21,000
Teak	„	8,000	„	15,000
Pine (Norway)	„	7,000	„	14,000
Larch	„	9,000	„	10,000
Iron wire	„	94,000	„	113,000
Swedish iron	„	53,000	„	78,000
English iron	„	55,000	„	66,000
Cast-iron	„	16,000	„	33,000

(J. R.)

Practical Remarks.

We now give a few remarks on the foregoing subjects, which may be of use to practical men who may not be acquainted with the higher branches of mathematics. It has been seen that the foregoing treatise has explained the limit of the strength of materials, and that they fail in three ways:—1st, By tension, or being pulled asunder; 2d, By compression, or being crushed; 3d, By transverse strain, or being broken across, either by heavy weights or other similar causes.

Failure of material.

Tension.

With the first cause, the practical constructor has but little to do beyond consulting Mr Emerson's tables. They will afford a near approximation (quality being taken into the account) for weights to be suspended by iron-rods and other materials; but, since his time, iron-chains have been brought into much greater use, and iron wire-rope invented. It is impossible, in our space, to give anything like the information that has been published on this subject; our readers, however, will find full tables of the breaking weight, from 1 to 54 tons; the size in inches; the weight; and relative cost per fathom of wire-rope, hempen-rope, and chain, in Weale's *Engineers' Pocket-Book.*

For the tensile strength of iron and steel, we must refer to a very valuable paper in the *Transactions of the Institution of Engineers in Scotland,* by Mr Robert Napier, from experiments conducted by Mr David Kirkaldy, and the valuable tables subjoined thereto, just published. It would be impossible to give them in our limited space, as they extend over many columns of closely printed matter. It appears, however, that the breaking weight of bar-steel, per square inch of its original area, varied from 132,000 lb. to 62,000 lb., while that of iron has varied from 96,000 lb. to 44,000 lb. The like breaking weight of steel-plate varied from 96,000 lb. to 72,000 lb.; and that of iron from 56,000 lb. to 41,000 lb., and this is less than is generally given to iron; but it establishes the fact, that when used as bar and plate iron, for rough reckoning may be considered to have only about two-thirds the strength of steel.

Compression.

Practically it is seldom necessary to consider the weight any bodies would bear without crushing, except the wooden story posts, or iron columns that support the fronts of our houses, or the floors of our warehouses. The power of brick or stone to resist crushing being generally so very much more than those materials can have to carry, it does not come into the consideration of the builder, or engineer, except for very large works, where high professional assistance ought always to be sought. It will be seen, by an inspection of fig. 17, that posts generally fail first by crippling or buckling; and it is easy to perceive how any horizontal strut placed opposite to F, to prevent the timber bending in that direction, must add important strength to the post AB; and though it has been shown that Euler and his followers have pushed deductions drawn from such theories to the verge of absurdity, still, to the practical man, this is matter of grave consideration. If in a shop-front, for instance, we can get a strong transom between the story posts 3 feet from the pavement, those posts are much stronger than if they rose from floor to bressummer without any cross strut, or stay. Formulæ have been given again and again on the subject; but as they necessitate involution and evolution to cubic, and sometimes biquadratic, powers, they should not be used except by skilled mathematicians. There are, however, some very valuable tables given in Barlow's *Tredgold,* Nos. 16, 17, 18, and 19, for the scantlings of story posts to carry the fronts of ordinary houses, from two to five stories high, placed at various distances, from 4 to 8 feet apart, ranging from 8 to 16 feet in height; and some excellent information in Nicholson's *Carpentry,* chap. ii., 212, &c., on story posts generally.

Story posts.

Iron columns.

Their superiority, in many points of view, has led to the extensive use of iron columns. The best engineers, for some years, have been occupied in making series of experiments on their bearing and breaking weights; but none on so large a scale as those of Mr Eaton Hodgkinson. The

Mr Hodgkinson's experiments.

results of which were communicated to the Royal Society first in 1840, and again in 1857; and which, by the kindness of the author, are now before us; with an Appendix up to the present time. We regret we have not space for his valuable tables. The results, however, may be stated that he found that, in cylindrical pillars of cast-iron, the top and bottom of which were turned perfectly true and flat, the breaking weight varied as the 3·55th power of the diameter, and inversely as the 1·7th power of the length, so that, instead of the theory of Euler (commented on before in page 760), which comes out $\frac{d^4}{l^2}$, it was found to be $\frac{d^{3\cdot 55}}{l^{1\cdot 7}}$, d being the diameter, and l the length. In hollow pillars, as $\frac{d^{3\cdot 55} - d_1^{3\cdot 55}}{l^{1\cdot 7}}$, d and d_1 representing the outer and inner diameters, and this for cases where the lengths varied from 30 times the dimensions of the diameters to 120 times. But as it continually happens that practical men wish to employ cast-iron columns, we must refer them to a series of eleven tables, given in Weale's *Engineers' Pocket-Book;* and subsequently in his *Contractors' Price-Book*, which give the lengths in feet, the load in hundredweights, and the extent of floor solid cast-iron columns will support from 2 inches to 8 inches in diameter, and hollow columns from 3 inches to 18 inches of various thicknesses of metal.

Cross strains.

In the third branch of our subject, transverse strains, we have first to regard those of beams of wood, and it has been shown that in breaking a beam of wood by any weight pulling downwards in the centre, that the upper half of the beam is in a state of compression, and the lower in a state of tension. The practical man will understand this better if he will take a small lead tube, or a piece of a boy's rattan cane, and bend it downwards in the middle. He will find the top of the cane or tube will pucker up, the particles being crushed together, while the lower half will be torn asunder. In fact, we push together the fibres of the upper half and draw apart those of the lower half. From this simple fact all theories as to girders, whether of wood, or of cast or wrought iron are based. Several things must be borne in mind before we proceed; first, that a beam will bear twice the weight equally distributed over its surface than if collected in the middle; that a beam of double width will only carry a double load, but a beam of double depth will carry four times the load of a single beam. This may be understood by an inspection of fig. 3. If another beam of the same size were placed alongside of it, the two beams would do double the work of one; but if the beam ABCD were of double depth, the two triangles EG*e*, FG*f* would also be of double depth, and the power of the leverage of *each* would be doubled.

Tension and compression.

Distributed weight.

Proportion of depth to width.

If supported on both ends.

At one end.

If ends secured.

If a beam of any given length and width be fixed in a wall at one end only, it will break with half the weight a beam of half the length would bear, fixed at one end only. In other words, a fourth of its strength is taken away by removing the support from one end. If the ends are well wedged into a wall, instead of lying loose on the supports, the strength is much increased, as the ends which lie on a wall must "cock up;" if the middle bends down while they are loose, but should they be kept down tight by the superincumbent weight of the wall, they will counteract to a great degree the tendency to bending, and of course breaking. The securing the ends of beams into walls is said to increase their power to resist breaking weight from $\frac{1}{4}$ to $\frac{1}{3}$.

To calculate the strength of a beam.

The formulæ given by Tredgold are too abstruse for general purposes. There is, however, one given by Nicholson which is simple, and not far from the truth. A number of experiments were made on pieces of various woods, each one inch square and a foot long, and the weights which broke them recorded. Then as this weight c : is to the length of any given beam in feet l : : so is the weight the beam will have to bear (in pounds) W : to the breadth b multiplied into the square of the depth d of the intended beam; or as $c : l :: W : b \times d^2$. Any of these three being given, the fourth is easily found. The breaking weight of Memel fir he gives as 330, that of oak he gives as 810, but this last seems too much. Suppose there is a warehouse 16 feet wide, the girders of which are 10 feet apart, and each superficial foot is to carry 3 cwt. or 336 lb. Then as each girder supports $16 \times 10 = 160$ feet superficial, and as each foot is to carry 336 lb., the total weight to be carried is 53,760 lb. distributed over the whole, or half this 26,880 lb. in the centre. Then as 330 : 16 : : 26,880 : 1303, or the breadth multiplied into the square of the depth. But this is breaking weight, and no timber ought to be used of less strength than four times this. Then $1303 \times 4 = 5212$, the least amount we ought to reckon upon. Now we have our choice either to assume a breadth or a depth. Suppose we are confined to 17 inches for the latter. Then $\frac{5212}{17 \times 17} = 18$ inches very nearly. If we assume 15 inches as our breadth, then $\frac{5212}{15} = 347$, the square root of which is nearly 19 inches; so that we may have a girder 18 inches wide and 17 inches deep, or one 15 inches wide and 19 inches deep, as we please.

Scantlings of timber.

As has been said before, formulæ for calculating these have been given, but too abstruse for general practice. Valuable tables, however, will be found both in *Gwilt, Encyclopædia of Architecture*, in *Tredgold*, and several other books, both for floors and roofs. For floors, in *Gwilt*, Art. 2015 to 2022; in *Tredgold*, Tables Nos. 1 to 4: for roofs, in *Gwilt*, Art. 2036 to 2040; in *Tredgold*, Tables Nos. 5 to 15. The former author seems to give stronger scantlings in proportion than the second, but of course considerable discretion must be used, as we must take into account the weight of the covering and flatness of pitch. It must be remembered, also, that common joists are much strengthened by cross strutting, and all girders above 25 feet in length should be trussed. (See BUILDING, pp. 748-749.)

Inclined beams.

The strength of an inclined beam as a rafter has been shown to be as the cosine of the angle it forms with the horizon. Therefore the strength of the rafter AB, Art. ROOF, fig. 3, is the same as that of a beam of similar scantling in a horizontal position of the length between the perpendiculars of its two ends, as AF.

Advantages and disadvantages of timber beams.

The advantages of timber beams are, they do not shrink in length, and they show signs of fracture before there is danger, and yield gradually if overloaded. The disadvantages—they shrink a great deal in thickness, occupy much space, become rotten by time or damp, and, worst of all, are combustible.

Iron beams.

These circumstances have led to the use of cast-iron as horizontal supports. The history of its introduction and use have been given in our foregoing articles, and at greater length in Mr Fairbairn's book, *The Application of Cast and Wrought Iron to Building*, just published. It will be therefore useless to enumerate the various stages of the invention. Suffice it to say, that from a simple flat plate of iron, which was the original form, and which in fact was a simple imitation of a beam of wood, a top and bottom flanch have by degrees been added, which have proved a great addition of strength, as well as a saving of metal. We have before explained in this page that the upper part of a beam, when it is intended to be bent, is in a state of compression, and the lower half in a state of tension. We must now add, that between these there is a point affected by neither of these forces, and which is called the neutral axis. If a parallel beam of the thickness of EG be widened as at AB, the power to resist compression becomes greater, and the same thing happens with regard to tension if

Use of flanges.

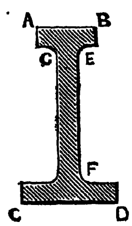


Fig. 24.

the thickness of the flitch EG be increased, as at CD. What is called the "web" EF is principally of use to keep the flanches apart, and increase the resistance by increased leverage.

The web. The works of Messrs Hodgkinson and Fairbairn amply show examples of all these, which we should gladly give *in extenso* did our space permit; and though these are valuable for reference in special cases, the practical constructor needs some tolerably simple rule to give him an idea what size an iron girder ought to be to support a given weight.

Rules to calculate. A number of formulæ have been published, the most elaborate, and perhaps the nearest the truth, is that of Mr H. Grissell, the eminent founder, in his evidence before the House of Lords, in which he takes into consideration the dimension of the top flange as well as that of the bottom. But by far the simplest is that of Mr Hodgkinson, adopted by Mr Fairbairn, viz.:—

$$W=\frac{cad}{l}$$

where W = breaking weight in the middle in tons.
a = the section of the bottom rib or flange.
d = the depth of the beam.
l = the length or distance between the supports (all these in inches).
c = a constant quantity derived from the result of various experiments, which varies according to the quality of iron, and other causes, from 25 to 27·5, and is generally taken at 26. An example is given of a bridge girder at Manchester 26 feet or 312 inches in the clear of the supports. The bottom flange CD is 16 inches wide and 3 inches deep. The whole depth A to C $27\frac{1}{2}$ inches. Then $l=312$ $a=48$ $d=27·5$ and $c=26$, as above.

Then $\frac{26\times 48\times 27·5}{312}=110$ tons, which is the breaking weight in the *middle* of the beam. No notice is here taken of the upper flange, but the omission is justified by the fact that the constant c has been taken from frequent experiments on girders having top and bottom flanges of proper proportions, and that therefore it comes into the account one way if not in another. In very particular instances, however, we think it ought to be calculated, as, it is said, cast-iron has eight times greater power to resist compression than tension.

Safe load. Much difference exists among engineers as to the proportion the permanent safe-load has to breaking weight; some saying it should be three times as much, others six, and some, where there is great momentum or impact, ten times as much. It was confessed, however, in the former cases the formulæ were fuller than ordinary. It is more common lately to take six times the load as the size on which to reckon.

Proof. But as there are so many hidden defects in cast-iron, and when a failure takes place, as it gives no warning, but all goes to ruin at once, and as there have been such fearful accidents with this material, every girder should be proved by placing actual weights on them.

Over-proof. But this precaution may be carried to excess, for instances have been known where a sound girder has been strained in the proof, and has afterwards broken with a very small weight. A good authority has laid it down as a rule, that a girder should be designed to carry six times the load it is intended at any time to bear, and should be proved to three times. By this rule the girder just described should be proved in the middle to 55 tons, and never have more than $18\frac{1}{3}$ tons in the centre, or 37 tons if the weight be equally distributed. It is well also to sound the girder throughout with a hammer, as they do railway axles.

Compound girders. These are partly of cast trussed with wrought-iron, but are seldom used except in very large structures. We fear, after all that has been said in their favour, that, as temperature changes, the particles of the two materials are often in a different state of tension, and therefore they are very unsafe. We have, however, no space here to enter into the argument.

Wrought-iron girders. The sudden accidents arising from the failure of cast-iron, and their fearful results, have suggested the use of wrought-iron; and as its manufacture is now so much cheaper from the great improvements in rolling T and L iron, and in punching and riveting machines, the wrought-iron girder is now a very important consideration to the designer of a building. We shall endeavour to give some short formulæ to guide the practical man, though, as has been said before, in all important works reference should be had to the higher branches of science.

Wrought girder. There are two sorts of wrought-iron beams now employed, generally called either plate-girders or box-girders. Fig. 25 shows the former, and fig. 26 the latter. Neither have been in use long enough, nor have there been such a multiplicity of experiments on them, to afford such certain formulæ as have been published for cast-iron beams. But we give what we gather to be a near approximation of the theories

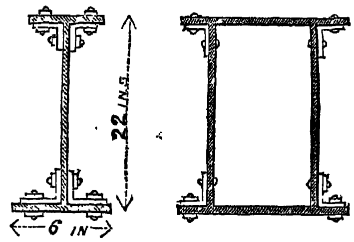


Fig. 25. Fig. 26.

just published as far as they go, and venture, under correction of such authorities, to suggest they are incomplete as regards the upper flange, just as in the former theories. Nay, more so, inasmuch as the upper flange requires to be the *strongest* in wrought-iron, that material being more easily compressed than rent by tension (which is just the contrary with cast-iron, where we have shown the lower flange ought to be of largest area). The constant c is given as 75. Taking the former formula, $W=\frac{cad}{l}$ in a case where the length between the supports is 30 feet (or 360 inches), the depth 22 inches of $\frac{5}{16}$ metal, and the bottom flanges 3×3 each, of $1\frac{1}{2}$ inch metal (see fig. 25), we have $\frac{75\times 6\times 22}{360}=27\frac{1}{2}$ tons as breaking weight. From Mr Fairbairn's careful experiments, however, we should gather that 75 is a fair constant where the top flange has double the strength of the lower flange.

Box girders. The formulæ collected for these is quite on another principle from those of the plate-girder. Instead of regarding the bottom flange alone, writers base their theories in the sectional area of the metal of top, bottom, and sides, and given as a formula $W=\frac{Ad\,C.}{l}$ Here A is the area of the entire cross-section (fig. 26). Now, as the girders vary very much in form, some being square in section, some flat, and some oblong, it follows that the constant C must vary according to each section; and not only so, but with the relative strength of the top and bottom flanges. Experiments have shown where the top has been only half the strength of the bottom flange, the constant was as low as under 10, but turning the very same girder bottom upwards, so that the top flange was then double the strength of the lower, a constant of nearly 18, or nearly double, was got out of the same section. Mr Fairbairn thinks that 21·5 is a fair constant to be reckoned for rectangular tubes, when the upper flange is double the strength of that below. Of course, these girders, like all others, ought to be proved; but, as has been before explained, there is always a greater security about them than those of cast-iron.

Trellis girders. The formulæ for these are the same as for plate-girders, but the constants vary enormously. Experiments show a

difference from 44 to 17. It seems, however, to be the opinion of many, that a well constructed trellis girder may be calculated to bear about half what a close plate-girder of the same dimension would carry; but as these are little used in building, we shall not go further into the investigation.

See Barlow, *Experiments on Timber*, 1835; do., 1837. Booth, *A popular treatise on the Strength of Materials used in Building*, 1836. Camus de Mezières, *Traité de la Force de Bois*, 1782. Fairbairn, *Useful Information, &c.*, and several other very valuable works up to 1859. Hodgkinson, the like, also up to 1859. Lea, *Strength of Timber* (Tables of), 1850. Morin, *Resistance, &c.*, 1853. Penn, *Tables*, &c., 1825. Rennie—Many works, especially the experiments on Strength of Materials in the *Office-Book for Architects*, &c. Tate *On Strength of Materials*, 1851. Tredgold, *Elementary Instructions*, 1836, and many other works. Turnbull, *Strength and Stress of Timber*, 1833. Ware, *Dynamics*, 1851. Wedeke and Romberg, *Die baumateriel, &c.* We can also refer to *the Report of the Royal Commissioners on Iron, &c., &c.*, 1849; and generally to the works of Rondelet, Gauthey, Nicholson, Barlow, Tredgold, Hodgkinson, Fairbairn, Gregory, Emerson, Eytelwein; almost all of which have before been cited in our pages. There are also many excellent articles interspersed in the *Transactions* of the Institution of Civil Engineers; Royal Institute of British Architects; the various French *Annales*; the Franklin Institute of America, &c.; and in the Architect and Civil Engineers' *Pocket-book*, the *Office-Book*, and various works of this description. (A. A.)

STRICKLAND, Hugh Edwin, the grandson of Sir George Strickland, and of the eminent Dr Edmund Cartwright, was born at Righton in the East Riding of Yorkshire, on the 2d of March 1811. He studied under Dr Arnold at Laleham, and subsequently at Oriel College, Oxford. While at Oxford his taste was directed by the teaching of Dr Buckland to the study of geology; and on his retirement to Tewkesbury he studied with great diligence and success the geology and natural history of the Cotswold Hills and of the great valley of the Severn. From numerous papers which appeared from Strickland's pen in the *Transactions of the Geological Society*, it appeared that he was a very industrious inquirer, an accurate observer, and a just reasoner on the geological phenomena which came under his observation. In 1835, he made a geological tour to Asia Minor, and published papers on the various topics which drew his attention during his travels. He succeeded Dr Buckland as reader in geology to the University of Oxford on the failure of that gentleman's health. In zoology he was distinguished as an ornithologist, and various contributions from Strickland appeared in the *Proceedings of the Zoological Society*. He likewise wrote a book on *The Dodo and its Kindred* in 1848, in which he concluded that this extinct bird belonged to the family of Columbidæ. He was one of the original founders of the Ray Society, and he had just edited the third volume of Agassiz's *Bibliographia Zoologiæ et Geologiæ*, when he was killed by a passenger-train on the Gainsborough and Retford Railway, a portion of the cuttings of which he was too diligently examining, on the 14th September 1853.

STRIEGAU, a town of the Prussian monarchy, Silesia, in the government and 27 miles W.S.W of Breslau. It has a court-house, Protestant and Roman Catholic churches, an ancient Carmelite convent, a Benedictine nunnery, hospital, and poor-house. Linen and woollen cloth are woven here, and some trade is carried on. Pop. 5884.

STROMBOLI (anc. *Strongyle*), one of the Lipari Islands, 35 miles off the north coast of Sicily. It is about 9 miles in circuit, and entirely volcanic in its formation, rising to the height of 2500 feet near the N.W. extremity. There is a crater 170 yards across, which is continually sending out smoke and flame, with loud explosions, but no proper eruption has taken place for a very long time. Wheat, barley, cotton, wine, raisins, and figs are raised on the island. There are a small town and a battery on the east side, and some ancient remains throughout the island. Pop. 1200.

STROMNESS, a seaport and burgh of barony of Scotland, on the island of Mainland, Orkney, 12 miles W.S.W. of Kirkwall. It is irregularly built, consisting of one main street extending along the shore, and lined with substantial stone houses. There are a parish church, Free church, and United Presbyterian church; several schools, a public library, and a museum. Boat and ship-building is carried on, and there is a small rope-work. The harbour is good, admitting vessels of all sizes. The trade of the place is considerable. Pop. 2055.

STROPHE (στρέφω, *I turn*), in Greek poetry, the first division of a choral ode, of which the other parts were the antistrophe and the epode.

STROUD, or Stroudwater, a market-town and parliamentary borough of England, Gloucestershire, in a beautiful valley, at the union of two streams which form the Stroud Water, 9 miles S. by E. from Gloucester, and 101 W. by N. of London. It is the centre of the woollen manufacture in the county, and has many dye-houses, woollen and fulling mills, which stand in deep ravines on the side of the valley, near streams which flow into the main river. The houses are irregularly scattered on the hill-sides; and the valley is also densely filled with them. The town was formerly very ill built, but has been much improved of late. The principal buildings are the large parish church, with nave, chancel, aisles, and spire; Trinity Church; and Baptist, Independent, and Methodist chapels. There are also National, British, and other schools; a dispensary, and an hospital. The Stroud water is believed to be peculiarly adapted for use in the process of dying scarlet. A considerable trade is carried on, for which the Great Western Railway and the Thames and Severn Canal afford important facilities. Weekly markets and two annual fairs are held. The borough of Stroud, which includes a large and important manufacturing district, is represented in parliament by two members. Pop. of the parl. borough, 36,535; of the parish, 8798.

STRUENSEE and BRANDT. See Denmark.

STRUTT, Joseph, an artist and antiquary of considerable merit, was born at Springfield in Essex, October 27, 1742. After spending sometime with Wynne Ryland, he afterwards became a student in the Royal Academy, and in 1771, while engaged in the reading-room of the British Museum, he obtained the embellishments for many of the subsequent works which were then simmering in his brain. In 1773 appeared his *Regal and Ecclesiastical Antiquities of England, containing the representations of the English Monarchs from Edward the Confessor to Henry VIII.*; in 1774 his *Horda-Angel-Cynnan*, a work which he completed in 3 volumes in 1776. His *Chronicle of England*, 2 volumes, appeared in 1777 and 1778. His next work was *A Biographical Dictionary of Engravers* in 2 vols., 1785 and 1786. His *Complete View of the Dress and Habits of the People of England* was published in 2 vols. 1796–99; and his work on *The Sports and Pastimes of the People of England* originally appeared in 1811. Strutt, after all his diligence and plodding industry, died in narrow circumstances in London, October 16th 1802. His manuscripts, which contained dramas, dramatic tales, &c., were published by his son after his death. His *Queen Hoo Hall*, a romance illustrative of ancient manners, was completed by Sir Walter Scott in 1808.

STRYPE, John, a meritorious labourer in ecclesiastical and literary history, was born at Stepney on the 1st of November 1643. His father, John van Stryp, was a native of Brabant, and sought refuge in England on account of his religion. He was a merchant and silk-thrower. The son received his early education at St Paul's school, where

he remained for six years. In 1662 he proceeded to Jesus College, Cambridge, from which he was transferred to Catherine Hall. In 1665, he there took the degree of A.B., and that of A.M. four years afterwards. He was appointed to the perpetual curacy of Theydon-Boys, in the county of Essex, in 1669; but he only retained it for a few months, having been appointed minister of Low Leyton, in the same county. When far advanced in life, Strype was presented by Archbishop Tenison to the sinecure of Tarring in Sussex. He was also appointed to the lectureship of Hackney, which he resigned in 1724. At Hackney he resided, in his old age, under the roof of one Harris, an apothecary, who was married to his grand-daughter. In this house he died on the 11th of December 1737, at the patriarchal age of ninety-four.

Strype's principal works are—*The Life of Archbishop Cranmer*, 1694, fol.; *The Life of Sir Thomas Smith*, 1698, 8vo; *The Life of Dr John Aylmer, Bishop of London*, 1701, 8vo; *The Life of Sir John Cheke*, 1705, 8vo; *Annals of the Reformation*, 4 vols.: vol. i. 1709, reprinted 1725; vol. ii., 1725; vol. iii., 1728; vol. iv., 1731; *The Life of Archbishop Grindal*, 1710, fol.; *The Life and Letters of Archbishop Parker*, 1711, fol.; *The Life of Archbishop Whitgift*, 1718, fol.; *Ecclesiastical Memorials*, 1721, 3 vols. fol.

The writings of Strype were for many years neglected, but they are now held in deserved estimation; and they have all been reprinted at the Clarendon press. He is not remarkable for the methodical arrangement of his materials, nor did he ever attain to much proficiency in the art of composition; but no one ever denied him the praise of diligence and fidelity. Besides these works, he published *Lessons for Youth and Old Age*, 1699, 12mo. He likewise published the second volume of Dr Lightfoot's *Works*, in 1684; and an elaborate edition of Stow's *Survey of London*, 1720, 2 vols. fol.

STUARTS, The. See Scotland and Great Britain.

STUART, Gilbert, an eminent jurist and historian, was born at Edinburgh in the year 1742. He was educated in the public school and in the University of his native city. To the pursuit of jurisprudence he devoted himself with uncommon ardour; but although he had a strong relish for the study of law, he anticipated no delight from its practice, and he was never called to the bar. Of his early progress in this study he exhibited a very conspicuous specimen in a work published without his name; *An Historical Dissertation concerning the Antiquity of the English Constitution*, Edinb., 1768, 8vo. Stuart's Dissertation, distinguished by so much vigour of intellect and maturity of juridical learning, procured him from the university the degree of LL.D., which is very rarely bestowed upon so young a scholar. A second edition, bearing the author's name, was published at London in the year 1771, and he then prefixed a dedication to the Earl of Mansfield. The dedication is dated at London in the month of January 1770; and before this period he had become a regular contributor to the *Monthly Review*, with which he continued his connection from 1768 to 1774. We likewise find him employed as the editor of *An Historical Treatise on the Feudal Law, and the Constitution and Laws of England; with a Commentary on Magna Charta, and necessary Illustrations of many of the English Statutes; in a Course of Lectures read in the University of Dublin, by the late Francis Stoughton Sullivan, LL.D., Royal Professor of the Common Law in that University*, Lond., 1772, 4to. A pseudonymous work, of a very different denomination, has been ascribed to Dr Stuart. It bears the title of *Animadversions on Mr Adam's Latin and English Grammar; being an Exhibition of its Defects, and an Illustration of the Danger of Introducing it into Schools.* By John Richard Busby, Master of Arts, Edinb., 1773, 8vo.

Dr Stuart now undertook the management of *The Edinburgh Magazine and Review*, of which the first number bears the date of November 1773. Smellie was the printer, and Stuart was the principal writer. Lord Hailes, Dr Blacklock, Professor Richardson of Glasgow, Professor Barron of St Andrews, and Smellie, were among the number of the contributors. The work was certainly clever, but much too satirical; and it consequently merely outlived the fifth volume, and expired in August 1776. Notwithstanding the failure of this project, Dr Stuart had displayed so much talent in his principal articles, that his reputation as a man of letters suffered no diminution. He however felt a very painful mortification at the unsuccessful result of his labours; and his mind was so badly regulated that, instead of reflecting on the natural tendency of his own conduct, he continued to cherish a most bitter and indiscriminate resentment. He was still in the early vigour of manhood, and he speedily roused himself to new and greater exertions. After an interval of less than two years, he produced what we are disposed to regard as the best of his works, *A View of Society in Europe, in its Progress from Rudeness to Refinement; or, Inquiries concerning the History of Law, Government, and Manners*," Edinburgh, 1778, 4to. The style of this work, though never languid or feeble, may, however, be considered as deficient in fluency and variety. His periods are, perhaps, too uniformly short. "This brevity," he avers, "is a conspicuous part of oratory, and is consistent with the greatest elevation and dignity. Where Cicero himself is most eloquent, and where the tide of his language is most rapid and powerful, his sentences are concise; and he avoids with care the periodic swell, as cold, artificial, and unnatural. And, indeed, it is to be laid down as a general rule, that where sentences are uniformly long, as in Milton and in Clarendon, there is no eloquence in the composition, and little connection in the argument."—*Edinburgh Magazine and Review*, vol. v., p. 250.

Being disappointed in his expectations regarding the professorship of civil law in Edinburgh, he allowed his embittered spirit to find vent in all his future publications. This spirit is very easily to be discerned in his next publication, *Observations concerning the Public Law and the Constitutional History of Scotland: with occasional Remarks concerning English Antiquity*, Edinb., 1779, 8vo. This publication was speedily followed by *The History of the Establishment of the Reformation of Religion in Scotland*, Lond., 1780, 4to. The work is written with his usual ability, but it cannot be affirmed that such an undertaking was peculiarly adapted to his habits of thinking. He however displays a greater degree of impartiality than could well have been anticipated. Of this work, his next publication may be considered as the sequel: *The History of Scotland, from the Establishment of the Reformation till the death of Queen Mary*, Lond., 1782, 2 vols. 4to. Here the author has made a great, and indeed a splendid effort, to eclipse the reputation of Robertson, whom he both envied and hated. As the one historian considered Mary guilty of some of the foulest crimes laid to her charge, it was almost an obvious consequence that the other should represent her as innocent. The preface to the *History of Scotland* is dated at London on the 1st of March 1782; and soon after this period he undertook the management of the *English Review* in 1783. How long he continued to conduct the *English Review* we are not informed. In 1785 he became the editor of *The Political Herald and Review*. This work, it is believed, only reached a second volume. It is too well known that Stuart's mode of life had been such as to impair his health and strength. With a constitution undermined by disease, and a mind soured by disappointment, he embarked for Leith, and sought a place of rest under the roof of his father, who having become emeritus professor in 1775, was then residing at Musselburgh. The son was labouring under a dropsy, from which the usual operation afforded him a temporary

relief; but all medical aid was ineffectual, and he descended to his grave at the premature age of forty-four. He died on the 13th of August 1786, and his father survived till the 18th of June 1793.

Gilbert Stuart is thus described by a writer who seems to have had some personal knowledge of him: He "was about the middle size, and justly proportioned. His countenance was modest and expressive, sometimes announcing sentiments of glowing friendship, of which he is said to have been truly susceptible; at others, displaying strong indignation against folly and vice, which he had also shown in his writings. With all his ardour for study, he yielded to the love of intemperance, to which, notwithstanding a strong constitution, he fell an early sacrifice."

Stuart, *Gilbert Charles*, sometimes called American Stuart, was an eminent painter, born of Scottish parents at Narraganset, Rhode Island, United States, in 1755. He accompanied a travelling artist, named Alexander, to Scotland, where he resided for some time, but returned again to America in 1773. Having again proceeded to London in 1775, he contrived to support himself by playing as an organist in a church in that city. Meeting with his countryman, Benjamin West, who took him into his studio as his pupil and assistant, his career henceforward was one of prosperity. His life, however, was a scene of change and confusion, caused entirely by his intemperate habits. After painting the portraits of many distinguished men in London, Dublin, and Paris, he returned to America, where he exercised his pencil on portraits of Washington, Jefferson, J. Q. Adams, and many other men of note. He died at Boston July 1828. Stuart is generally recognised to be one of the greatest portrait-painters which America has yet produced.

Stuart, *James*, author of the *Antiquities of Athens*, and frequently, on that account, known as Athenian Stuart, was born in London of poor parents in 1713. He originally assisted Goupy of the Strand, and in 1742 he set out for Rome. After remaining in that city for seven years, industriously engaged in painting, he had proposals made to him by Revett and Gavin Hamilton, to start for Greece on an architectural expedition. Hamilton ultimately declined accompanying them, and Stuart and Revett accordingly set out for Greece in 1751. They remained in that country till about the end of 1753. On returning to England Stuart found more work than he could accomplish. He engaged in the literary portion of the *Antiquities of Athens*, the first volume of which appeared in 1762. The work, on the whole, was a great success. Stuart, by the encouragement which he received got sluggish; and while he executed various designs for noblemen, societies, &c., in Grecian architecture, he allowed the *Antiquities* to slumber in his hand until both head and hand were cold. He died the 2d February 1788. The second volume of this work was edited after his decease by Newton, and published in 1790, and the third by Beverley in 1794.

STUHLWEISSENBURG, a town of Hungary, capital of a county of the same name, on the Csargo, in a marshy region, near the west border of the morass of Sarret, 38 miles S.S.W. of Buda, and about 100 S.E. of Vienna. It is a large and ancient town, with ill paved, irregular streets. The principal building is the Cathedral of St Mary, formerly the place of coronation and burial for the kings of Hungary, and containing many of their tombs. This building is handsome and richly decorated. There are here five other churches, an episcopal palace, county buildings, gymnasium, military academy, and other schools, hospital and theatre. Woollen and linen cloth, hardware, and other articles are manufactured here; and there is an active trade in wine and fruit. On account of the scarcity of good water, several Artesian wells have been bored here. Pop. (1851) 14,971.

STUKELEY, William, an eminent antiquary, descended from an ancient family in Lincolnshire, was born at Holbeach in that county, on the 7th of November 1687. From the free school of his native town he was removed to Corpus Christi College, Cambridge, where he was admitted on the 7th of November 1703. Having chosen the medical profession, he took the degree of M.B. in 1709, and that of M.D. in 1719. He first settled as a practitioner at Boston; but in 1717 he removed to London, and was admitted a fellow of the College of Physicians in 1720. By the recommendation of Dr Mead, he was chosen a fellow of the Royal Society. He contributed to the re-establishment of the Society of Antiquaries, of which he officiated as secretary for many years. In 1726 he left the metropolis, and settled at Grantham in Lincolnshire, where he soon obtained extensive practice. In 1728 he married Frances, the daughter of Robert Williamson, Esq. of Allington, a lady of good family and fortune. Being much afflicted with gout, he found the exercise of his profession very laborious, and therefore meditated a retreat into the church. On the 20th of July 1720, being then in the thirty-third year of his age, he received ordination from Archbishop Wake; and in the ensuing October was presented by the Lord-chancellor King to the living of All-Saints in Stamford. He became a widower in 1737, and, in the course of the following year, married the only daughter of Dr Gale, the learned dean of York. In 1739 the living of Somerby, near Grantham, was bestowed upon him by the Duke of Ancaster. In 1747 the Duke of Montagu presented him to the rectory of St George, Queen Square, and he then vacated his other benefices. He survived till the 3d of March 1765.

Dr Stukeley was a man of varied learning, but was chiefly distinguished by his knowledge of antiquities. His writings are numerous, and partly relate to medical as well as theological subjects; but we shall confine ourselves to an enumeration of the most important or curious of his antiquarian publications.

An Account of a Roman Temple near Graham's Dike, 1720, 4to. *Of the Roman Amphitheatre at Dorchester*, Lond., 1723, 4to. *Itinerarium Curiosum; or, an Account of the Antiquities and remarkable Curiosities in Great Britain*, Lond., 1724, fol.; Lond., 1776, 2 vols. fol. *Stonehenge; a Temple restor'd to the British Druids*, Lond., 1740, fol. *Abury; A Temple of the British Druids: with some others described*, Lond., 1743, fol. *Palæographia Britannica; or, Discourses on Antiquities in Britain*, Lond., 1743–52, 4to. *An Account of Richard of Cirencester*, Lond., 1757, 4to. *The Medallic History of Marcus Aurelius Valerius Carausius, Emperor in Britain*, Lond., 1757–9, 2 vols. 4to.

STURM, Jacques Charles François, the discoverer of the algebraic theorem which bears his name, was born in Geneva in 1803. Originally tutor to the son of Madame de Staël, he subsequently resolved, in conjunction with his school-fellow Colladon, to try his fortune in the French metropolis. Sturm soon made the acquaintance of the foremost mathematicians in the capital, and obtained employment on the *Bulletin Universelle*. On the discovery of his important theorem, namely, the determination of the number of real roots of a numerical equation which are included between given limits, in 23d May 1829, he rapidly rose to fortune and public honours. He was chosen a member of the French Academy in 1836, and was afterwards appointed to succeed Poisson in the chair of Physics at Paris. He presented numerous memoirs to the academy, of which it has been said that an impartial posterity will place them by the side of the finest memoirs of Lagrange. Sturm died on the 18th of December 1855.

Sturm, *Johann*, better known by the name of Sturmius, a learned philologer and rhetorician, was born at Schleiden, near Cologne, on the 1st of October 1507. He afterwards pursued his study at Liege, in the College of St Jerome, and then went to Louvain in 1524. He there spent five years, three in learning and two in teaching.

He set up a printing-press with Rudger Rescius, professor of Greek, and printed several Greek authors. In 1529 he went to Paris, where he was highly esteemed, and read public lectures on the Greek and Latin writers, and on logic. In 1537 he went to Strasburg, and the year following opened a school, which became famous, and by his means obtained of Maximilian II. the privileges of a university in the year 1566. He was very well skilled in polite literature, wrote Latin with great purity, and was an able teacher. His talents were not confined to the school; for he was frequently intrusted with deputations in Germany and foreign countries, and discharged these employments with great honour. He showed extreme charity to the refugees on account of religion: he not only laboured to assist them by his advice and recommendations, but he even impoverished himself to aid them. He died on the 3d of March 1589, in the eighty-second year of his age. He was a learned writer, and published various works, which were found to be useful and important by his contemporaries. One of these was an edition of Cicero, in 9 vols. 8vo. He bestowed much labour in elucidating the rhetorical works of Aristotle, Hermogenes, and Cicero. With the view of improving the system of education, he published several treatises, one of which was frequently reprinted. It is entitled *De Literarum Ludis recte aperiendis liber*, Argent., 1538, 4to. F. A. Hallbauer edited a collection of his tracts under the title *De Institutione Scholastica Opuscula omnia*, Jenæ, 1730, 8vo.

STUTTGART, a town of Germany, capital of the kingdom of Würtemberg, on the Nesenbach, an affluent of the Neckar, 38 miles E.S.E. of Carlsruhe, and 97 S.E. of Frankfort. It occupies a very beautiful situation in a valley closely environed with vine-clad hills, and further off with woody mountains. The old part of the town lies low, and has narrow crooked streets and insignificant houses, mostly built of wood; but the more modern portion, which occupies a loftier position, consists of straight, broad, and regular streets, with large and handsome houses. The place is almost entirely of modern growth, and owes its present prosperity in a very great degree to its being the residence of the court. The principal street occupies the site of the ancient city moat; it is straight and broad. Opposite the royal palace is a large public square; and there are several others of smaller size in different parts of the town. The new palace was begun in 1746 and finished in 1806. It is a large building of freestone, not very fine externally, but splendidly decorated and furnished in the interior. The old palace, which stands to the south-west, is a massive building resembling a feudal castle. It was completed in 1570, and is now occupied by the government offices. This edifice fronts a square, two sides of which are formed by another palace, that of Prince Frederic, the king's son-in-law. In the square stands a large bronze statue of Schiller, by Thorwaldsen; and on its other side is a fine old Gothic Church of the fifteenth and sixteenth centuries. It has a lofty tower, and contains a fine organ, many ancient sculptures, and monuments of many princes of the Würtemberg family. The hospital church is also Gothic; its exterior is clumsy, but the interior is very fine, and contains the grave of Reuchlin, and Danneker's model of his statue of Christ, now at Regensburg. The other churches in the town are modern and of little merit. The *Ständehaus*, where the estates or parliament of the kingdom meet, was built in 1580, but only adapted to its present purpose in 1819. The town-hall, which stands in the market-place in the older part of the town, is a building of the fifteenth century. Stuttgart has also a Museum of Natural History, containing a valuable collection; a public library of 200,000 volumes, and about 3220 MSS., including a very large collection of Bibles; a royal cabinet of medals, containing about 17,000 specimens, besides various other antiquities; a museum of the fine arts, with many fine statues and pictures; a theatre, bazaar, post-office, and other buildings. The educational establishments comprise a gymnasium, military academy, school of art, polytechnic school, and others. There are numerous hospitals, asylums, alms-houses, and other benevolent institutions. A striking feature in this comparatively small town is the number of barracks which it contains. The infantry barracks is one of the largest buildings of the kind in Germany; it can accommodate with ease 3000 men. There are besides cavalry barracks of somewhat less size. The principal manufactures of the town are the making of woollen and cotton cloth, gold, silver, and bronze wares, musical, optical, and philosophical instruments, and the various branches of industry connected with the book trade, which is extensively carried on here. There is also a considerable trade in bark. The town is advantageously situated for commerce, as by means of the Neckar it communicates with the Rhine, and by railways with the principal towns of Germany. In the vicinity of Stuttgart there are some fine gardens and pleasure-grounds; among the rest those of the palace, to which the public are freely admitted. The date of the foundation of the town is not exactly known, and there are no important events connected with its history. Pop. (1858) 51,655.

STYLES. See CHRONOLOGY.

STYLITES, SIMEON, a famous anchoret in the fifth century, who first took up his abode on a column six cubits high, then on a second of twelve cubits, a third of twenty-two, a fourth of thirty-six, and on another of forty cubits, where he thus passed thirty-seven years of his life. The tops of these columns were only three feet in diameter, and were defended by a rail that reached almost to the girdle, but did not permit the votary to lie down. Other solitaries who practised this sort of stupid devotion were known by the name of "Pillar Saints." The faquirs, or devout people of the East, imitate this mode of life to the present day.

STYRIA (Germ. *Steyermark*), DUCHY OF, a province of the Austrian Empire, bounded on the N. by the archduchy of Austria; E. by Hungary; S. by Croatia and Carniola; S.W. and W. by Carinthia and Salzburg. Its form is very irregular. Length, from N. to S. 124 miles; greatest breadth, 112; area, 8646 square miles. Pop. (1857), exclusive of the military, 1,070,747. (See AUSTRIA.)

STYX, a waterfall of Greece, descending from a lofty rock above the town of Nonacris, in the N.E. of Arcadia, and forming a stream that falls into the Crathis. The descriptions given by Homer and Hesiod of the water of the Styx agree with the natural features of this mountain-torrent; and Pausanias states that the passage in which Homer represents Juno as swearing by the Styx seems just as if the poet had the waterfall before his eye. The water was supposed by the Greeks to be poisonous, and to destroy everything that was thrown into it; and there was a report that Alexander the Great was poisoned by the water of the Styx. A similar belief has prevailed in the vicinity down to the present day. In Greek mythology, the Styx was represented as a river of hell, round which it flows nine times. The gods held its waters in such veneration, that to swear by them was reckoned an oath altogether inviolable. If any of the gods had broken this oath, Jupiter obliged them to drink the waters of the Styx, which lulled them for a whole year into a senseless stupidity. It is said that this veneration was shown to the Styx, because it received its name from the nymph Styx, who, with her three daughters, assisted Jupiter in his war against the Titans. Styx was a river which it was necessary for departed shades to pass before they could enter the infernal regions; and it was the office of Charon to ferry them over. Mythological writers have said that the Egyptians framed

both this and some other fables relating to the dead, from certain customs peculiar to their country; that in particular there was, not far from Memphis, a famous burying-place, to which the dead bodies were conveyed in a boat across the Lake Acherusia; and that Charon was a boatman who had long officiated in that service.

SUAKIN, a seaport of Nubia, on an island close to the shore of the Red Sea, N. Lat. 19. 7.; E. Long. 37. 20. Besides the town itself, on the island, there is on the mainland the much larger suburb of El Geyf. The houses are built of blocks of madrepore; and are one or two storeys in height. The town itself has three mosques, and the suburb another. The bay forms a good harbour; and the town is an important trading place between the interior of Africa and the opposite coast of Arabia. From three to four thousand slaves are annually shipped from this port to Arabia. Gold, tobacco, ostrich feathers, ivory, salt, &c., are among the articles of commerce. Suakin is much frequented by pilgrims to Mecca. Pop. 8000.

SUAREZ, Francis, a renowned Jesuit, was born at Grenada on the 5th of January 1548. He belonged to a noble family, and was sent to prosecute the study of law in the University of Salamanca; but when he had finished his course, he was induced to change his destination, and assume the habit of St Ignatius. He at first experienced much difficulty in comprehending the principles of the philosophy which was then taught; but having been placed under the guidance of Rodriguez, he soon began to be distinguished by the uncommon rapidity of his progress, and became one of the most distinguished members of the society. Having taught philosophy at Segovia, he was afterwards employed in teaching theology at Valladolid, Rome, Alcala, and Salamanca. Wherever he taught, his lectures attracted a numerous auditory. He was at length appointed to the first chair of divinity in the university of Coimbra; but, before entering upon his office, he went to Evora and took his doctor's degree. Here his reputation continued to increase. At the instigation of the Pope, he prepared an elaborate work, entitled *Defensio Catholicæ Fidei contra Anglicanæ Sectæ Errores*, Conimbricæ, 1613, fol. This work gave much offence to King James, and was burned at St Paul's by the hands of the hangman. Nor did it receive better treatment from the parliament of Paris; who, by an *arrêt* pronounced on the 26th of June 1614, condemned it to the flames, as containing maxims contrary to the rights of sovereigns. It was ably refuted by Robert Abbot, afterwards bishop of Salisbury. Suarez, having been called to Lisbon for some weighty conference, died there on the 25th of September 1617. An instant before he expired, he said to those who surrounded his bed, "I never knew it was so pleasant to die."

Suarez was a great master of the scholastic philosophy and theology of his age, nor was he a mean or ordinary proficient in jurisprudence. Grotius has described him as the most acute of philosophers and divines. His treatise *De Legibus et Deo Legislatore*, is commended by Sir James Mackintosh, "as exhibiting the most accessible and perspicuous abridgment of the theological philosophy in its latest form." Of this learned Jesuit, the works are very numerous. An edition of them in twenty-three vols. fol. began to be published at Mentz and Lyon in the year 1630. An edition was published at Venice in the year 1740.

SUBIACO (anc. *Sublaqueum*), a town of the Papal states in the Comarca, and 34 miles east of Rome, on a hill near the right bank of the Teverone. It stands in the midst of beautiful scenery; but has itself dark narrow streets, lined with old and gloomy houses. On the top of the hill stands an old castle, which was long a summer residence of the Pope. Subiaco has also a handsome church, containing many works of art; and in the vicinity are the remains of a palace of Nero, and a fine monastery. Pop. 6000.

SUBPŒNA, in *Law*, a writ by which persons are called into chancery, in cases where the common law has provided an ordinary remedy; and the name of it proceeds from the words therein, which charge the party called to appear at the day and place affirmed, "sub pœna centum librarum," &c.

SUCHET. See France.

SU-CHEW, a city of China, in the province of Kiang-su, on the Great Canal, near Lake Tai-hou, 55 miles W.N.W. of Shanghai. Like Venice it is built on islands, and interpenetrated by canals, which are navigable for large vessels. It is surrounded by fortifications, 10 miles in circuit; and beyond these there are four large suburbs. Here are numerous fine temples and other buildings; manufactures of silk, nankeen, and other goods are carried on, and there is an active trade. Su-chew is not only the residence of the richest merchants of China, but a flourishing seat of art and science, taste and beauty, for here are to be seen the most beautiful women in China; and hence it has received the name of the paradise on earth. Pop. 600,000.

SUCKLING, Sir John, an English poet and dramatist, was the son of Sir John Suckling, comptroller of the household to King Charles I., and was born in the year 1608–9. He discovered an uncommon aptitude for the acquiring of languages, insomuch that he is reported to have spoken Latin at five years of age, and to have written it at nine. When he grew up he travelled; but seems to have affected nothing more than the character of a courtier and fine gentleman, which he so far attained that he was allowed to have the peculiar happiness of making everything he did become him. In his travels he made a campaign under the great Gustavus Adolphus; and his loyalty, if not his valour, appeared in the beginning of our civil wars; for, after his return to England, he raised a troop of horse for the king's service, entirely at his own charge, and mounted them so completely and richly that they are said to have cost him L.12,000. This troop, with Sir John at its head, behaved so ill in the engagement with the Scots upon the English borders, in 1639, as to occasion a famous lampoon, composed by Sir John Mennis, which was set to a brisk tune, and much sung by the parliamentarians. This disastrous expedition, and the ridicule that attended it, were supposed to have hastened his death; but he survived till the 7th of May 1641. Some say that he died by his own hand at Paris, and family tradition confirms the report. He was a sprightly wit and an easy versifier, but no great poet. His poems, plays, speeches, tracts, and letters were collected into an octavo volume in the year 1709; and another edition, consisting of selections from his writings, with a life, by Rev. Alfred Suckling, appeared in 1836.

SUDBURY, a market-town and municipal borough of England, Suffolkshire, on the left bank of the Stour, 16 miles S. of Bury St Edmunds, and 54 N.E. of London. It is a neat, clean, and generally well-built town, connected by a bridge across the river, with a suburb, Ballingdon, in Essex. The principal buildings are the town-hall and corn exchange, of modern erection, and three parish churches of older date. The latter are large and handsome, chiefly in the perpendicular style of architecture. One of them, St Gregory's, contains in its chancel the grave of Archbishop Theobald, who was killed by Wat Tyler's mob in 1381. The Dominican friars had a church and priory here, erected in the thirteenth century; but of these few remains are now to be seen. There was also here anciently an establishment of the knights of St John near the bridge, and a Benedictine cell not far off. Sudbury contains places of worship for Independents, Baptists, and Quakers; a grammar school, national, British, and Church of England schools; a theatre, savings bank, hospital, and poor-house. Silk is the principal article manufactured. A considerable trade is carried on; but the navigation of the river is not

Sue.

good, and has been superseded to a large extent by railways. Weekly markets and annual fairs are held in Sudbury. The borough is governed by a mayor, four aldermen, and twelve councillors. It formerly returned two members to Parliament, but was disfranchised for bribery in 1844. Sudbury was one of the first towns in which Edward III. settled the Flemish woollen manufactures, in order to instruct his people in that branch of industry. This trade has now fallen off here, but has been succeeded by the manufacture of silk. Sudbury was the birthplace of the celebrated painter Gainsborough. Pop. 6042.

SUE, Eugène, a popular French novelist, was born at Paris on the 10th of December 1804. He belonged to a family of physicians, who had distinguished themselves in more than one reign of the sovereigns of France. His father was household physician to Napoleon, and the future novelist was presented at the font by the Empress Josephine and her son Eugène Beauharnais. Having received his name from so illustrious a house, it became his care afterwards to do what he could to render it immortal. Sue originally began the family profession, but gave it up in a short while for the more showy career of a military man. After pursuing his adventures both by land and sea for a number of years, he in 1831 returned to Paris, where he found his father dead, and some L.1600 a year awaiting him. He began to spend it with great good-will, and took to writing first as an amusement, and subsequently as a necessity. His first novels were received with neglect, such as *Plick et Plock*, 1831; *Atar-Gull*, 1831; *La Salamandre*, 1832; *La Coucaratcha*, 4 vols., 1832–34; *La Vigie de Koat-Ven*, 4 vols., 1833. Next followed his conspicuous failure, *L'Histoire de la Marine Française*, 5 vols. 1835–37, which provoked the waggish jocularity of some of the naval officers at Toulon, who presented the author with a silver medal to express "the gratitude of the French navy to Eugène Sue for the history he has not written." Numerous romances followed this historical attempt, in which vice, as is usual with French novels, triumphed over virtue. In 1840 M. Sue resolved to try the virtuous novel, and, as a commercial speculation, it had an amazing success. One of the great literary events of Louis Phillippe's reign is described as the publication of Sue's *Mathilde*, in 6 vols., 1841. On this followed in close succession, *Les Mystères de Paris*, 10 vols., 1842; *Le Juif Errant*, 10 vols., 1844–5, all which appeared in the pages of *La Presse*, *Les Debats*, and *Le Constitutionnel*. This literary lion, for such he had now become, was feasted and praised as only Frenchmen can praise and feast. This vicious panderer to the lowest feelings and worst passions of the mob was, to the great mass of the French people, the immortal delineator of manners, and the most exquisite writer which had ever appeared. This virtuous author would not hold his public in suspense, he accordingly gave them *Le Morne au Diable*, 2 vols., 1842; *Martin l'Enfant Trouve*, 12 vols., 1847; *Les Sept Péchés Capitaux*, 16 vols., 1847–49. The *Mystères du Peuple*, 1849-56, was in process of publication when, in 1857, it was condemned, and suppressed as immoral and seditious by the assize court of Paris. This was a timely hint to Sue that his services were no longer needed as the instructor of his age. He afterwards wrote, with a marked decrease of popularity, his *Les Enfans de l'Amour*, 4 vols., 1850; *La Bonne Aventure*, 6 vols. 1851; *Ferdinand Duplessis, ou Memoirs d'un Mari*, 6 vols, 1852. In 1848, Sue, who was an extreme Socialist, was elected a representative of the Assemblée Nationale; but on the election of Napoleon III. he was expelled from the French territory. He retired to Annecy, where he died on the 3d of July 1857.

Suetonius.

SUETONIUS, C. Tranquillus, a celebrated Roman historian, who flourished in the reigns of Trajan and Hadrian. The facts known about his biography are few, and are mainly derived from the letters of Pliny, and from one or two allusions in his own works. He was born about the year A.D. 70, since he calls himself "adolescens" at the period of the false Nero's appearance in Parthia, which was twenty years after the true Nero's death, A.D. 68 (Nero, c. lvii.), and "adolescentulus" in the reign of Domitian (Domit., xii.) His father, C. Suetonius Lenis, was a tribune of the 13th legion, and probably of equestrian rank (*augusticlavius*), and he had been present at the battle of Bedriacum, in which Otho was defeated by Vitellius (Otho, x.) In the face of this direct testimony, it is absurd in Muretus to argue, from a supposed various reading, that the father of the historian was that famous Suetonius Paulinus whose splendid achievements have been recorded by Tacitus.[1] Nor it is possible that Paulinus could have been his grandfather, since Suetonius would otherwise have unquestionably mentioned the fact when he alludes to his grandfather in the Life of Caligula (c. xix.) Why he altered the cognomen Lenis into Tranquillus is uncertain; perhaps merely from the same sense of euphony which induced Melancthon to Græcise his own harsh German patronymic. At one time Suetonius was in the army, and Pliny, to whose friendship and patronage he owed most of his advantages, obtained for him the rank of tribune; this position was, however, unsuited to his studious habits, and at his own request it was transferred to one of his relatives.[2] He also seems to have practised at the bar, for he begs Pliny to procure him a delay in pleading a cause in consequence of an ill-omened dream.[3] But we should infer from the term "scholasticus" which we find applied to him, and from the fact that Suidas[4] only calls him a grammarian, that his *public* appearances as an orator were few, although he may have given private lessons in rhetoric as well as in grammar. He generally lived in Rome or its environs, and his circumstances must have been easy, for he requests Pliny to purchase for him a little estate which had many attractions.[5] The same firm and constant friend obtained for him the *jus trium liberorum*, although, as he had no children, he was not legally entitled to enjoy it: the privilege was so important, that it was only obtained by the exercise of strong court influence.[6] Suetonius was finally elevated to the post of *magister epistolarum*, an office probably founded by Hadrian,[7] which would be likely to give him ample opportunities of private intercourse with the emperor,[8] and a free access to the imperial archives. He lost this office in consequence of an indiscreet familiarity with the Empress Sabina, and Septicius Clarus, the prætorian præfect, with many others, were involved in his disgrace. We can account for this conduct when we are told that Hadrian himself was in the habit of treating his wife like a common servant, and that she was ultimately driven to commit suicide. This example was one which courtiers would not be slow to imitate, but Hadrian resented it as *unauthorized* ("*injussu ejus* familiarius se egerant)."[9] That there was nothing directly *culpable* in the conduct of Suetonius is clear, both from the language of Spartianus, and from the certainty that the moral character of the empress afforded her husband no pretext for the divorce which he so ardently desired. This event took place in the year 119; and although we acquit Suetonius of *guilt*, it is clear that his behaviour must have been notoriously irregular, or it would hardly have reached the ears of Hadrian, who was at that time busily engaged in building the great wall by which he hoped to protect Britain from the incursions of the Picts and Scots. From this time forward

[1] Tac. *Ann.* xiv. 29–37, &c.
[2] Plin. *Epp.* iii. 8.
[3] Id. i. 18.
[4] Suid. s. v. Τράγκυλλος.
[5] *Epp.* i. 24.
[6] Id. x. 95, 96.
[7] Gutherius *de Officiis domus*, sug. iii., 6, quoted by Bayle.
[8] Suet. Aug. 5.
[9] Spart. *Vit. Hadr.* xi., and Salmasuis in loc. Aurel. Vict. Hadr.

we lose sight of Suetonius, who probably spent the remainder of his life in the composition of his numerous works, and the uninterrupted enjoyment of literary pursuits.

It is difficult to estimate the personal character of Suetonius: except his rudeness to Sabina, we know of no positive facts against him, and Pliny speaks in the highest terms of his learning and uprightness. "Suetonium Tranquillum," he writes to the emperor, "*probissimum, honestissimum*, eruditissimum virum, et mores ejus secutus et studia jampridem, domine, in contubernium assumpsi; tantoque magis diligere cæpi, quanto hunc propius inspexi."[1] On the other hand, it is impossible to acquit him of the grossest and most detestable prurience in his writings. He gloats over the distortions of debauchery, and betrays a hideous familiarity with the arcana of crime. He clearly enjoys the loathsome details of excesses which exhausted the fertility of a vicious vocabulary,[2] or he would not go out of his way to record them with such fatal accuracy. There is something sickening in the manner in which he thinks it necessary to chronicle with the minutest fidelity the merely personal excesses of a series of monsters; and the words "de quibus *singillatim ab exordio* referam"—which preface two chapters wherein he sees fit to plunge us under the Stygian stream of iniquity, which even the vilest of emperors thought it necessary to conceal on an inaccessible rock—are unmatched for their philosophic indifference.

It is no excuse to say that he is merely recording facts, and that the record was necessary and desirable for the warning of mankind.[3] When we have paid Suetonius the very questionable compliment of St Jerome, that he wrote as freely as the emperors lived, we have said all that can be said in his apology. But there are some facts so horrible, that as their commission is an insult to humanity, so the narrative of them is an unpardonable injury. We hold with Tacitus, "Ostendi debent scelera, *abscondi flagitia*." It is true that we find in the highest and holiest histories a record of the most fearful crimes, but the *manner* of the record makes all the difference. In Tacitus, nay, even in the Holy Scriptures, we find proofs sufficiently deadly of human depravity; but they are narrated only with horror and reluctance. Quintilian's dictum, that "historia scribitur ad narrandum non ad probandum," though it has been taken as the motto of an historical school, may serve to excuse the cold and naked analysis of Suetonius, but could never be adopted by men whose powers of moral indignation have been unweakened by familiarity with vice. It is unjust to compare Suetonius and Tacitus in their account of the same disgraceful enormities. Tacitus alludes to them, indeed, but only in such a way as would make the blush of honest shame burn on every cheek; Suetonius lingers over them with a gloating curiosity, which makes him share their guiltiness. Tacitus writes to visit the offenders with the vengeance of posthumous execration; Suetonius perseveringly degrades himself into an incentive of jaded sensuality. Of him, as of writers like Spartianus[4] and Lampridius, we are forced to say, "*parum abest a docente qui talia narrat;*" and we agree with Muretus, that the biography of the emperors is a course of reading "ruinous to youths, and dangerous even to men of full years."[5]

As an historian, Suetonius ranks very low. "He was a man of great learning, and did not write badly; but he had no survey of his subject, nor any historical talent. His description of the time in which he himself lived is even worse than those of previous periods, in which he had the works of others which he could follow; and this circumstance is the best evidence that he had no vocation to write history. His history is written in the form of biographies, and this idea is quite right; but he had no plan: he wanders about from one subject to another, in consequence of which his biographies are without any definite character."[6] For chronology he is nearly worthless, and he was incompetent to form any distinct or profound conception of those whose lives he wrote. He heaps together a loose and incoherent heap of separate details, from which we must judge for ourselves. No doubt he was accurate, impartial, and laborious, and was in no hurry to publish his writings[7] until he had carefully elaborated them; but he must be regarded, not as an historian, but as an "anecdotier," a very good name applied to him by Laharpe. In spite of the pains which he took to collect information from every possible source—tradition, conversations, documents, memoirs, inscriptions—we should find ourselves very much at a loss for anything like history, if we had nothing to guide us but his scandalous gossip. Linguet, in the *Révolutions Romaines*, went so far as to say, that no fact need be believed if Suetonius was the only authority for it; but Krause[8] and others have sufficiently defended him from the charge of wilfully perverting truth, although he occasionally admits an incredible calumny.

Suetonius is valuable as the commentator and supplement of Tacitus. It is doubtful whether the *Vitæ Cæsarum* or the *Annales* were written first, but Niebuhr thinks it certain that the work of Suetonius was published early in his life, and that it would not have been so unsatisfactory as it often is, if he had been able to avail himself of the guidance of Tacitus.

Napoleon[9] once remarked, that Tacitus did not explain how it was that the emperors, monsters as they were, continued the idols of the people. This enigma is solved by Suetonius, who ruthlessly pulls up the curtain which hides the dark interior into which Tacitus would not condescend to intrude. The people, as Montesquieu has observed, did not hate those in whom they saw a magnified reflection of their own baseness, and at whose hands they received the spoils of wealthy families and fertile provinces. In supplying us with the facts that were requisite for a complete understanding of a deeply interesting, though a deeply degraded period, Suetonius has rendered a service which almost makes us forget his slugglish sensibilities, in admiration for the interest of his communications, and the graphic simplicity of his style.

Suetonius was a voluminous writer. Besides the *Vitæ XII. Cæsarum*, and the treatises, *De Illustribus Grammaticis*, and *De Claris Rhetoribus*, the extant lives of Terence, Horace, Lucan, Juvenal, Persius, and Pliny the Elder, pass under his name; and Suidas attributes to him a long list of other works of which only small fragments exist, and the names of which are hardly worth recording. He was long a favourite author, and the editions of his works are very numerous; before the year 1500 there were no less than fifteen editions, of which the oldest with a date is, Romæ, 1470. Others are—Casaubon, Paris, 1610; Schild., 1647; Burmaum, 1736; and Baumgarten-Krusius, ed. Nase., Paris, 1828. There is an expurgated French translation by Duteil., 1699; and English translations by Philemon Holland, 1606; and S. Thomson, 1796. (F. W. F.)

SUEUR, LE. See PAINTING.

SUEVI, the name given by the Romans to a large section of the people of ancient Germany. The meaning of the name is unknown; and it cannot be determined, with

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[1] *Ep.* x. 95. [2] *Tac. Ann.* vi. 1. [3] This is the defence urged by Erasmus, *Epist. dedic. ad opp. Sueton.*, &c.
[4] Tillemont, *Hist. des Emp. II.*, 488.
[5] On this subject see some passages quoted in Bayle; Muretus, Tillemont, and others, censure Suetonius, while Politian, Erasmus, Mothe-le-Vayer, &c., defend him. [6] Niebuhr's *Lect.*, iii. 170, 211. [7] Plin. *Ep.* xi. 5.
[8] *De Suetonii auctoritate*, 1841. [9] Charpentier, *des Ecrivains Latins*, p. 376.

any approach to certainty, whether it is of Teutonic, Celtic, or Slavonian origin. A similar obscurity hangs over the people themselves. According to the accounts of Cæsar, they dwelt on the east bank of the Rhine, about the modern Baden; but Tacitus places them further to the north-east; and Strabo asserts, that in his time they occupied the country between the Rhine and the Elbe, and even stretched beyond the latter river. The name was probably a general one, including many distinct tribes, such as the Semnones, Longobardi, Chatti, &c.; and as Germany became better known to the Romans, the general appellation was dropped, and the several tribes designated by their particular names. Towards the end of the third century we find the name again restricted to the district to which Cæsar applied it; and from this use of the term has come the modern *Swabia*, *Swabians*, &c.

SUEZ, a seaport-town of Egypt, situated at the head of the Gulf of Suez, the western and longer of the two arms in which the Red Sea terminates,—76 miles E. of Cairo, in Lat. 29. 57. 30. N., Long. 32. 31. 30. E. It is a small town, having a stationary population of only about 1600, but is of importance as being one of the stations on the overland line of route to India. The streets are unpaved, and houses are in general poorly built. The only respectable building in the place is a large and handsome hotel recently erected by the Pasha. The town is protected on three sides by a wall mounting a few cannon. It has a good quay, but only boats of not more than 60 tons can come up to the town, larger vessels having to anchor in the roadstead about two miles off. The country around Suez is a perfect desert, no fresh water nor any kind of verdure being to be seen, and hence water and all kinds of provisions have to be brought to it from a great distance.

SUEZ, *Gulf of*. See RED SEA.

SUEZ, *Isthmus of*, a neck of land connecting the two continents of Asia and Africa, and separating the Red Sea from the Mediterranean. Its breadth between the two seas is 90 miles, from the Gulf of Pelusium to that of Suez. The connection of the Mediterranean with the Red Sea by means of a canal has long been a very desirable object, and even as early as the time of the Pharoahs, several centuries before the Christian era, such a canal was constructed, extending from the Nile near Belbeis to the Gulf of Suez. (See EGYPT.) In recent times Napoleon projected a canal across the isthmus, and predicted that the execution of this great work would promote the prosperity and ensure the safety of the Turkish empire. Since the overland route was established, the importance of such a work has been deeply felt, and in 1852 M. F. de Lesseps, a French engineer, conceived the idea of forming a joint-stock company for cutting a ship-canal across the isthmus. In 1854 he received a firman from Mohammed Said, the viceroy of Egypt, conferring upon him the exclusive privilege of forming a company for that purpose. He then proceeded to Constantinople to obtain the adhesion of the Porte, and at first it is said that the Sultan was favourable to the scheme, but he deferred giving his sanction to it at the instance, it is said, of Lord Stratford de Redcliffe, the British ambassador, who wished to communicate with his government. In the summer of 1855 M. de Lesseps came to England for the purpose of giving information on the subject of his scheme. The same year a commission of eminent engineers of various countries was appointed to make an examination of the proposed route. The report drawn up by them was to the effect "that the direct canal between Pelusium and Suez was the only solution of the problem, and that there existed no other practical method of joining the Red Sea with the Mediterranean; that the execution of this maritime canal was easy, and its success certain; and that the two harbours required to be constructed, as Suez and Pelusium presented no difficulties but such as were of an ordinary character." A few days after the reports of the commission, on 5th January 1856, the charter of concession was granted by the Viceroy of Egypt. According to it the works to be executed are—1. A canal navigable by large vessels between Suez and Pelusium; 2. A canal of irrigation adapted to the river traffic of the Nile, and connecting that river with the Suez Canal. 3. Two branches for irrigation and supply, striking out of the preceding canal in the directions respectively of Suez and Pelusium. These works to be completed within six years, and four-fifths of the workmen employed to be Egyptians; Lake Témsah to be converted into an inland harbour fit for vessels of the highest tonnage; a harbour of refuge to be constructed at the entrance of the maritime canal into the Gulf of Pelusium; and the necessary improvements to be made in the port and roadstead of Suez. The Egyptian government to have a claim of 15 per cent. on the net profits of each year. It is farther provided that the canal shall always remain open as a neutral passage to every merchant-ship; that the maximum toll for passage shall be 10 francs per ton on ships and per head on passengers; and that the provisions of this charter shall be in force for ninety-nine years after the opening of the canal.

The isthmus from Pelusium to Suez forms a longitudinal depression. It is believed that at one time the two seas were united, and even now a considerable portion of the soil is below the level of the two seas. There are three of these depressions or basins,—the Bitter Lakes, Lake Témsah, and Lake Menzaleh. The basin of the Bitter Lakes extends over an area of 81,612 acres, and is altogether dry. Lake Témsah is midway between the two seas, forming, as it were, the centre of the isthmus. It covers about 5000 acres, and it is said that at very little cost it might be made into a large and safe inland harbour. On the north-west mouth of the isthmus, and separated from the Mediterranean by a narrow strip of land which the waves overleap in rough weather, is Lake Menzaleh, which communicates with the Mediterranean. The rest of the isthmus has an elevation of from 5 to 8 feet above the level of the two seas, with the exception of two inconsiderable ridges, the Serapeum and El Guisr,—the former having a medium height of 30, the latter of 45 feet. The cutting in the latter of these will extend over about 5 miles. In November 1858 the subscription was opened, and by the end of the month the entire capital of L.8,000,000 was subscribed for; and the company was definitely constituted on the 5th of January 1859. The Ship Canal is to be 90 miles in length, 330 feet wide at the water-line, and its bottom 20 feet below low water-level in the Mediterranean. The present port of Suez is to be improved and deepened, and a harbour is to be formed in the Gulf of Pelusium. Lake Témsah is to be formed into an inland harbour, communicating with the Nile by means of a canal 80 feet wide on the water-line, and about 22 feet deep.

We have here followed principally the account of M. de Lesseps, but it is evident that, in such an undertaking, there are difficulties to contend with that do not seem to have been sufficiently taken into account. The works employing many thousands of men are to be carried on in a sandy desert many miles from a spot where a drop of water or a morsel of food can be obtained; while the canal, when completed, will always be in danger of being injured by drifting sand. From the nature of the Gulf of Pelusium, a harbour can only be formed here by means of piers carried out for several miles, while the immense quantity of sand and mud carried down by the Nile, constantly drifting about on this coast, will render it liable to be blocked up by the formation of bars.

A railway has been constructed from Alexandria to Cairo, and a portion of the continuation to Suez is now open.

SUFEID KOH, or the WHITE MOUNTAIN, a range in Afghanistan, running from E. to W., parallel to the Hindoo Koosh, to the south of the Valley of the Cabool, about N. Lat. 23. 50.; E. Lon. from 69. 30. to 71. 16. It is chiefly of primary formation, and consists of three parallel chains, the two lower of which are covered with pine-forests; while the highest is rocky and precipitous, rising above the line of perpetual snow. The culminating point of the range is 14,100 feet above the sea.

SUFFOLK, a maritime and agricultural county, in the eastern district of England, is bounded on the N. by Norfolk, W. by Cambridgeshire, S. by Essex, and E. by the German Ocean. Its length in a direct line from east to west is 56 miles, its breadth from north to south 32. It has nearly 50 miles of sea-coast on the eastern side. The area is 1481 square miles. It contains 947,681 statute acres, and 499 parishes. It is in the sees of Norwich and Ely, and in the Norfolk circuit.

Suffolk presents a gently undulating and diversified surface, but there is not an eminence worthy of particular mention in the county, and, excepting the Fens in the Mildenhall district, is not low. The woods are of small extent, and are not generally of luxuriant quality. The streams are numerous, though by no means large. The principal rivers are the Orwell, Gipping, Deben, Yare, Alde, Blyth, and Lark. There are also the Waveney, Little Ouse, and Stour; but these are border rivers, the two former separating the county from Norfolk, and the latter dividing it from Essex. There are a great number of fine springs and rivulets intersecting almost every part of the county. The turnpike roads in every part of the county are excellent, and so are most of the cross-roads. The Eastern Counties, the Eastern Union, and the East Suffolk Railways, run the entire length of the county. In the summer season sea-bathing attracts a considerable number of visitors to the shore at Lowestoft, Southwold, Aldeburgh, and Felixstowe, where every accommodation for such visitors is provided. The soil is so exceedingly variable, that it is difficult to define the localities of each. The heavy land district constitutes what is known as central Suffolk. The eastern Sands, extending from the mouth of the Deben to Yarmouth, is very light, and much of the district, from Beyton to Mildenhall, and from Newmarket to Brandon, consists of a blowing sand on a light chalky clay. The Fen district occupies the extreme north-west corner of the county, and is of very small extent. The quantity of pasture-land is much reduced. Formerly Suffolk sent large quantities of butter to the London market, now both butter and cheese are imported to supply the demand and consumption in the county itself. The rotation and manner of cultivation in the *heavy* land district is—first year, fallow, tares, beet, or turnips; second year, barley; third year, half clover, half peas, or beans alternately; fourth year, wheat. There is much variation in the course of cropping among the small farmers, but on the best cultivated farms this may be taken as the general course. On the *light* land a different course of management is adopted, but it is generally farmed on the four-course system. Thorough draining is much practised in the county. Beet-root has in some measure superseded the growth of carrots. Sainfoin and trefoil are cultivated in the sand district between Thetford and Newmarket. Flax has attracted much attention, but has made but little progress. Lucerne is grown on a small scale, and chicory has also been introduced. A few hops are cultivated, but only in two or three places in the county.

Suffolk takes a high rank as an agricultural county, but of late years a much smaller proportion of its population than formerly has been dependent upon agriculture for their subsistence. At the census in 1851, the returns relating to occupations refer to *individuals*, whilst those for 1811, 1821, and 1831 refer to *families*. It is not easy, therefore, to exhibit the proportion which the agricultural, commercial, and miscellaneous bore to each other at each of the decennial periods; but a gradual increase in the number of persons employed in trades, manufactures, and handicraft, has been going on in this county during the last quarter of a century. In 1851 the returns relating to those employed in agriculture and connected with land were—land proprietors, 423; farmers, 5637; farm bailiffs, 581; farm-servants (indoor), 645; agricultural labourers (outdoor), 42,783.

The draught-horses peculiar to the county are known by the name of Suffolk punches. They are excellent workers, are in great demand, and sell at high prices. Suffolk cows are generally considered to fill the pail better than any other kind. On the light soils extensive breeding flocks of sheep are kept, generally Down ewes, a little cross with the Norfolk to increase their size. There are but few Leicester flocks, and fewer still of pure Norfolk.

The net rental of landed property in Suffolk is estimated at L.912,062. The property is much divided, and there are no estates so large as to create a decided political preponderance; and it is said that there is in Suffolk a larger number of proprietors occupying their own lands than in any other county. On the heavy lands, farms seldom exceed 300 acres in extent, and are generally much smaller. On the light lands they vary from 300 to 1500. There are but few large farms, though there are many large farmers, men holding several farms, but more than half the farms in Suffolk range between 50 and 300 acres.

The following peers derive their titles from places in this county:—Earls of Suffolk, Orford, Euston, and Stradbroke, Viscount Brome, and Barons Rendlesham and Worlingham. The Dukes of Norfolk, Grafton, and Hamilton and Brandon; the Marquises of Hertford and Bristol; Lords Thurlow, Calthorpe, Huntingfield, and Henniker, also have seats in the county.

There are but few manufactures in the county; for although the cloth trade, introduced by the Flemings, at one time flourished, and nearly every labourer's wife was engaged at her spinning-wheel, the occupation has now entirely died out. Agricultural implements are perhaps more extensively manufactured in this than in any other county in England. Stays are made on a large scale at Ipswich. Silk winding and straw-plaiting give employment to large numbers at Sudbury, Lavenham and Hadleigh. A few are employed in the manufacture of lace, and a smaller number in the preparation of flax. Along the coast there is a great number of fishermen, and at Lowestoft many vessels are equipped. The herring fishery is an important one to that district. The fish are dried in houses erected on purpose in the town. At an earlier period of the year the same persons are engaged in the mackerel fishing, and the fish are transmitted by rail to the London market.

The population of this county at the six decennial periods of enumeration was found to amount in 1801 to 214,404; in 1811 to 233,963; in 1821 to 271,541; in 1831 to 296,317; in 1841 to 315,073; and in 1851 to 337,215. At the census in 1851 the males numbered 166,308, and the females, 170,907.

The number of inhabited houses in 1851 was 69,282; the uninhabited were 3107; and those building, 449. The annual value of the real property of the county, as assessed for the purposes of the property-tax in the year 1813, was L.1,127,404; in 1851, it was L.1,834,252. The annual value of real property rated to the poor was, in 1850, L.1,366,648.

The towns of this county containing more than 2000 inhabitants, with their population in 1851, were the following:—Ipswich, 32,914; Bury St Edmunds, 13,900; Lowestoft, 6781; Sudbury, 6043; Woodbridge, 5161; Beccles,

Suffolk. 4398; Mildenhall, 4374; Bungay, 3841; Stowmarket, 3306; Hadleigh, 3716; Halesworth, 2662; Long Melford, 2587; Eye, 2587; Framlingham, 2450; Southwold, 2109; Gorleston, a suburb to Yarmouth in Norfolk, and, by the Reform Bill, a part of that borough, 3999.

On looking at returns as to the social condition of the people in Suffolk, some curious facts present themselves for notice. Only 40 per cent. of the population are attendant upon the services of the Church of England; but 86 per cent. of the marriages in the county are celebrated according to the rites of the Establishment. The births are 1 in 32 of the population, and 8 per cent. of the births are classed as illegitimate. The deaths are 1 in 51 of the population, the proportion in all England being 1 in 46, and in Norfolk 1 in 48. The criminal returns exhibit a great increase of crime during the century. In 1801 the criminals were 51 in each 100,000 of the population, and in 1821 they were 93, in 1841, 157; and in 1851 the proportion was 168. The population increased 56 per cent.; crime more than 300 per cent. in the half-century. Pauperism is the plague spot of the county. In 1851, of every 10,000 persons 153 were paupers; whilst in Great Britain only 65 in every 10,000 were so classed. One out of every 12 persons in this county is a pauper, and the average cost of relief during the five years ending 1852 was L.142,688 per annum. The educational returns of this agricultural district are almost as discouraging. In 1851 there were 143 parishes, nearly one-third of the entire number of parishes in the county, in which, if there was a school, it was only a dame's school; 90 of these were entirely without a school. In the hundreds of Hoxne and Resbridge only 8 per cent. of the males attended school; and in a large number of the schools throughout the county the average time of a child's attendance is less than 2 years. Out of 1219 indoor paupers in Suffolk 10 only could read and write well; nearly 80 per cent. of the felons are without education, and 46 per cent. of the men and 52 per cent. of the women who are married are unable to sign their names to the marriage registers. In 1851 there were 20 literary and mechanics' institutes, having 2689 males and 119 females as members. The libraries contained 33,296 volumes. The attendance upon religious worship at the same period was found to range from 58 per cent. in the Hundred of Resbridge to 27 per cent. in the Hundred of Mutford. There were 895 places of worship, with 239,403 sittings.

Amongst the antiquities of the county, the foremost place must be given to the Roman castle at Burgh, the walls of which are still standing. There are several churches in Suffolk, portions of which lay claim to Saxon antiquity, as the Tower of Flixton, near Bungay. Norman architecture is of very frequent occurrence in the churches of the county. Several of these also display magnificent wooden roofs which exhibit a combination of boldness, picturesque effect, and geometrical skill. Of ancient monastic buildings, in which Suffolk was once so prolific, the remains are but few. The gateways of Bury Abbey attest the grandeur of this wealthy establishment, and at Butley, Sibton, Herringfleet, Bungay, and Leiston are more or less picturesque remains of former monastic splendour. Of castellated architecture, Orford, with its polygonal keep 90 feet in height; Framlingham, a mere shell of a proud fortress; Bungay Castle, with its massive ruins, as well as those of Wingfield and Mettingham, recall the stern magnificence of feudal times. Suffolk is especially rich in examples of domestic architecture. Helmingham, Hengrave, Melford, Kentwell, Parham, Flixton, Wenham, and Roos Halls are fine monuments of the taste, splendour, and hospitality of our wealthy ancestors.

The civil government of the county is peculiar. There are four sessional divisions in the county, named after their respective chief towns, Beccles, Woodbridge, Ipswich, and Bury. Each of these divisions has from time out of mind been considered a county by itself. Beccles has its own sessions, levies its own rate, repairs its own bridges, and pays the whole of its own charges; and Bury, Ipswich, and Woodbridge divisions do the same. Three boroughs, Bury St Edmunds, Ipswich, and Sudbury, have separate commissions of the peace and courts of quarter sessions. There are county gaols at Ipswich and Bury St Edmunds, a county-house of correction at Beccles, and borough prisons at Ipswich and Sudbury. The county is divided into twenty-one hundreds, besides the liberty of the borough of Ipswich, and is also sub-divided into the Geldable portion and the liberties of St Etheldred, St Edmund, and Duke of Norfolk. The liberty of St Edmund formerly returned a grand jury at the assizes distinct from that returned for the rest of the county; that privilege was abolished in 1837, and the assizes have since that period been held in the spring at Bury St Edmunds, and in the summer at Ipswich.

Suffolk returned sixteen members to Parliament prior to the passing of the Reform Bill, but Aldborough and Dunwich were disfranchised by that Act, and Eye reduced to one member. Sudbury has since been deprived of its privilege, on the ground of corruption. The county is divided, for electoral purposes, into two divisions, the eastern and the western. Each division returns two members. The polling places for the eastern division of the county are—Ipswich, Needham, Woodbridge, Framlingham, Saxmundham, Halesworth, Beccles, and Lowestoft. For the western division the places for polling are—Bury St Edmunds, Lavenham, Stowmarket, Wickham Brook, Mildenhall, and Hadleigh. Two members are also returned for each of the boroughs of Ipswich and Bury St Edmunds.

Sugar. SUGAR. Referring to CHEMISTRY (vi., 515–17) for the composition and chemical relations of sugar, we propose in the present article to give a brief technological view of the subject. Sugar, in one or other of its varieties, is widely diffused, and imparts sweetness to the juices of many vegetables. The practice of sweetening food is older than the knowledge of sugar. The ancients used honey for the purpose; and when the sweet produce of the cane became known it was called *mel arundinaceum*. In the first century, Dioscorides refers to the canes of India and of Arabia Felix as producing honey, and applies to it the term σακχαρον, or sugar, which Pliny refers to as being used only in medicine. Sugar was not known in northern Europe, at least as an article of food, until the time of the crusades. The sugar-cane was introduced into Cyprus from Asia, and was noticed in A.D. 1148 as being extensively cultivated in that island. It was transplanted from Cyprus to Madeira, and thence, in 1506, to the West Indies. The sugar-cane is said to have been also cultivated on the coasts of Andalusia before the invasion of the Arabs, who seem to have introduced the method of boiling down the juice for the production of sugar. The refining of raw sugar is of later date, and is referred to Venice. The refining of sugar was commenced in England about 1544; but *loaves of sugar* are spoken of as being sold in Scotland so early as 1329. There was a refinery in Dresden in 1597. Sugar-candy is noticed in the *Alchemia* of *Libavius* in 1595, and this is probably the form in which sugar was known to the ancients. The general introduction of tea and coffee caused a great demand for sugar, before which, and so late as the end of the seventeenth century, syrup and honey were in use among the poorer classes of Germany. In 1747, Margraaf discovered cane-sugar in the roots of many plants, especially in beet-root; but no attempt was made to manufacture that variety of sugar on an extensive scale until the time of Napoleon, who, in attempting to ruin the colonial trade of Great Britain, excluded our merchant-ships from the conti-

nent, and, to supply the demand for sugar, offered premiums for its manufacture from beet-root. Much skill and ingenuity were exercised in the manufacture, which is still extensively carried on in countries where the richer juice of the cane is excluded from competition by heavy imposts.

The sugar-cane (*Saccharum officinarum*) is a perennial plant, belonging to the family of the grasses. It varies in height from 6 to 15 feet, and upwards, and in diameter from $1\frac{1}{2}$ to 2 inches. Its stalk is knotty, with a leaf and an inner joint at each knot. The roots are slender, and nearly cylindrical, about a foot in length, furnished with a few short fibres.[1] The joints of the stalk or cane may vary in number from 40 to 60, and in the Brazilian cane they are as many as 80. The Otaheite cane has fewer joints, and they are further apart. Every joint contains a bud, which encloses the germ of a new cane. "The joints of the cane," as Mr Porter remarks in his work on the sugar-cane, (1843), "may be considered as concentric circles, the centre of which is always occupied by a point, which, expanding into a circle itself, is replaced by a new point,—circles which, rising successively one upon the other, enlarge and arrive in a given time at their greatest diameter." The first joint requires 4 or 5 months for its complete growth, during which 15 or 20 joints spring from it in succession, the decay of the leaf indicating the maturity of each joint; and when the leaves of the first two or three joints have withered, there are 12 or 15 leaves at the top, arranged like a fan. The last joint is called the *arrow;* it is 4 or 5 feet in length, and is terminated by a panicle of sterile flowers. The period of flowering is usually delayed by cultivation, new joints being formed instead. The sugar-cane requires a moist, nutritive soil, and a tropical or sub-tropical climate. It is propagated by slips or pieces of the stem with buds on them, and it requires from 12 to 16 months to arrive at maturity. The leaves fall off before flowering, and the stem becomes of a straw-yellow colour. The plantation should be managed so that the canes may ripen in succession. The land, unless naturally rich, requires abundance of manure, but saline matter should be avoided, since common salt, chloride of potassium, and muriate of ammonia, form non-crystallisable compounds with the sugar. One equivalent of common salt, for example, = 60, will combine with two equivalents of sugar = 342, and thus cause a loss of sugar $6\frac{1}{4}$ times greater than the weight of the salt in the compound. Beet-root sugar factories situate near the sea-shore have experienced great losses from this cause, which also operates to some extent on the windward coast of Barbadoes. After the cane harvest, the roots strike again and produce a fresh crop, but in about six years they must be removed: this period, however, is subject to variation in different places. The canes should be cut in dry weather: they should have a smooth, brittle skin, considerable weight, greyish pith, and a sweet, glutinous juice. The developed buds which form the secondary stole of the plant that has been cut are named *rattoons*, and they are *first*, *second*, or *third*, &c., according to the age of the parent root. They diminish every year in thickness and length of joint, and are said to yield a richer juice and to produce finer sugar than the original plant. The canes should be cut close to the stole, for this gives vigour to the rattoons, and, moreover, the lowest joint contains the richest juice. The cane-top, with one or two joints of the cane, must be cut off and rejected, as the juice of those parts is watery. The canes are tied up in bundles and sent to the crushing-mill, the amount of work done by this regulating the quantity of canes to be cut; for if the cut canes are kept many hours, they will ferment and spoil. The cane-mill usually consists of three massive cast-iron rollers, about 24 inches in external diameter, with projecting rims to prevent the canes from spreading over the sides, arranged horizontally, two below and one above and between: they are worked by means of toothed wheels attached to the axles. The canes are passed down an inclined plane between the first lower and the top roller, and, being crushed between them, are guided by plates between the top roller and the second lower roller, where the crushing is completed. The juice passes into a channel below, and thence to a reservoir. The first pair of rollers crushes the cane, and the second pair expresses the juice, and turns the crushed cane down a trough out of the mill. The first lower roller is usually grooved. In order to obtain the largest proportion of juice, the rollers must be set very close together, and revolve slowly under steam-power. It is stated that when the power was wind, only from 50 to 56 per cent. of the juice was obtained; animal-power gave 58·5; water-power, 61·8; and steam, 70 per cent. In general, however, the average of steam is not superior to that of water. From 12 to 14 tons of good ripe cane produce about 1500 gallons of juice, which are required for making one hogshead of sugar. The crushed cane known as *cane-straw*, *begasse*, or *cane-trash*, is used as fuel in evaporating the juice; it contains at least 18 per cent. of cane-juice. The opinion has been repeatedly expressed that the cane-trash should be returned to the land as manure, and, if spread over the spaces between the cane-roots, it would also serve to mitigate the effects of severe drought. Coals can be sent to the colonies from Great Britain at a cheap rate to supply the demand for fuel.

The juice of the cane is a solution of sugar in water, with traces of albumen, of gum, and of a peculiar substance resembling gluten, or vegetable gelatine; also a minute proportion of cerosin, and of a green vegetable wax. The mineral ingredients resemble those of other plants and vegetable juices, and consist of the sulphates of lime and of potash, chlorides of potassium and of sodium, phosphate of lime, silica, &c. The juice has usually a yellowish colour, but is sometimes colourless, and greyish globules suspended in it render it turbid. It has an agreeable but rather insipid taste, and a peculiar balsamic odour. It contains from 17 to 20 per cent. of crystalline cane-sugar; but the planter does not obtain more than $7\frac{1}{2}$ per cent. There is a loss of sugar in the mode employed of expressing the juice from the cane; and, secondly, a loss arising from the chemical change due to exposure to the air, whereby the crystalline sugar becomes degraded into mucilaginous or non-crystalline sugar, commonly called *molasses*. Indeed, did space permit, it would be easy to show that the loss to the planter commences in an imperfect system of agriculture, the ground being worked by hand-hoeing instead of deep ploughing, and from a frequent absence of agricultural and manufacturing machinery of improved construction.

The exposure of the juice to the air of a tropical climate, even for half an hour, would cause fermentation to set in; lime is therefore immediately added for the purpose of neutralizing the acid, and rendering some of the soluble impurities insoluble. The old method of clarification, or defecation of the juice, is by heating it in iron pans or *teaches*, arranged together in a row, and heated by one common fire. The juice-reservoir below the crushing-mill supplies the largest pan, the fifth in the row, and farthest from the fire, with juice. The milk of lime, or *temper*, as it is called, is equal to about $\frac{1}{800}$th of the weight of the juice, but the proportion varies with the quality of the juice, and the effect of the heat, which should not exceed 140°, is to

[1] There are three species of cane recognised by the cultivator:—1. The *Creole* cane, with dark green leaves and a thin knotty stem; it is indigenous in India. 2. The *Batavian* or *Striped* cane; it has a dense foliage, and is covered with purple stripes. 3. The *Otaheite* cane, which is the most luxuriant and juicy, and is cultivated in the West Indies and South America.

coagulate the albuminous portions of the juice, which rise to the surface in the form of scum. This is removed by skimming, and the juice is passed through the other four teaches, and evaporated at increasing temperatures until the sugar will crystallize out on cooling. Scum collects on the surface of each teache, and a greal deal of it is nearly pure sugar decomposed by the heat; it is passed into the molasses cistern, and is used for making rum. The teaches diminish in size as the juice diminishes in volume, and it is ladled by hand from one teache to another, thereby leading to further deterioration by exposure to the atmosphere. The syrup is passed from the last, or *skipping teache*, to the coolers usually by means of shoots, and it is known when the *granulating* point has been attained by taking a portion of the syrup upon the thumb, and placing the forefinger upon it, separating them so as to draw out a thread, and if it extend to the length of about an half-inch, the sugar is judged to be sufficiently boiled. This trial by the *touch* is thought to have given the name of *teache* or *tayche* to the pans, the term being sometimes restricted to the last or hottest pan. The coolers are shallow, open vessels of wood, in which, in the course of twenty-four hours, the sugar *grains*, or forms into a soft mass of crystals, embedded in molasses. The temperature in the coolers is rendered equable by stirring up the mass from time to time with iron rods. The contents of the coolers are removed to hogsheads, or *potting-casks*, placed on an open framework in the curing-house. The bottom of each cask is bored with holes, an inch in diameter, each hole containing a plantain stalk, or a crushed cane, long enough to reach to the top of the cask. The soft sugar is placed in these casks, and the molasses gradually drain away through the spongy stalks into a cistern lined with lead, forming the molasses reservoir. It may take from two to six weeks before the sugar is sufficiently dry for shipment; and there is a further drainage of molasses in the hold of the vessel, promoted by the deliquescent salts absorbing the damp air, and entailing a further loss of sugar, said to amount on an average to 12 per cent.

Such is the old system of manufacturing sugar, which, we regret, is not yet altogether abandoned in our colonies. Under this system it has been calculated that from every 1000 parts sugar-cane, from 60 to 80 parts raw sugar, and from 25 to 30 of molasses, are obtained; while, according to chemical analysis, the yield should be from 180 to 200 parts of crystallized sugar. Mr Kerr states, that of the 1500 gallons of juice required for a hogshead of sugar, netting 15 cwt. in the English market, the planter does not get a return of more than 6 per cent. of moist Muscovado sugar, and that of very inferior quality.

In proceeding to notice the more important of the improvements which have been suggested, and in many cases adopted, for improving the manufacture of raw sugar, we may state that the objects had in view have been the protection of the juice from fermentation, and its concentration with as little agitation and exposure to the air, and at as low a temperature as possible. Dr Mitchell proposed to dip the canes into hot water as soon as they are cut, for the purpose of coagulating the albumen, and preventing it from passing into the juice, and also to destroy the vitality of the glutinous fermenting matter. M. Payen recommends sulphurous acid or bi-sulphite of lime to be used instead of milk of lime. The French have also invented a contrivance for raising the juice from the crushing-mills to the clarifying vessels with but little agitation, by means of an apparatus called a *monte-jus;* in which steam acting on the surface of the liquor forces it up a pipe into the clarifier. This vessel, too, instead of being a naked copper, exposed to the fire, is surrounded by a cast-iron jacket, and steam being admitted into the space thus formed, a moderate and regulated temperature can be commanded. The bottom of the pan is furnished with a plug, containing two or three holes, one for disposing of the clear liquor, and another, and larger one, for passing off the thick scum and sediment. The juice is clarified at a temperature of 176°; particles which rise to the surface are skimmed off, and milk of lime is added in quantities just sufficient to neutralize the acid, and this is regulated by the frequent use of litmus-paper. When the scum on the surface begins to crack, the steam is shut off, and the whole is left for fifteen or twenty minutes, during which time the lighter impurities will have risen to the surface, and the heavier ones will have subsided. A hole in the plug, 3 or 4 inches above the bottom, is thrown open, and the liquor, which should be pale and clear, allowed to flow out; the heavy matters and the scum are passed through the larger opening into a cistern, and then placed in bags, and the juice expressed. The clarified juice still contains matters in suspension, which are removed by passing through fine copper-wire sieves, or flannel-bag filters, from which the filtered liquor is passed through a bed of bone-black, by means of which vegetable colouring matter is more or less removed, together with any excess of lime, and also mineral salts, originally present in the juice. The filtered liquor is next concentrated in open pans, heated by means of steam-pipes to about 25° to 28° Beaumé. The further concentration of the juice is completed in the vacuum-pan, as in the refining of sugar. There is also another contrivance for preparing the juice for the vacuum-pan. A series of straight copper pipes, placed one above the other, with the ends fixed in cast-iron boxes, or united by curved end pieces, is placed so as to receive the waste steam of the vacuum-pan, and over this arrangement of pipes thus heated, the weak juice is made to fall in a multitude of drops; so that while condensing the steam within, the juice sends off a considerable portion of vapour, and falls in a more concentrated state into a vessel below, from which it can be pumped up into the vacuum-pan.

As the vacuum-pan is no longer restricted to the refining of sugar, it may be noticed in this place in connection with the manufacture of the raw product. It depends for its action on the principle that liquids boil at temperatures dependent on the pressures they have to sustain. Thus water, under a pressure of 30 inches barometer, boils, that is, becomes rapidly converted into steam at 212° F., whereas water *in vacuo* will boil at about 80°. The vacuum-pan was patented by Howard in 1812; it consists, in its improved modern form, of a copper pan with a cast-iron jacket, within which steam is admitted for heating the pan, while within the pan, and corresponding to its curvature, is a worm or coil of copper pipe, through which steam is passed for boiling the juice. The pan is covered by a copper dome, fitting to it air-tight. In order to preserve a vacuum, or at any rate a greatly reduced pressure within the pan, the steam, as fast as it is generated by the boiling of the juice, is pumped out into a condenser, and condensed by the injection of cold water, or by the trickling of weak juice over a system of condensing pipes, as above described. In order to withdraw and examine the juice during the boiling, without disturbing the vacuum, a cylinder passes from one side of the domed top down into the liquor, which cylinder contains a piston called a *proof-stick*, furnished with a notch or receptacle, which becomes filled with sugar on plunging it down the cylinder, and can be withdrawn to a sufficient extent to bring the sample to the outside. A thermometer passes through an air-tight collar for indicating the temperature, and there is a barometer or vacuum-gauge for showing the internal pressure. There is also a measuring vessel of about 35 gallons, for regulating the quantity of juice admitted into the pan. There is also an overflow vessel for catching any liquor that may boil over from the pan. There are also peep-glasses in the domed top, one opposite to the other, so that, on looking through one, sufficient light

Sugar. passes through the other to show how the boiling is going on within. The bottom of the pan is a gun-metal saucer, ground into a socket, and on lowering this by means of a lever, the sugar can be run out of the pan. In connection with the vacuum-pan is also an expansion vessel for reducing the pressure of the steam to the point required within the pan. The heat employed for evaporating the weak syrup is from 180° to 190°; when the syrup begins to granulate the temperature is lowered to 160°, and just before the evaporation is completed, the temperature is lowered to 145°, the lowest temperature at which proof-sugar will boil under a pressure of 3 inches below a perfect vacuum. When the attendant finds by drawing out a thread against the light that crystals are beginning to form, he lets in another measure full of syrup into the pan, and continues the operation until the whole charge has been admitted. The crystals first formed seem to act as nuclei to the next charge. A large pan, 8 feet in diameter, for example, will boil 80 tons of sugar in 24 hours; but in smaller pans the skip or panful of concentrated sugar may be made in from 1½ to 2½ hours from the commencement of the boiling. Fine grained sugar requires a larger measure of syrup at each charge than the coarse. The concentrated juice, or *proof-sugar*, as it is called, consists of innumerable small crystals floating in syrup, and it is passed out of the pan at 145°, not into a cooler, as in the old process with the teache, but into a *heater* or copper pan, with an iron steam-jacket, raised to 180°, the temperature best adapted to the forming and hardening of the crystals. During this time the sugar is stirred with wooden oars to prevent granulation; it is ladled or run out into buckets or scoops, and so poured into moulds or small inverted cones, which are perforated at the point, but at first the hole is stopped with paper, and so they are left until the following morning at a temperature of about 100°, when the holes are opened and the temperature maintained for 3 or 4 days, during which time the process of *liquoring* is performed, that is, a saturated solution of pure sugar is poured into the top or wide part of the moulds, and this filtering through the mass carries with it the rest, or much of the colouring matter. The moulds rest with their points in pots or jars, which receive the drainings. When properly drained the sugar is turned out of the moulds in the form of loaves, which being trimmed to shapes, are dried in a hot room, and are then ready for the market. In this way, sugar, equal to refined, can be produced from the canes at one operation; indeed the work of the refiner in England is chiefly to remove the defects occasioned by the imperfection of the planter's apparatus: in fact, raw sugar, as generally supplied to the public, is a very impure product in consequence of defects in the manufacture which tend to lessen its sweetness, impart a coarse flavour, injure its colour, and render its solution milky or muddy. But in addition to chemical impurities, there are mechanical ones, such as earths, vegetable matters, and insects, the last of which may produce a well-known disease in the hands of the grocer.

The improved methods of manufacture which we have pointed out have been to a certain extent adopted, or are being gradually introduced. In Java, Cuba, and other places, where improved machinery has been introduced, an increase of from 30 to 40 per cent. on the quantity of sugar produced has been effected, while the market value has risen from 5s. to 10s. per cwt.

The various qualities of raw sugar imported into this country will be noticed presently; but it will be convenient first to review briefly the operations of the refiner. The cases, bags, and hogsheads of sugar are made to discharge their contents on the floor, and the casks are inverted over a steam-jet pipe, which quickly removes all the sugar that adheres to the staves. The sugar is passed through a sieve to break up the lumps, and water is added, and the solution quickly effected by the assistance of steam, which is made to blow up through a perforated pipe placed at the bottom of the pan; whence the melting pans are sometimes called *blow-up cisterns*. Even at this early stage it was recommended by the late Mr Finzel to substitute a vacuum-pan for the blow-up cistern, by which means the solution is said to be effected with greater rapidity, while exposure to air and high temperature are avoided. It has been found, however, in practice, that the impure sugars have so strong a tendency to froth up, that the vacuum-pan is constantly boiling over, so that the plan has been abandoned. While the sugar is being dissolved in the blow-up cistern, a small quantity of blood and some lime-water are added, to clarify the solution and neutralize the acid. The solution is kept in motion by a mechanical stirrer, or by two or three men with oars. The quantity of blood is not more than about ½ per cent., and its action is assisted by from 3 to 6 per cent. of powdered animal charcoal. The temperature is kept for a short time below 168°, at which the albumen of the blood coagulates, after which steam is fully admitted and the solution made to boil. The albumen being dispersed through the solution and then coagulating, forms a net which entangles the mechanical impurities, and rises with the charcoal in the form of a thick compact scum, which is removed. The liquor has been partly decolorised by the action of the charcoal, but it still contains impurities in suspension coated with albumen. The liquor is therefore passed through bag filters or long bags, from which it passes through charcoal beds, which, in the course of 15 or 20 hours, decolorise a quantity of syrup containing four times as much sugar as there is charcoal in the filters. The liquor is now passed into the vacuum-pan, and is concentrated to the density of 42° or 43° B. at a temperature varying from 230° to 240°. In this condition the sugar is held in solution by the high temperature, and when allowed to cool, rapid crystallization takes place, producing that fine sparkling grain which characterizes loaf-sugar. It is necessary, however, to transfer the liquor to the moulds at a certain temperature, just as the crystals have begun to form, and this is regulated in the vessel below the vacuum-pan into which the liquor is received, and from which a number of men fill their scoops and charge the moulds. The saccharine mass falls into the moulds with a sound as of wet sand, showing the formation of crystals in the mass. The moulds are of iron, coated with varnish or glaze, or painted. Galvanized iron moulds have been introduced, but they do not give to the surface of the loaf so good a texture as the ordinary iron moulds. The holes in the points of the moulds are stopped up during the filling, which is performed on the lowest floor, and they are raised by an endless chain or band, called a *mould-carrier*, to a floor above. The sugar is frequently stirred to prevent it from crystallizing at the sides, and to promote the formation of a compact net-work of small crystals enclosing the mother liquor or saturated solution, which is impure and coloured, while the crystals are pure and colourless. The liquid portion is somewhat viscid, and drains off with difficulty, although assisted by a temperature of 75° and upwards. When the plugs are removed, the draining is allowed to go on for 24 hours. The first syrup that drains off into pots or troughs placed to receive it is called *green* syrup; the after syrups are called *seconds* and *drips*, and are more valuable, because stronger and of better colour. The syrups are passed through funnels and pipes into their proper cistern, the different syrups being kept apart for re-boiling. After the sugar has set, the face is cut out with a trowel, and the scrapings, with other similar sugar material, is formed with water into a *magma* or pasty mass, which is poured into the several moulds for the purpose of removing the colouring matter. After this, nearly saturated solutions of refined or other white or fine sugars are applied cold to the surfaces in small quantities by means of a ladle

or a nose-pipe, the last in succession being the finest. By this means the coloured syrup is completely removed by the passing through of the pale or colourless syrups, and a coating of pure sugar is given to the grains, so that after having passed through the stove the sugar has lost its hygrometric quality, and remains permanent in the air.

The process of *claying*, as it is called, has the same object as the above, and may be used instead of, or in conjunction with it. White pottery clay, washed, to separate soluble matters, is made into a thin paste, and placed on the sugar in the mould, in a cavity formed by loosening and scooping out the sugar. It is also usual first to remove the sugar from the mould, and take away the solid crust formed at the point. The action of claying is as follows:—The water which separates drives the molasses before it, and becoming itself a saturated solution of sugar, sinks through the loaf, expels the mother liquor, and thus gets rid of the colouring matter. The syrup which drains off is termed *clayed syrup*. When the sugar is removed from the moulds, the point is usually knocked off, and a new top afterwards produced, by turning between crooked knives, and then the loaves are dried in a hot room at 77°, which is gradually raised to 122°.

The above methods of cleaning the sugar are tedious, and various modes of quickening the process have been tried; such as the action of compressed air on the surface of the mass; the production of a partial vacuum below the moulds (known as the *pneumatic* process); and thirdly, the *centrifugal* process; this has been tried in two ways. 1. The moulds, with their contents, were set in a circular machine, and whirled round with great velocity. This dangerous plan, however, has not come into use, at least not in Great Britain. 2. The sugar is run in a pasty state into the wire-basket, or perforated plate vessel of a *hydro-extractor*, which, revolving at the rate of several hundred turns per minute, during a period of from 3 to 15 minutes, according to the quality of the charge, a dry granular sugar is thus produced fit for the market. When the plan was first introduced by Mr Finzel, the product consisted of large beautiful crystals of pure sugar, which were for a time in favour; but the very perfection of the crystalline structure, rendering this sugar less soluble in the same time than an equal weight of a coarser raw sugar, it was declared not to sweeten so well, and it did not maintain the position it deserved. The plan, however, has since been modified: the apparatus has been simplified, and the granular syrups being put into the perforated cylinder, the latter is made to revolve from 1200 to 1500 times a minute during a space of five minutes, the result is a clean, granular, sparkling, light-coloured moist sugar, for which there is now a great demand in London. The syrups whirled out of the extractor during the process are boiled down with other syrups, and again passed through the machine. The centrifugal machine has been introduced into the colonies with advantage to the planter, and the marked improvement of his product. We may also mention, that the superior variety of treacle known as *golden syrup* is obtained by passing the treacle once through a charcoal filter.

Refined sugar, of the first quality, is prepared in small moulds, and the various syrups which drain off from it during the cleansing produce several kinds of what are called *bastard sugars*. Some of these syrups produce sugar too soft for loaf, but furnish a superior quality of moist sugar. Others are run into large bastard moulds, and are crystallized at a higher temperature in proportion as they are impure. A small first quality mould will contain about 30 lb. weight of wet granulated sugar, from which about 10 lb. of green syrup will drain off, and if the remaining 20 lb. be dried without claying, the weight will be 17 lb., but if clayed only 11 lb.; but the sugar is of the first quality. A bastard mould will contain 60 lb. of granulated sugar of the second quality, from which 25 lb. of molasses will drain off, leaving 35 lb. of unclayed moist sugar, or 32 lb. when dry; but if this be clayed and dried it will produce 17 lb. of second quality loaf-sugar. The time occupied in refining varies from 8 to 10 days, but for the inferior qualities longer. What is called *stamped* sugar is prepared from the inferior qualities, by grating the moist soft lump, passing the flour through a sieve, and, while moist, stamping it in layers in a first quality mould, from which it is removed and dried.

The large crystals of sugar known as *sugar-candy* are prepared chiefly in Holland and Belgium, from syrup boiled over an open fire, and set aside to crystallize in a vessel in which strings are stretched, to serve as nuclei to the crystals. In the course of six or eight days the crystallization is complete, and the vessel, which is contracted towards the bottom, is inverted, when, after breaking up the surface, the syrup drains off, and the crystals are removed and dried. The usual crystalline form is a six-sided prism, commonly flattened, and terminated irregularly. A solution of sugar, saturated at 230°, forms, in cooling, a granular mass, or *tablet;* but when rapidly boiled until it acquires a tendency to a vitreous fracture on cooling, or when sugar is fused at about 280°, or from that to 320°, so that a portion *feathers* or concretes on being thrown upon a cold surface, it may be poured out upon a marble slab, and will cool into an amorphous mass. Such is *barley-sugar*, so called from the sugar having been formerly concentrated by rapidly boiling in barley-water or sweet wort. It is usually sold in sticks, to which a spiral twist has been given while hot. This vitreous transparent substance deteriorates by keeping. It becomes opaque first on the surface, and then throughout the mass, passing in fact into the crystalline condition; heat is given out during the change. Confectioners add a little vinegar or tartaric acid to the sugar, which retards, if it does not altogether prevent, the opacity. The show-sticks resembling barley-sugar in grocers' windows are made of coloured glass.

The sugar-refiner receives most of the sugars of commerce into his establishment, and it will be well to enumerate the principal varieties of them here. West Indian and other American raw sugars are known as *Muscovado*, from the Spanish, or rather Portuguese word *mascabado*, "more advanced." These are made marketable by being crystallized and cleared of molasses, without any attempt to dry or decolorise them. They form the favourite *scale* or grocery sugars of this country, the muscovado of Jamaica being preferred. There is, however, an important exception in the case of Cuba, three-fourths of the sugar from that island being clayed. Clayed sugar is not so large or well defined in its crystals as muscovado. The removal of the coating of syrup from the surface of its crystals gives it a grey and less pleasing shade or complexion than muscovado, which, when well made, is bright yellow or straw-coloured. The clayed sugars, therefore, are not used for grocery sale. What is called *white clayed* is that portion which forms the upper part of the mould in the process of claying; it is whiter or further removed from brown than ordinary clayed. Clayed sugars are commonly stronger, that is, they yield a larger percentage of refined sugar and less of the lower products than muscovado. The sugars of St Croix are much admired. The sugars of Porto-Rico and Barbadoes are esteemed; but the softness and quantity of *foot*, as the wet side of the contents of the cask is called, in the case of Barbadoes sugar, is an objection. The sugars of Brazil are usually clayed, and are sold as *white clayed* and *brown clayed*, the latter being nearer the apex of the mould. The Mauritius produces two-thirds as much sugar as all our West Indian colonies together. The sugar is subjected to a process analogous to claying; that is, it is washed with a surface application of concentrated cane-

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juice, which percolates through the mass as the water does in claying. Such sugar is spoken of as *claircé;* it is much esteemed by the refiners of France and of the United Kingdom. There is an inferior class of sugars (analogous to refinery bastards), known as *syrup sugars*, prepared from the molasses of the foregoing varieties, and from that obtained from lower kinds. The sugars of the British East Indies are made by various processes, and are of various qualities, as indicated by the names *Khaur*, *Goor*, *Jagery*, the two former belonging to Bengal, the last to Madras. Some sugars made by European refiners in Hindostan are named after the factories where they are worked, such as *Cossipore*, *Ballykhal*, &c. The sugars of Java are mostly clayed. They are well adapted for refining, and are chiefly used in Holland. The Philippine Islands produce *Manilla* sugar; it is a strong brown raw material, adapted for refining. Much of it is unclayed, and under the names of *Taal*, *Zebu*, &c., finds its way to the Australian and British markets. It is converted into yellow crushed sugar. In addition to these *tropical* sugars there are occasional importations of brown sugar in cakes or loaves (*Rapaduros*). Such sugars are made in small establishments, and are moulded often without parting with the molasses. Attempts have also been made to introduce cane-juice in a concentrated or inspissated state for the use of the refiners, but without much success. The *Melado* of Cuba is of this kind. The sugars imported into the British markets are distinguished as *British colonial*, *foreign*, and *beet*, the first being the produce of our own colonies, the last of the continent of Europe. *Maple sugar* is never imported except for presents. *Date sugar* is largely used by the refiners. *Beet raw sugar* is imported from France by the refiner, but requires to be used with caution on account of its peculiar flavour.

The packages in which sugar is made up are as varied as the sources of supply. West India muscovados are sent over in *hogsheads* (hhds.), *tierces*, (trs.), and *barrels* (brls.) The average net weights of the hogsheads are 10 and 18 cwts. respectively, those of Porto-Rico being the smallest, those of Jamaica the largest; of the tierces, 7 and 10 cwts., and of the barrels, 2 cwts. The clayed sugar of Cuba, called *Havannah* sugar, from the name of the principal port of shipment, is packed in boxes of about 4 cwt. It is the produce chiefly of the north side of the island, the southern side furnishing more muscovado or hogshead sugar. Much of the Brazil crop is packed in cases or chests of from 12 to 18 cwt.; but the more convenient and economical form of *bags* is superseding the unwieldy packages; the bag weighs about 160 lb. Mauritius sugar is shipped in *mats*, or bags covered with strong reed or cane matting, of about the same weight as the Brazil bags. East India sugar is supplied in bags of rather less than 2 cwt., that of Manilla in mats of from 50 to 150 lb., and that of Java in *baskets* or *kanasters* of from 5 to 6 cwt. The tares allowed on these several packages by the customs and by merchants vary in different places, the merchants' or market tare differing at different ports of the same country.

In the year 1843 the consumption of sugar in the United Kingdom was 202,400 tons; in the year 1859 it was 457,500 tons. In the year 1858 the quantities of unrefined sugar imported into the United Kingdom amounted to 9,010,813 cwts., of the computed real value of L.12,322,405. Of this quantity there were entered for home consumption 8,746,934 cwt. In the same year were also imported of refined sugar and sugar-candy 386,839 cwts., of cane-juice 56,418 cwts., and molasses 775,657 cwts., of which quantities there were entered for home consumption respectively, 257,339 cwts., 57,361 cwts., and 819,226 cwts., the last number including 17,553 cwt. delivered duty free for use in distilleries. The import of the refined sugar was of the computed real value of L.753,681, and of the molasses L.391,787. Raw sugar is entered as of first quality, equal to white clayed; second quality, not equal to white but equal to brown clayed; and third quality, not equal to brown clayed. Of the whole quantity of unrefined sugar imported into the United Kingdom in 1858, rather more than one-third, or 3,628,912 cwts., were from foreign ports, the remainder from British possessions. Of refined sugar and sugar-candy in the same year, 204 cwt. were from British possessions, and 386,635 cwt. of foreign, 326 cwt. of British, and 255,914 cwt. of foreign respectively. The duty on the unrefined sugar entered for home consumption amounted to L.5,848,170. Sugar, whether the produce of British or foreign possessions, being now subject to the same rate of duty, the custom-house entries have ceased to distinguish them, except as the port of shipment serves to indicate their origin. The average price for the year was 29s. 7d. per cwt.

On the continent of Europe the beet-root (*Beta vulgaris*) is cultivated on account of its saccharine juice being available for the manufacture of sugar. There are many varieties of this plant, such as the *large field beet*, the *disette* of the French, and the *mangel-wurzel* of the Germans. In this variety the flesh, skin, and leaf-stalk are white, the bulb is nearly cylindrical, protrudes much from the ground, and weighs 25 lb. and upwards. There is a sub-variety of a reddish colour, known as *long red mangels;* another variety of beet is represented by the *White Silesian;* it is somewhat pear-shaped, with a white flesh and skin, and occasionally rose-red rings in the flesh. Its largest roots do not exceed 5 lb. It abounds in sugar, and the juice is more free from salts and other injurious ingredients, so that it is a favourite with the sugar manufacturers. The three sub-varieties of the White Silesian are distinguished by the colour of the ring presented by a cross-section of the crown close to the bulb. The first is the *collet rose*, with a rose-red ring; the second the *collet vert*, with a green ring; the third the *collet jaune*, with a yellow ring. There is a third group of beet-root known as the *globular*, of which the *yellow globe mangel-wurzel*, or *Castelnaudary beet* is the type. It is pear-shaped, approaching to globular, with the skin flesh-yellow, or passing on into orange, yellowish-green leaf-stalks, and a soft and juicy flesh. It grows to a much larger size than the Silesian, and four sub-varieties of it are recognised. There is a softer variety than the Silesian, known as the *Siberian beet;* it is of a flattened pear-shaped form, with a white or occasionally rose-red flesh; the bulb grows almost entirely out of the soil, which is a disadvantage, since the part exposed to the action of the sun contains less sugar than the covered portion. All the varieties of beet tend to change their colour, and to become red in the skin and slightly rosy in the flesh; they do not, apparently, differ in chemical composition, although some are better adapted to the manufacture of sugar than others. The collet rose is said to contain the richest and purest juice and is most prized, but the *Quedlinburg beet* is preferred in North Germany; it is thought to keep better than the Silesian, and its juice to be less acted on by the air. The sugar of the beet is identical with that of the cane; it gradually increases in quantity until the beet is ripe, and by good cultivation, the percentage of sugar may nearly equal that of the sugar-cane. When the flower-stalk begins to form, the percentage of sugar declines; and when the seed is mature, it is almost nothing. Good beet contains, on an average, 10 per cent. of sugar, 3 of pectin, soluble salts, &c., and 83 per cent. of water, thus making 96 of juice, the remaining 4 parts consisting of albumen, woody fibre, and insoluble salts. The juice ferments like that of the sugar-cane, but mannite is produced at the expense of the sugar, and a kind of mucus is formed, which is precipitated by alcohol, and resembles gum-arabic. Beet will grow almost anywhere in the temperate zone, and upon all kinds

of soil, but a light rich loam inclining to clay rather than sand is best. Care should be taken in the application of manure, especially of the nitrogenous kind, lest the juice be rendered impure, and the proportion of fermenting azotised matter be increased. The beet-roots may be kept for some months in what are called *silos*, or shallow ditches dug in the sandy soil, protected from the air by a thatch, and built into trunks of wood in the mass, to serve as ventilating apertures. But there is danger of the sugar passing into the non-crystalline variety. The leaf-stalks and root are removed as soon as the plant is gathered; the former penetrate somewhat deeply into the bulb, and form the *heart;* this contains very little sugar, but a large proportion of salts, especially nitrates.

When the roots are to be used in the manufacture of sugar, the bruised, decayed, and mouldy parts should be cut away, or the juice may be injured. The bulbs are washed in a large revolving drum, formed of laths or bars of wood partly immersed in water; this gets rid of sand and earth. The axis of the drum is somewhat inclined; the bulbs are fed in at the upper end and pass slowly down to the lower, where they are raised by a scoop and thrown upon a lattice frame. They then pass through a rasping or grating machine, which tears open the cells containing the saccharine juice, and reduces the bulbs to pulp. This machine consists of a drum, the surface of which is thickly studded with teeth, against which the bulbs are pressed, while the drum rotates, and a stream of water plays against them, to prevent them from being clogged. The drum makes 700 or 800 revolutions per minute, and reduces from 300 to 350 cwt. of bulbs to pulp every day while it is in action. The pulp passes into a cistern below the rasp, and is immediately placed in bags of woollen cloth or hemp, and is pressed by means of a hydraulic press. The bags are separated from each other by means of metal plates, or hurdles of plaited willow twigs. After the pressing, from 15 to 20 per cent. of juice remains in the pulp. To recover a portion of this the bags are dipped in water containing 1000th part of tannin in solution, to check fermentation, when the bags swell up to their former bulk, and are again pressed. The juice is collected into a reservoir. The table at which the bags are filled is furnished with a gutter leading to the juice-reservoir, and in some cases the first pressure is made at this table by means of a small hand-press, which expresses 30 to 40 per cent. of the juice. The waste pulp or *husk* still contains a small proportion of sugar, and is used as food for cattle, mixed with other kinds of fodder. There is also a loss of sugar during the rasping and pressing, in consequence of exposure to the air, and some of the finer particles of the pulp find their way into the juice. Hence an attempt has been made to obtain the juice by maceration, such as cutting the bulbs into thin slices, and digesting them repeatedly in warm water; but the objection is to the great dilution of the juice by this means. Attempts have also been made to dry the beet-root as soon as it is harvested, so as to get rid of 83 per cent. of water; but the expense of fuel is an objection, although the method of manufacturing sugar from *cossettes*, as the dried fragments are called, is occasionally adopted; but here, again, in proceeding to the manufacture, water, or lime and water, must be added.

As soon as the beet-root juice is obtained, it is raised to the temperature of 140°, and the defecation is conducted by means of hydrate of lime. In order to clear the liquor, an excess of lime is used, and this is got rid of by means of ammonia alum, whereby sulphate of lime is formed, and, the alumina set free, assists the clarification. Pectic acid may also be employed to get rid of the lime, but there is an objection to sulphuric acid which was formerly used, for this converts some of the crystallizable sugar into glucose. The liquor is filtered through charcoal-beds, evaporated at a steam-heat in an open vessel to 25° B., filtered again, and then passed into the vacuum-pan. In evaporating the syrup, various forms of apparatus are in use, some of which take the place of the vacuum-pan, of which kind we may mention the evaporating cone of Lembeck, consisting of a double conical envelope about 16 feet high, heated by steam of the pressure of four or five atmospheres, while the syrup is distributed over the interior by means of a six- or eight-way-funnel, and in descending is divided and distributed by means of hollow conical segments, toothed at the lower edge. The exterior surface of the cone also receives a supply of the syrup which is to be evaporated, and as the syrup descends it increases in strength, and passes by small channels into a trough leading to a cistern. By means of a ball-cock arrangement the syrup is made to flow quicker or slower, according to the rate of evaporation.

The workmen have several kinds of tests for ascertaining the degree of concentration of the syrup. The *preuve au filet*, or *string-test* already referred to in the manufacture of raw sugar, consists in taking a drop of syrup between the finger and thumb, and if, on suddenly separating them, it draw out into a thread, the syrup is judged to be sufficiently concentrated; if the thread break and curl up into a little hook, the evaporation is said to have been carried to the *preuve au crochet*, of which there are two kinds, the weak and the strong. In making sugar-candy there is the *preuve au soufflé*, or bubble-test, in which a man dips a skimmer into the syrup, and removing it, holds it upright, and blows forcibly through the holes so as to form bubbles of syrup on the other side: if a number of bubbles are blown away, the proof is said to be *soufflé fort;* if only a few, *soufflé leger*. In making barley-sugar, &c., the proofs are *le petit cassé*, *le grand cassé*, and *le cassé sur le doigt*. In the first, the moist finger is dipped into the syrup, next into cold water; the sugar is then rolled up into a ball, and this, on being thrown to the ground, splits and loses its shape. In the second proof, the ball is so brittle as to fly to pieces by this treatment, and in the third it solidifies and becomes brittle on the finger. According to M. Payen, the foregoing tests depend upon the following temperatures and percentages of sugar:—

Tests.	Temperature.	100 parts contain	
	Fahr.	Sugar.	Water.
Filet	228·2°	85	15
Crochet leger	230·9	87	13
„ fort	233·6	88	12
Soufflé leger	240 8	90	10
„ fort	249·8	92	8
Cassé petit	251·6	92·67	7·33
„ grand	263·3	95·75	4·25
„ sur le doigt	270·5	96·55	3·45

There are certain points to be attended to in the defecation and clarification of the syrup, or the evaporation will not be successful. If there has been a deficiency of lime, the syrup will froth and foam in the boiling, to remedy which a lump of butter is thrown into the syrup, which spreads over the surface and lubricates the bubbles. If there has been an excess of lime the syrup will not boil, especially if much oxalate of potash be present in the beet. When the syrup is sufficiently concentrated, it is drawn off into coolers or heaters, as the case may be, then passed into moulds, where its treatment resembles that of cane-sugar.

We have referred to an excess of lime being injurious, and it is so chiefly in the mode of getting rid of it. Sugar unites with lime without changing its properties, and may be recovered with little or no loss. This fact has led to several plans for economising the manufacture of beet-root sugar; an excess of lime is employed for the purpose of converting the whole of the sugar into saccharate of lime; and then, after defecation and evaporation, the sugar is re-

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covered by saturating the lime with carbonic acid, obtained by the combustion of coke and charcoal. The advantages are, great saving in animal charcoal, and the protection of the juice from deteriorating influences.

The secondary products of the manufacture consist of the pulp, as already noticed, while the molasses contain the non-crystalline sugar, various salts, organic matters, gum or mucus, which imparts a nauseous taste; it is occasionally mixed with the refuse pulp, and is given to cattle, or is used in the production of alcohol. The scum, the bone-black, &c., are used as manure.

Although, as already stated, Napoleon I. endeavoured to encourage the manufacture of beet-root sugar in France, it declined after his fall; but in 1825 it revived again. In 1827–8 France produced 4000 tons of beet-sugar; in 1837–8, the production had increased to 39,000 tons; and in 1857–8 to 150,000 tons. In 1858–9 it was 130,000 tons. The French duties, as well as those in Belgium, are charged on the density of the juice as measured by the areometer.

In Germany the sugar-beet manufacture dates from about 1835. In 1858–9 the Zollverein worked up 36,668,557 cwt. of roots. There were 250 refineries in the Zollverein in 1859, of which number 221 were in Prussia. Up to 1853 the customs calculated 20 cwt. of roots as being equal to 1 cwt. of raw sugar. Since that date 15 cwt., and now even 12½ cwt. of roots are considered equal to 1 cwt. of sugar. The present duty is about 3 thalers 22 silbergroschen per cwt., and that from cane as used in the inland refineries 5 thalers. In the Austrian empire the quantity of beet-root worked up in 1859 was 16,042,248 cwt. Here also the system of protection is adopted in favour of beet-sugar.

In Belgium the quantity of sugar produced in 1859 was 18,000 tons. Here, too, there is a protective duty. It is stated that in Russia from 30,000 to 40,000 tons are produced annually.

Another source of sugar is the maple (*Acer saccharinum*), the sweet juice of which supplies the natives of the United States and Canada with a considerable proportion of their sugar. The juice is collected in February and March, when the sap is most abundant, for which purpose two holes are bored on the south side of the tree, 4 or 5 inches apart, and 18 or 20 inches from the ground. They are made to slope upwards, and not to penetrate more than half-an-inch into the white bark or splint of the stem. Wooden pipes are put into the holes thus formed, and the juice is allowed to flow during about six weeks into wooden troughs, from which it is removed in cans to reservoirs which supply the boiling pans, which are of the capacity of from 13 to 15 gallons. The juice must be removed from the troughs every two or three days, or it will ferment. The boilers are heated over a brisk fire; the scum is removed as it forms, and fresh juice is added to supply the loss from evaporation. The syrup is strained through a woollen cloth, boiled rapidly down in a second pan, cooled, and poured into moulds to crystallize. After the syrup has drained off, the resulting sugar is dry in the grain, of pure taste, and about equal to raw colonial sugar. There is a pleasant maple flavour belonging to this sugar; it finds a ready sale in the United States in the form of small, well-proportioned, square-sided cakes. In good seasons a tree will yield from 3 to 9½ lb. of sugar, and we have seen it stated that one sugar orchard has yielded on an average as much as 6 lb. per tree for 80 years. According to a recent calculation, as much as 27,000 tons of maple sugar are produced in the United States in one year.

Attempts have been made to manufacture sugar from the stems of Indian corn, from the common gourd, and from various kinds of palm. From the last-named source, a juice charged with cane-sugar is known in India as *toddy*, when fermented and distilled *arrack*; but by the evaporation of the toddy, the sugar known as *jagery* is obtained. The ryots or peasants of India cultivate the sugar-cane, express the juice, boil it down to a thick syrup, which, under the name of *goor*, is sold to the goldars, who produce the solid product. Other sources of sugar have been proposed, such as chesnuts, the fruit of the *Cactus Opuntia*, and a species of wild daffodil, *Asphodelus*.

The Chinese and African sugar-canes, known as the *sorgho* and *imphee* (*Holcus saccharatus*), are the names of gramineous sugar-bearing plants or millets: they were introduced to European notice in 1786 by Professor Pietro Arduino, of Florence, who attempted to introduce the imphee from Caffreland into Italy, but did not succeed. In 1851 the Count de Montigny, the French consul at Shanghai, sent home some seeds of the *Holcus saccharatus*; and about the same time Mr Leonard Wray called attention to the same plant as cultivated by the Zooloo Caffres, not for the purpose of manufacturing sugar therefrom, but for chewing and sucking the stalks. He discovered no less than sixteen kinds of imphee of various degrees of saccharine richness. The plant, however, has been cultivated as a source of sugar in China and Japan from time immemorial, and flourishes most on light sandy soils, and calcareous soils, but particularly on alluvial deposits. It has a tall straight stalk, 16 or 18 feet high, with knots or nodes at intervals, from which spring alternately long spreading, tapering, and drooping leaves. The outer coating of the stalk is smooth and siliceous, like the stalks of maize, and becomes harder as the plant approaches maturity. The seed is formed on the tuft at the top. The soft green pulp undergoes a change of colour as the plant ripens, becoming violet, then brown, and lastly purple, almost black. In this state the maximum of sugar is obtained. The *bagasse* or crushed stalks should, as in the case of the ordinary sugar-cane, be returned to the soil as manure. The sorgho has been introduced into the United States of America (*Sorgho and Imphee, the Chinese and African sugar-canes*, by Henry S. Olcott, New York, 1857). Various accounts have been given of its productiveness. A sample grown near Washington yielded nearly 14 per cent. of dry saccharine matter. Mr Wray's plants yielded 16 per cent.; some results are as low as 10, and others as high as 23 per cent. It is stated that an English acre of imphee will, if the circumstances be favourable, yield 2 tons and upwards of dry sugar; but Mr Wray does not estimate the average crop at more than 1½ tons.

The canes are cut as close to the ground as possible, the leaves are stripped off and the tuft removed, and they are carted to the mill as fast as they can be ground. After the crushing, the juice is immediately transferred to the boiler, and heated to about 180° Fahr., an infusion of nut-galls being added. The syrup is then raised to the boiling point, when the fire is suddenly checked, to allow the scum to rise to the surface and be skimmed off, when the heat is again urged until it granulates on cooling. The after-treatment of the sugar has no novelty requiring notice.

The sorgho and the imphee have been introduced into the West Indies, but they are not equal to the canes previously cultivated there. In the United States of America, however, where frosts are destructive to the ordinary sugar-cane, the new plants appear likely to be valuable. In 1857, according to Mr Olcott, 50,000 acres were under cultivation; but unfortunately this gives no information respecting the use of the imphee as a sugar-bearing plant, since much of the seed was sown for the sake of the green crops.

In this brief notice of a vast subject, our attention has been chiefly occupied with technological details. The subject may be profitably viewed from other points of view, such as the political, the commercial, the botanical, the chemical, and even the physiological. For informa-

tion under these heads the reader is referred to other parts of this work, and also to the following books and memoirs selected from the literature of the subject. Porter *On the Sugar-Cane*, 2d ed., 1843; Wray's *Practical Sugar Planter*, 1848; Evans's *Sugar Planter's Manual*, 1847; Kerr, *Cultivation of the Sugar-Cane*, &c., 1851; Knapp's *Technology*, English translation, vol. iii.; Scoffern, *Manufacture of Sugar in the Colonies*, 1849; Leon, *Art of Manufacturing and Refining Sugar*, 1850. There are also articles of importance in M'Culloch's *Commercial Dictionary;* Ure's *Dictionary of Arts*, &c.; Tomlinson's *Cyclopædia of Useful Arts*, &c. The manufacture of beet-root sugar is given at considerable length in Dumas's *Traite de Chimie appliquée aux Arts*, tome vi.; Payen's *Chimie Industrielle*, 1851; Dureau *De la Fabrication du Sucre de Betterave*, 1858. We have also to acknowledge the considerable assistance we have received in this article from manuscript information placed at our disposal by an eminent firm in Liverpool. Also to the Messrs Fairrie, the well-known sugar-refiners of Whitechapel, London, who allowed us to inspect their works, and furnished some interesting particulars for the purposes of this article. (C. T.)

SUHARUNPORE, a town of British India, capital of a district of the same name, in the N.W. provinces, 1007 miles N.W. of Calcutta, on the small river Dumoulao, about a mile from the Doab Canal. It stands in an open, level, and fertile region; and is surrounded by numerous groves of palms, mangoes, and other trees, which, as they display indications of care and intelligence not common in India, contribute, along with the many British residences in the environs, to give the place a very pleasant appearance, and to render it one of the handsomest English stations in the country. It has a fort, a military cantonment, and a government depôt. Here also is a botanic garden, formed in 1817, and now in a flourishing condition, and very tastefully laid out. Pop. (1848) 37,968. The district, which lies between the Ganges and the Jumna, the former dividing it from Gurhwal and Bignour on the east, and the latter from Serhond on the west, is bounded on the north by Dehra Dhoon, and on the south by Mozuffurnuggur. Its length is about 68 miles, its breadth 60, and its area 2165 square miles. The surface is very uniform, sloping gradually downwards from the Sewalik Hills in the north, and is only broken by ridges of low sand-hills parallel to the Ganges and Jumna. It is drained by small rivers flowing southwards, and falling into one or other of the great ones which bound the district. Owing to the high latitude and the elevation of the country, the climate is cooler than that of most parts of India, and there is a great range of temperature in the course of the year. The land produces wheat, barley, oats, pulse, and other vegetables, rice, cotton, indigo, and maize. Irrigation is carried on by means of the Doab Canal, which derives its water from the Jumna. Suharunpore was ceded to the British in 1803. Pop. 801,325.

SUHL, a town of the Prussian monarchy, in the province of Saxony, government and 30 miles S.W. of Erfurt, on the Aue or Lauter. It has several churches, a school, hospital, workhouse, and public offices. In the neighbouring country there are many iron forges, and mills for boring and polishing the metal. Suhl is a centre of the manufacture of arms, and of all sorts of hardware. Woollen and linen cloth, especially fustian, are also made here. Pop. 8892.

SUHM, PETER FREDERIK VON, one of the most laborious writers of Denmark, was born at Copenhagen on the 18th of October 1728. He is said to have read nearly all his father's library, consisting of some 1500 volumes, before he entered college in 1746. He began the study of jurisprudence, but soon turned aside from the law, even when the brightest prospects in that profession were luring him on, to pursue his literary tastes. He began by studying northern history and antiquities; and with that purpose he visited Norway, and remained there from 1751 to 1765. His best writings are—*Odin, or the Mythology of Northern Paganism*, 1771; the *Critical History of Denmark*, 4 vols., 1774–81; and the *History of Denmark*, 7 vols., 1782. He likewise wrote *Idylls* and *Tales* with grace and spirit. These will be found in his *Samlade Skrifter*, 16 vols., 1788–99. His benevolence was as conspicuous a feature of his character as his immense literary industry. His great library, consisting of 100,000 volumes, he threw open to the public, and he consented that it should be united to the royal library a short time before his death, which took place on the 7th September 1798.

SUICIDE, the crime of self-murder, or the person who commits it. Some crimes are peculiar to certain stages of society, some to certain nations. Suicide is one of those crimes which we are led to believe not common among savage nations. The first instances recorded of it in the Jewish history are those of Saul and Ahitophel; for we do not think the death of Samson a proper example. We have no reason to suppose that it became common among the Jews till their wars with the Romans, when multitudes slaughtered themselves that they might not fall alive into the hands of their enemies. Among the Greeks this crime was forbidden by Pythagoras, as we learn from Athenæus, by Socrates and Aristotle, and by the Theban and Athenian laws. In the earliest ages of the Roman republic it was seldom committed; but when luxury and the Epicurean and Stoical philosophy had corrupted the simplicity and virtue of the Roman character, they then began to seek shelter in suicide from their misfortunes or the effects of their own vices. The religious principles of the Brahmins of India led them to admire suicide on particular occasions as honourable. Accustomed to abstinence, mortification, and the contempt of death, they considered it as a mark of weakness of mind to submit to the infirmities of old age. A custom similar to this prevailed among many nations on the continent of America. When a chief died, a certain number of his wives, of his favourites, and of his slaves were put to death, and interred together with him, that he might appear with the same dignity in his future station, and be waited upon by the same attendants. This persuasion was so deeply rooted, that many of their retainers offered themselves as victims. A like custom prevails among many of the negro nations in Africa. The tribes of of Scandinavia, which worshipped Odin, the "father of slaughter," were taught, that dying in the field of battle was the most glorious event that could befall them. This was a maxim suited to a warlike nation. In order to establish it more firmly in the mind, all were excluded from Odin's feast of heroes who died a natural death. In Asgard stood the hall of Odin, where, seated on a throne, he received the souls of his departed heroes. This place was called *Valhalla*, signifying "the hall of those who died by violence." Natural death being thus deemed inglorious, and punished with exclusion from Valhalla, the paradise of Odin, he who could not enjoy death in the field of battle was led to seek it by his own hands, when sickness or old age began to assail him. In such a nation suicide must have been very common. Among the numerous Norse legends there are many picturesque instances of suicide. Beowulph's father, for example, is represented by the old scald as gathering his attendants around him by the seashore, to witness his embarkation for the other world. After arranging round him all the spoils of war which he had gained during his life, his money and his weapons, the old hero lay down by the root of the mast: the sails were set and the helm set fair, and the lonely old man in the lonely ship stood out to sea, and was never heard of more. As suicide prevailed much in the decline of the Roman Empire, when luxury, licentiousness, profligacy, and false philosophy pervaded the world, so it continued to prevail even after

Christianity was established. The Romans, when they became converts to Christianity, did not renounce their ancient prejudices and false opinions, but blended them with the new religion which they embraced. The Gothic nations, also, who subverted the Roman Empire, while they received the Christian religion, adhered to many of their former opinions and manners. Among other criminal practices which were retained by the Romans and their conquerors, that of suicide was one; but the principles from which it proceeded were explained so as to appear more agreeable to the new system which they had espoused. It was committed either to secure from the danger of apostacy, to procure the honour of martyrdom, or to preserve the crown of virginity.

Mercier says, that at Paris it was the lower ranks who were most commonly guilty of it; that it was mostly committed in garrets or hired lodgings; and that it proceeded from poverty and oppression. A great many, he says, wrote letters to the magistrates before their death. Dr Moore's correspondent from Geneva informed him that, from the year 1777 to 1787, more than 100 suicides were committed in Geneva; that two-thirds of these unfortunate persons were men; that few of the clerical order have been known to commit it; and that it is not so much the end of an immoral, irreligious, dissipated life, as the effect of melancholy and poverty. Quetelet, in commenting on the proportion of suicides annually committed throughout the world, gives the following:—Russia, 1 to 49,182 inhabitants; Austria, 1 to 20,900; France, 1 to 18,000; State of Pennsylvania, 1 to 15,875; Prussia, 1 to 14,404; city of Baltimore, 1 to 13,656; Boston, 1 to 12,500; New York, 1 to 7797.

The statistics of the registrar-general of England and Wales give the following results:—Upwards of 1000 persons in England and Wales seek refuge from suffering by suicidal death every year. The quinquennium, from 1852 to 1856, gives a total of 5415 suicides, of which 1182 were committed in 1856, and 1076 in 1855. The number returned is probably less by one-tenth than the number ascertained to have occurred. Of the suicides included in the registrar's tables, 3886 were males, and 1529 females, making an average annual mortality of 8·51 of the former and 32·5 of the latter sex in every million persons living from 10 years and upwards of each sex respectively. The maximum is attained in the decennium 45–55; and then there is a steady decline until the decennium, 85–95. It would seem that the greatest tendency to suicide in this country is manifested in the male sex, from the 55th to the 65th year; in the female, from the 65th to the 75th year; and that in both sexes the tendency to suicide is greater during middle age and the decline of life than during early life and adolescence.

The returns of 1838–9 indicate that the tendency to suicide is greatest during middle age and the decline of life. In the quinquennium already mentioned, 19 males and 14 females destroyed themselves at 10 years of age; 348 males and 273 females at 15; 547 males and 244 females at 25; 726 males and 272 females at 35; 940 males and 346 females at 45; 778 males and 219 females at 55; 410 males and 135 females at 65; 127 males and 28 females at 75; and 9 males with 5 females at 85 years of age. The modes of suicide are various, and adapted to all tastes. There were 10 suicides on railroads, 13 by self-precipitation down the shafts of mines, 1424 by mechanical injuries of all kinds, 561 by chemical injuries, such as fire and poison, and 3212 by suspension of the respiration. It is strange and almost incredible that, while the apothecary's shop offers so many easy methods of terminating existence, yet in England the vulgar death of hanging, or strangulation, is preferred both by males and females. With males, cutting the throat ranks next; drowning, third; and poisoning, fourth: with females, the order is strangulation, drowning, poisoning, and cutting of throats. Females resort to the rope and to steel less frequently than men; they prefer the bowl and the water. Among poisons, females very judiciously choose opium, and its preparations, as the favourite agent of destruction; next come arsenic and oxalic acid, two clumsy and barbarous means, because slow and torturing. Women use essential oil of almonds more than pure prussic acid. Ten different forms of poison are used by males, and 17 by females; even nitric acid, camphor, and phosphorus have been used, and one female took the deadly cyanide of potassium as her sleeping potion. It may be deduced from the extant statistics, that the annual average number of suicides occurring in England and Wales, in every 100,000 of the population in the five years 1852–56, was 5·81; and the annual average proportion per cent. to the total number of deaths from all causes, 0·26. There is no doubt that many more suicides are committed, but that these are hushed up for obvious reasons, owing particularly to the peculiar and almost superstitious abhorrence of suicide in this country. In Geneva, for example, the annual average of suicide to the mortality from all causes is as high as 1·21 per cent., and in this canton the suicides took place at a far earlier period of life. In Geneva, the maximum is reached at 30 years of age, in England not till 55; in the one country it occurs in early life, in the other when life has begun to decline. In Paris the maximum is also attained, as in Geneva, at 30 years; but the maximum of suicides in Paris coincides with that of females but not of male suicides, the greatest number of the latter occurring from 30 to 40. The excess of early suicides in Paris (from 20 to 30 years) has led to much inquiry among psychologists. The number of suicides is invariably greater among males than females, who have fewer of the struggles of life to sustain. Suicides by hanging, and suicides by cut-throat, are more numerous in France by twice and thrice respectively than in England; poisoning is also more common, in the rate of seven to four; asphyxia, or suffocation by carbonic acid gas (the charcoal process), and suicides by falls from elevated places, appear peculiar to France, Geneva, and Sardinia. (See *Journal of Psychological Medicine for* 1859.) John Stuart Mill, who is decidedly opposed to legislative interference with the sale of poisons, as exerting over the subject an entirely unnecessary degree of state surveillance, has nevertheless the following remarks:—"When there is not a certainty," he remarks, "but only a danger of mischief, no one but the person himself can judge of the sufficiency of the motive which may prompt him to incur the risk [of buying poison, *e.g.*;] in this case, therefore (unless he is a child, or delirious, or in some state of excitement or absorption incompatible with the full use of the reflecting faculty), he ought, I conceive, to be only warned of the danger, not forcibly prevented from exposing himself to it." (On *Liberty*, p. 173.) Buckle, a somewhat hasty theorist, regards suicide as a common and constant phenomenon, and tries to show the folly of law-givers thinking that by their enactments they can diminish suicide. Preventive measures, however, have been recently tried in London with success; and Plutarch acquaints us that an unaccountable passion for suicide seized the Milesian virgins, from indulging which they could not be prevented by the tears and entreaties of parents and friends; but what persuasion and entreaty could not effect was accomplished by very different means. A decree was issued, "that the body of every young woman who hanged herself should be dragged naked through the streets by the same rope with which she had committed the deed." This wise edict put a complete stop to the extraordinary phrenzy, and suicide was no longer committed by the virgins of Miletus.

Buckle justly remarks, farther on in his *History of Civilization*, vol. i., "that suicide is merely the product of the

general condition of society, and that the individual felon only carries into effect what is a necessary consequence of preceding circumstances. In a given state of society a certain number of persons must put an end to their own life." He remarks again—"We are able to predict within a small limit of error the number of voluntary deaths for each ensuing period, supposing, of course, that the social circumstances do not undergo any marked change."

As suicide was deemed criminal by the most illustrious and virtuous of the Greek philosophers, it was considered as a crime by the laws, and treated with ignominy. By the law of Thebes suicides were to have no honours paid to their memory. The Athenian law ordained the hand which committed the deed to be cut off, and burned apart from the rest of the body. The body was not buried with the usual solemnities, but was ignominiously thrown into some pit. In Cea and Massilia (the ancient *Marseille*), it was considered as a crime against the state; and it was, therefore, necessary for those who wished to destroy themselves to obtain permission from the magistrates.

In the early part of the Roman history there seems to have been seldom occasion for framing any laws against suicide. The only instance recorded occurs in the reign of Tarquinius Priscus. The soldiers who were appointed to make drains and common sewers, thinking themselves disgraced by such servile offices, put themselves to death in great numbers. The king ordered the bodies of all the self-murderers to be exposed on crosses, and this put an effectual stop to the practice. In Justinian's Pandects there is a law, by which it was enacted, "that if persons accused, or who had been found guilty, of any crime, should make away with themselves, their effects should be confiscated." But this punishment only took place when confiscation of goods happened to be the penalty appointed by the law for the crime of which the self-murderer was accused or found guilty, and was not inflicted for suicide committed in any other circumstances.

It was decreed in the sixth century, that no commemoration should be made in the eucharist for such as destroyed themselves; neither should their bodies be carried out to burial with psalms, nor have the usual service read over them. This ecclesiastical law continued till the Reformation, when it was admitted into the statute law of England. As an additional punishment, however, confiscation of land and goods seems to have been adopted from the Danes, as we learn from Bracton. At present the punishment consists in confiscating all the personal property of a *felo de se* for the use of the crown, and in excluding his body from Christian burial.

SUIDAS, a Greek lexicographer, is supposed by Fabricius to have lived during the latter part of the eleventh century; but other writers are disposed to believe that he must have belonged to a more recent period. His country and his personal history are alike unknown. From authors of various denominations he compiled an ample dictionary, which, with all its imperfections, has been found a most valuable repository of ancient erudition; and no scholar, intimately acquainted with the Greek language and literature, is unacquainted with the *Lexicon* of Suidas. The first edition, which is very elegantly printed, was published by Demetrius Chalcondylus, Mediol., 1499, fol. He had access to several manuscripts. The text of Aldus has some appearance of being derived from a different source, Venet., 1514, fol. A third edition, with various interpolations, followed after a longer interval, Basil, 1544, fol. It was succeeded by the Latin version of Wolfius, Basil, 1564, fol.; Basil., 1581, fol. An edition of the Greek text, accompanied with a Latin version, was published by Æmilius Portus, Colon. Allobrog., 1619, 2 tom. fol. A splendid and valuable edition was at length produced by Küster, Cantab., 1705, 3 tom. fol. Here the version of Portus has received innumerable corrections; and from the collation of manuscripts, as well as by the aid of his own critical sagacity, he effected a great reformation of the text. The text of Suidas was afterwards illustrated by many other writers, particularly by Toup, *Emendationes in Suidam*, Lond., 1760–6, 3 tom. 8vo, Oxon., 1790, 4 tom. 8vo. The labours of these learned men prepared the way for a most valuable edition, published under the following title: *Suidæ Lexicon post Ludolphum Kusterum ad codices manuscriptos recensuit* Thomas Gaisford, S.T.P. Ædis Christi Decanus, necnon Græcæ Linguæ Professor Regius, Oxon., 1834, 3 tom. fol. The third volume is very thin, and merely includes three Indices. Bernhardt published an edition founded on Gaisford's in 1834 and 1853; and Bekker has recently issued an edition of Suidas in 1854.

SULLA. See Roman History, §§ 26, 27.

SULLY, Maximilien de Bethune, Duke of, was born at Rosny on the 13th of December 1560, and died at Villebon on the 22d of December 1640. His name is so conspicuous in the public annals of France, that a mere outline of his personal history would require an ample allotment of space. He participated in the fortunes of Henry IV., and rendered him the most important services in the cabinet as well as the field. He was grand-master of the artillery, and superintendent of the finances. Rigidly attentive to the interest of the king, he had no disposition to neglect his own; and in the course of a long life he accumulated an immense fortune, of which he laid the foundation by his marriage with Anne de Courtenay, a rich heiress. He was remarkable for his decision of character and bluntness of manners; and in spite of all the allurements presented to him, he steadily adhered to the Protestant faith. The Memoirs of Sully furnish some of the most curious and valuable materials for the history of that eventful era.

SULMONA, a town of Naples, in the province of Abruzzo Ultra II., in a fertile valley, 24 miles S.S.W. of Chieti. The valley is drained by the Sagittariæ, an affluent of the Pescara, and forms an important pass across the Apennines. The town itself is old and gloomy; it is surrounded by walls, and it contains a fine cathedral, numerous other churches, monasteries and nunneries, and a town-hall in the cinque cento style. Dyeing, papermaking, the manufacture of catgut and of sausages, are carried on; and the town has long been celebrated for its confectionary. There are some remains of an ancient aqueduct with pointed arches. The ancient Sulmo, the birthplace of Ovid, stood near Sulmona. Pop. 9200.

SULPHUR. See Chemistry.

SULPICIA, a Roman poetess, who lived under the reign of Domitian, and has been so much admired as to be termed the Roman Sappho. We have nothing, however, left of her writings but a satire, or rather the fragment of one, ascribed to this poetess, written against Domitian, who published a decree for the banishment of philosophers from Rome. This satire is to be found in Scaliger's *Appendix Virgiliana*, and in other collections. It was separately published, with elaborate annotations by C. G. Schwartz, Altorf., 1721, 8vo; Hamb., 1819, 4to. She is mentioned by Martial and Sidonius Apollinaris; and is said to have addressed a poem on conjugal love to her husband Calenus, a Roman knight.

SULPICIUS, Severus, an ecclesiastical writer, was born in Aquitania about the year 363 A.D. His father was a man of superior rank. Having received a suitable education, the son applied himself to the practice of the law, and distinguished himself by his learning and eloquence. He married a rich wife, and was thus placed in a state of greater independence. He chiefly resided at Toulouse, and at *Eluso* or *Elusio*, near Carcassonne. The death of his wife weaned his affections from the world, and he is

Sulzer.

supposed to have devoted himself to an ecclesiastical, if not a monastic life. He had recourse to the instructions of Martin bishop of Tours, whose life he has written; and he likewise contracted a friendship with Paulinus bishop of Nola. The invasion of the Vandals impelled him to seek a place of refuge at Marseille, where he entered a monastery, and is supposed to have died about the year 410. His principal work is his *Historia Sacra*, brought down from the creation of the world to his own time, and written in a style superior to the standard of that declining age of Latinity. He has with propriety been designated the "Christian Sallust." The first edition was published by Flacius Illyricus, Basil. [1556] 8vo. Various editions of his works subsequently appeared; some of which were illustrated by the notes of Sigonius, Vorstius, Horn, and Le Clerc. A more elaborate edition was undertaken by De Prato, Veronæ, 1741–54, 2 tom. 4to. He promised a third volume, which, however, did not make its appearance.

SULZER, Johann Georg, a philosophical writer of distinction, was born at Winterthur, in the canton of Zürich, on the 16th of October 1720. He was the youngest of twenty-five children. At the age of sixteen, when he went to the University of Zürich, he had not the smallest notion of the sciences or of elegant literature, and consequently no taste for study. The first incident that developed in him a hidden germ of philosophical genius, was his meeting with Wolf's *Metaphysics*. This was the birth of his taste for science; but he wanted a guide. The clergyman with whom he lodged was an ignorant man; and the academical prelections were, as yet, above the reach of his comprehension. On the other hand, a sedentary life was not suitable to his taste; and a sociable turn of mind often led him into company, where he lost much time in frivolous amusements, yet without corrupting his morals. Who that observed him at this period, says Formey in his *Eloge*, would have thought that Sulzer would one day be numbered among the most knowing and wise men of his time? John Gessner, who became an eminent naturalist, rendered Sulzer's inclination to study triumphant over his passion for amusement and company. Animated by the counsels and example of this fellow-student, he applied himself to philosophy and mathematics with great ardour, and resumed the pursuit of Greek literature and the oriental languages. He was settled as a pastor in a rural district. In 1741, he published *Moral Contemplations on the Works of Nature;* and in the following year an *Account of a Journey through the Alps*, which showed at the same time his knowledge of natural history, and the taste and sensibility with which he surveyed the beauties of nature, and the grandeur and goodness of its Author. He afterwards became private tutor to a young gentleman at Magdeburg. This procured him the acquaintance of Euler, Maupertuis, and Sack, which opened to his merit the path of preferment, and advanced him successively to the place of mathematical professor in the Gymnasium of Berlin in 1747, and to that of member of the Royal Academy in 1750. In this last quality he distinguished himself in a very eminent manner, enriched the class of speculative philosophy with a great number of excellent memoirs, and was justly considered as one of the first-rate metaphysicians in Germany. But his genius was not confined to this branch of science. His *Universal Theory of the Fine Arts* is a valuable production. A profound knowledge of the arts and sciences, and a perfect acquaintance with true taste, are eminently displayed in this work, and will secure to its author a permanent and distinguished rank in the republic of letters. The first volume of this excellent work was published in 1771, and the second in 1774. His *Remarks on the Philosophical Essays of Hume* is a work of real merit, which does justice to the acuteness, while it often detects the sophistry, of the Scottish philosopher. The moral character of Sulzer was amiable and virtuous; sociability and benevolence were its characteristic features.

Sumarokov || Sumatra.

SUMAROKOV. See Russia.

SUMATRA, a large island in the East Indian Archipelago, stretching from N.W. to S.E.; between 5. 45. N. and 5. 55. S. Lat.; 95. 20., and 106. 5. E. Long.; and separated from the Malay peninsula by the Straits of Malacca on the N.E. It is bounded on the E. by the Java Sea; S. by the narrow Strait of Sunda, separating it from Java; S.W. and W. by the Indian Ocean; and N. by the Bay of Bengal. Its length is more than 900 miles; its average breadth in the southern part, 210, but in the northern, 140 miles; and its area is estimated at 160,000 square miles. It is thus second only to Borneo in size among the islands of Asia.

Surface and mountains.

Along the south-western coast of Sumatra there extends a mountain-chain, rising steeply in some places at a distance of only two miles from the sea; the north-eastern portion, on the other hand, spreads out into vast unbroken plains, very little above the level of the sea. The island is thus divided generally, according to the character of its surface, into two parts, a mountainous and a level one, by a line passing through its centre in the direction of its length. And the mountainous region itself consists of three distinct parts; the southern, the central, and the northern. The southern mountainous region is formed by two chief ranges, and covers a tract of ground about 100 miles in length by 40 in breadth. The mountains rise abruptly from the shore of the Strait of Sunda, which washes the southern extremity of the island; and from the three promontories of Tanjong Toca, Tanjong Kamantara, and Flat Point, which enclose the two bays of Lampong and Samangka, three separate chains take their origin and unite into one above the head of Samangka Bay. This chain stretches north-west parallel and close to the coast, which is here lined by a series of lofty hills and narrow glens, which are sterile and thinly peopled. Much more elevated than this is the other range, which runs parallel to this, considerably further inland. Between these two chains lies a lofty tableland, undulating and hilly in its surface, and containing several large lakes. The principal summits in this southern portion of the Sumatran Mountains are Raja Bassa, about 16,000 feet, and Keyzer's Peak, about 5000 feet high. The central part of the mountainous district both contains all the loftiest summits of Sumatra, and stretches over a greater breadth of the island than either of the others. It is, however, further away from the coast, for the mountains rarely approach nearer than 20 miles to the sea, and in some places recede as far back as 30. They are separated from the sea by a plain tract, sloping very gradually up to their foot, from which they rise pretty abruptly, and in some places precipitously. The mountains themselves in this region have been very little explored. They seem to form three, and in some places even more parallel ranges. Many of the peaks are volcanoes, some of which are still active. The chief of them are the following:—Derupo, in S. Lat. 3° 52′, 10,440 feet high; Indrapura, S. Lat. 1° 34′, 12,140 feet; Talang, S. Lat. 1°, 8480 feet; Merapi, S. Lat. 0° 24′, 9700 feet; Singallang, S. Lat. 0° 28′, 10,150 feet; and Ophir, N. Lat. 0° 12′, 9500 feet. All of these, except the two last, are volcanoes; and all except Talang have the crater at some distance below the summit. Besides these, Sumatra contains about 15 other volcanoes, generally from 6000 to 7000 feet in height. In the midst of this mountainous region there are many valleys and lakes, surrounded with rich and fertile tracts, which are frequently well cultivated. One of the most remarkable of these districts is Menangcabau, which lies between Mount Talang and the equator. It is a broken and hilly tableland, about 50 miles each way, and enclosed on all sides with high mountains. The lowest part of it is occupied by the Lake of Sinkara, and the whole is well cultivated, densely inhabited, and

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dotted with towns and villages. The central mountain region may be considered to terminate at Tapanooly Bay, about N. Lat. 1° 40′. North of this lies the third or northern region, extending to the extremity of the island. It consists of three or four parallel ranges, which occupy a breadth of about 25 miles, and are separated from the ocean by a plain 10 or 12 miles broad. Their general height is less than the mountains further south; but there are some considerably elevated peaks, such as Loesa, 11,150 feet high; Abong-Abong, 10,350 feet; and Queen's Mountain, 6900 feet. These mountains are almost all covered with dense forests. The eastern range here is the loftiest, and forms the water-shed of the island. The chain terminates at Acheen Point, the northern extremity of the island; but there is also a hilly tract that stretches eastward along the north coast as far as Diamond Point, at the entrance of the Straits of Malacca.

Valleys and plains.

The eastern part of Sumatra, forming probably the greater part of the whole island, from Diamond Point in the north to Tanjong Toca in the south, is occupied by an immense plain of a very uniform character, except along the coast, where there is some variety. It is but slightly elevated above the sea-level, and a large portion of its seaward margin, occupying the centre, from Rakan River to Lucepara Point, is so low as to be laid under water at spring-tides, and thus to be converted periodically into a vast swamp. Behind this, the land gradually rises; and the more northerly and southerly regions seem both to be sufficiently elevated to escape the danger of inundation. Another important plain in Sumatra lies on the west coast between the sea and the central part of the mountains. This region is better known than any other part of the island, as it has been for two centuries the seat of several European settlements. It is a low and somewhat uneven tract, intersected by numerous swamps, which in some places form islands and peninsulas of considerable size. There are no important valleys in Sumatra. Those that descend laterally from the mountains are in almost all cases very narrow and steep, so as to afford but an ungenial soil and few attractions to the husbandman. The longitudinal valleys and plateaus among the mountains are of greater size and fertility. Some of these have been already noticed. Another stretches for about 100 miles from the peak of Merapi, northwards to that of Lubu Raja. These mountain-valleys are the chief seats of the native population, but they are as yet but little known to Europeans.

Lakes and rivers.

In the mountain region there are several lakes, but most of them are of small size. The most important are Sinkara, which is 12 miles long by 4 wide; Dano, which is of smaller size, 1500 feet above the sea; Eik Daho, said to be 4000 feet high; and St George's Lake. Numerous rivers flow from the mountains towards the south-west, but those which take this direction are for the most part of small size. The largest is the Sinkel, which has a course of more than 100 miles, and receives from the right the Sikeri. It enters the sea about N. Lat. 2° 15′. Proceeding southwards along the coast we pass in succession the mouths of the Batang Tara, Tabuyong, Indrapura, Spov, and Kataun, besides many others of smaller size. The eastern part of the island is watered by more considerable streams. Of these the largest is the Palembang, which rises by numerous branches in the southern mountains, between 2° 30′ and 5° S. Lat. The principal of these upper branches is that known at first as the Ayer Musi, but lower down in its course as the Tatong. All the other branches unite with this near the town of Palembang, where they form a river more than a mile wide, which bears the name of Palembang down to the sea. It is navigable for boats 250 miles above its mouths, and it falls into the Strait of Banca, forming a delta about 24 miles broad, south of the Palembang. The largest river is the Talan Booang; and north of it there are the Jambi, flowing from St George's Lake; the Indragiri, the Kampar, the Siak, the Rakan, the Assahan, the Batu Bhara, and the Delli, all flowing in more or less tortuous courses from the mountains down to the sea, many of them forming considerable estuaries, and being navigable for some distance. There are no considerable inlets of the sea along the coasts of Sumatra.

Capes and islands.

The southern extremity of the island is formed as has been already stated, of three capes, which enclose two small bays, in which there are several good roadsteads. Along the whole length of the south-west coast there are no considerable headlands; but there is a series of islands extending in a line parallel to the shore at some distance from it. There are, beginning at the south, Engano, South Poggy, North Poggy, Sepora, Sebeeroo, Batoe, Nias, and Hog Island. The two capes which form the northern termination of the island are Acheen Head and Diamond Point; the former at the western and the latter at the eastern extremity of the steep rugged coast, which has been called the coast of Pedir, about 150 miles in length. The chief headlands on the eastern coast are Perhabean Point at the mouth of the Rakan; Jaboeng Point, at that of the Jambi; and Cape Lucepara, at the southern entrance of the Strait of Banca. Off this coast lie the Islands of Rupat, separated from Sumatra by the strait of the same name; those of Baccalisse, Padang, and Rankan, all lying together and separated from Sumatra by the Brewer's Strait; and that of Banca separated by the Strait of Banca from the main island. In general it may be said that the south-west and north coasts of Sumatra are rocky, and in some places steep; while the north-east coast is low, and lined for the most part with shoals and sand-banks.

Climate.

As Sumatra lies directly beneath the equator, the climate is very warm; but it is remarkable that, on the sea-level near the shore, the heats are more moderate than in other countries within the tropics. At the most sultry hour in the afternoon the thermometer fluctuates between 82 and 85 degrees: it seldom rises above 86 in the shade, and at sun-rise it is usually as low as 70. Very dense fogs frequently prevail in the mountainous regions. The island is subject to the monsoons, and as, during their prevalence, the mountains arrest all the vapours with which they are charged, the island, at least its southern portion, is almost incessantly deluged with rain. The climate of the northern portion is not so moist, probably on account of the vicinity of the Malay peninsula. Besides the monsoons, which vary every six months, there is a daily variation in the winds, which blow from the sea to the land during so many hours of each day, and during the night in the opposite direction, from the land to the sea. Thunder and lightning prevail in Sumatra, especially during the north-west monsoon, when the explosions are extremely violent; and waterspouts are also frequent along the west coast. The island is unfortunately subject to earthquakes, which often prove most destructive. In the marshes and flats along the coasts, the climate of Sumatra has been found very insalubrious by the Europeans; but amid the mountains of the interior the native inhabitants seem to find it healthy, and they attain frequently to a great longevity.

Soil and produce.

The soil has been celebrated for its fertility; and it certainly produces a most luxuriant vegetation. Of the greater part of the island but little is known, as it is covered with impenetrable forests; but wherever it has been explored the soil seems to consist of a stiff, reddish clay, covered with a layer of black mould, of no considerable depth. From this there springs a strong and perpetual verdure of rank grass, brushwood, or timber trees, according as the country has remained for a longer or shorter period uncultivated; and this forest or jungle, as there is but a scanty population, affords abundant cover for wild beasts of the most ferocious kind by which the country is infested. Many of the plants

Sumatra. and trees that compose the forests of Sumatra are remarkable for their gigantic size. Few of the trees are under 100 feet in height, and many of them are nearly twice as much; while the gigantic creepers and parasites, and the enormous flowers of some of the plants are, if possible, still more astonishing. The most important article of cultivation is rice, which is exported in considerable quantities from Acheen to India. Maize, yams, potatoes, peas, beans, and other vegetables are also raised. The cocoa-nut tree is one of the most valuable productions, furnishing an article of food which is in almost universal use. There are also large plantations of the betel-nut tree and the bamboo; the latter growing thick into an impenetrable mass, is used in the fortification of villages. The sago-tree also flourishes, and there is a great variety of palms. Capsicum pepper, turmeric, ginger, coriander and cummin seed, are raised in the gardens of the natives. Pepper is grown here in large quantities. The plant appears to flourish in any of the different soils that are found in this island, and it is a great article of commerce. The pepper plants, which are in even rows, running parallel and at right angles with each other, present a fine contrast to the wild scenes of nature which surround them. The camphor-tree, which grows in the northern parts of the island, is valued for its juice, which is an article of trade, and sells at a high price. The benzoin is produced from a tree which grows in the same district, as also does the tree that yields cassia. Cotton is also produced, and forms an article of export. Various other shrubs and plants are cultivated, and are converted by the natives to many useful purposes. Hemp is extensively cultivated, not however for the purpose of making ropes, but to procure an intoxicating liquor called *bang*, which the natives smoke in pipes along with tobacco. Plantations of the latter plant are met with in almost every district; and there is a variety of other creeping plants, which are manufactured into twine, thread, and other articles of the same nature. No country in the world is more distinguished than Sumatra for the variety of fine fruits with which it abounds, and which are the spontaneous produce of the earth. The most remarkable are the mangustin, which is produced in abundance, and which for delicacy and flavour holds pre-eminence over all the Indian fruits; the pine-apple, which, though not indigenous, grows in great plenty with ordinary culture; the orange, which is in great perfection and variety; the shadock of the West Indies, which is here very fine, and is distinguished into the white and the red. Limes and lemons abound; as also the bread-fruit; the jack-fruit; the mango, a rich high-flavoured fruit of the plum kind; the papaw, a fruit substantial and wholesome, like a smooth sort of melon, but not very highly flavoured; the pomegranate, the tamarind, nuts and almonds of different kinds, besides various other fruits of which the names are scarcely known in Europe. Owing to the equable temperature that prevails throughout the year, there is a perpetual succession of shrubs and flowers, which diffuse a pleasant fragrance, and are, many of them, used in medicine, or in affording useful dyes. The castor-oil plant is found in abundance, especially near the seashore; also the caoutchouc or India-rubber plant, the indigo plant, and several others.

Animals. The zoology of Sumatra is distinguished by some of the most remarkable animals in nature. The shelter afforded by its vast forests or tracts of jungle is most favourable to the breed of wild animals, which abound throughout the island. Numerous herds of elephants range over the forests, and are pursued and killed for their teeth; they are extremely destructive to the plantations of the natives, which they trample down by merely walking through the grounds, and thus obliterating all traces of cultivation. The rhinoceros, both the single and the double horned, is also a native of the woods. Of beasts of prey the tiger is the most remarkable. It grows to an enormous size, and its strength is so prodigious that it is able to drag into the woods the largest prey, and by a stroke of the fore-paw will break the leg of a horse or buffalo. Whole villages are sometimes depopulated by these animals, and great numbers of inhabitants lose their lives. When a tiger enters a village, these ignorant people prepare rice and fruits as an offering to the animal, conceiving that he will be pleased with these hospitable attentions, and pass on without doing them any harm. Tigers are occasionally caught in traps, which are ingeniously contrived in the form of a cage with falling doors, into which the beast is enticed, and is then enclosed; or a large beam of timber is so placed as to fall on its back and crush him. Another expedient is to entice it to ascend a plank, which being nearly balanced, is weighed down by it when it is past the centre, so that it falls upon sharp stakes prepared below. The natives sometimes contrive to poison tigers. The bear is common; it is small and black, and climbs the cocoa-trees, feeding upon the tender part or cabbage. Two species of deer are found in the forests, and the monkey tribes are innumerable. Here are also sloths, squirrels, civet-cats, tiger-cats, porcupines, hedgehogs, armadillos, bats of all kinds, alligators in the rivers, which are also haunted by the hippopotamus, guanas, chameleons, flying lizards, tortoises, and turtle. Among the domesticated animals the most useful is the buffalo, which also exists in a wild state, and is remarkably strong and active. This animal supplies the inhabitants with milk, butter, and beef. Black cattle exist on the island, but in no great numbers, except on the northern coast, where they are employed in agriculture. The breed of horses is small, but they are well made and hardy. The sheep are also a small breed; the other animals are the goat and the hog, both domestic and wild; the otter, the cat, the rat, and the dog. Frogs, toads, and reptiles of every kind, abound in the swamps; and the noise which they make on the approach of rain is tremendous. Among the poisonous serpents is the viper; and the hooded snake is sometimes found in the country. The boa-constrictor is also to be met with, and sometimes grows to the length of 30 feet, and is of proportionate bulk and strength. The surrounding seas abound in fish. Among these are the duyong, a large sea-animal of the order mammalia; besides sharks, skates, the muræna gymnotus, rock cod, mullet, the flying-fish, and many others. Of birds there is a great variety, for besides common fowls, which are abundant, the island contains peacocks, eagles, vultures, kites and crows, jackdaws, kingfishers, the rhinoceros bird, remarkable for its horn, the stork, the snipe, coot, plover, pigeons, quails, starlings, swallows, minas, parrots, parroquets, geese, ducks, teal, &c. The Sumatran pheasant is a bird of great magnificence and beauty, perhaps the finest that the island contains. Sumatra may be said literally to swarm with insects, many of which are extremely annoying and destructive. These consist of cockroaches, crickets, flies of all sorts, mosquitoes, scorpions, and centipedes. Ants exist in immense numbers and varieties. Bees are also numerous, but the honey is of an inferior quality.

Minerals. Gold is a production for which Sumatra was once famed, and it is still found in considerable quantities chiefly in the mountains surrounding Menangcabau, but also in some other places. Copper exists in the northern part of the mountain region; but though it is plentiful, and in some places contains gold, it is only worked to a very small extent. In the country of Menangcabau iron ore is collected, smelted, and formed into metal, and there are indications of its existence in other parts of the island. Tin is one of the great mineral products of the island. It chiefly abounds in the neighbourhood of Palembang, on the east coast; but in many other parts its existence is indicated, and particularly in the neighbourhood of Bencoolen. Sulphur

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may be gathered in any quantity near the volcanoes; arsenic is also found, and is an article of traffic; and saltpetre is procured, and is used by the natives for making gunpowder. Coal exists in various parts, and is washed down to the coast in floods; but it is not esteemed good, being found near the surface of the earth. Mineral and hot springs are discovered in many districts.

Inhabitants.

The majority of the present inhabitants of the island belong to one race; though there are various portions of them distinguished by peculiar characteristics, and hence sometimes considered as separate nations. But the differences are not very considerable; and the languages that are spoken may all be considered as dialects of one common tongue. The people may be designated, in general, Malays, and are commonly divided into the following five tribes or nations:—1. The Acheenese, who occupy the extreme north of the island, and probably, on account of their mixture with Hindoo immigrants, differ considerably from the other tribes, being darker in complexion, taller, and stouter, but still retaining the general character of the Malay race. 2. The Battas, who occupy the country from sea to sea, between the Acheenese and Menangcabau, or from the river Senkel to the Tabuyong. They are of smaller stature and fairer complexion than the former, and live in a very rude and savage condition. 3. The Malays proper, occupying the valley of Menangcabau (which is said to have been the original cradle of the race), and the whole of the eastern plain from the Rakan to the Masuse. 4. The Rejangs or Sumatrans, who inhabit the west coast from the Tabuyong southwards to the Padang Guchi, a race of men small in size, but well formed, and bearing some resemblance to the Chinese. 5. The Lampangs, occupying the mountains and plains in the extreme south of the island, a race which resembles very strongly the Chinese, and whose language differs considerably from that of any other tribe. Besides these nations, who form the majority of the population, there are two other races who live in a very savage state, wandering in the woods with little intercourse with the others. These are the Orang Kuba and the Orang Gugu; and it is not certain whether or not these represent an aboriginal race of inhabitants. In respect of civilisation the people of Menangcabau and those of Acheen are the furthest advanced of all the Sumatran tribes. The Battas have made considerable progress in some respects, but they retain the custom of cannibalism, in the case of criminals and prisoners of war, with circumstances of peculiar atrocity and cruelty.

Manufactures.

There are some branches of industry which are prosecuted in Sumatra with a large measure of skill and success. The Malays about Palembang build very excellent boats. The Battas erect good substantial houses; and though their farming implements are very rude, they are not only successful in agriculture, but carry on a system of irrigation which is very extensive and ingenious. But the chief seat of manufacturing industry is Menangcabau, where iron and steel are wrought to a high degree of perfection; and the blades of *krises* or daggers made here are celebrated throughout the East Indies. In this district iron has been worked from time immemorial; and an extensive manufactory of coarse pottery, near the banks of the lake, supplies not only Padang, but Bencoolen, with that useful article. The Sumatrans are entire strangers to the art of painting and drawing. In cane and basket work they are particularly neat and expert, as well as in mats, of which some kinds are much prized for their extreme fineness, and for the beauty and taste of the borders with which they are ornamented. They excel also in the manufacture of silk and cotton cloths of varied colours, chiefly for domestic use. Their apparatus for weaving is, however, of the rudest description, and renders their progress tedious. The women are expert at embroidery, the gold and silver thread for which is procured from China, as well as their needles. Gunpowder is manufactured in various parts of the island, chiefly among the people of Menangcabau, the Battas, and Acheenese, among whom, as they are frequently at war, it is an article in great request. It is not, however, well made, being imperfectly granulated, and often hastily prepared for immediate use. Different kinds of earthenware are manufactured in the island. The manufacture of filagree is here carried to the greatest perfection. There is no manufacture in any part of the world that has been more justly admired and celebrated than the fine gold and silver filagree of Sumatra; this is the work of the Malays, to whose superior taste and industry many of the monuments of art which remain are ascribed. This manufacture is in universal use in the country; and its fineness and beauty form a singular contrast to the coarseness of the tools which are employed in the workmanship, and which are rudely and inartificially formed by the goldsmith from any old iron that he can pick up. A piece of iron hoop as a wire-drawing instrument, an old hammer-head stuck in a block as an anvil, and two old nails tied together as a pair of compasses, are the chief instruments. They have no bellows, but blow the fire with their mouths through a reed. They are very inexpert at polishing the plain parts, but in other respects nothing can exceed the extraordinary delicacy of the Malay work. They are extremely skilful in manufacturing fishing-nets and springs for catching birds.

Religion.

The Malays and a part of the Sumatrans proper are Mohammedans; the other tribes, in as far as they exhibit any traces of religion at all, are heathens. Mohammedanism seems to have superseded in this country the Buddhist doctrines, which prevailed here at an early period; but it has never made much progress among the tribes in the interior, owing probably, among other reasons, to the immense numbers of swine, which constitute an important part of the wealth of these people, as well as a favourite article of food. The Battas have a religious system and an influential priesthood, but they worship no idol.

Language.

The Malay language, which is understood to be the original language in the peninsula of Malacca, has extended itself through all these Asiatic islands, and has become the common tongue in this part of the globe. It is spoken everywhere along the coasts of Sumatra. It also prevails in the inland country of Menangcabau, and is understood in almost every part of the island. From the smoothness and sweetness of its sound, it has been called the Italian of the East. Their writing is in the Arabic character, very little corrupted; owing to which, and the adoption of the Mohammedan religion, a great number of Arabic words are incorporated with the Malay. The Battas have an ancient and peculiar mode of writing, from the bottom upwards; but of their books in this character little is known, and they seem to be of no great value.

Divisions.

In a political point of view, Sumatra is divided between the native independent states and the Dutch possessions. Of the former, the largest is Acheen, occupying the whole northern part of the island. (See Acheen.) It is governed by a sultan, who had formerly under him many subject-princes; but most of these have now become independent. On the east coast lies the state of Siak, which is also governed by a sultan, and has a capital of the same name at the mouth of the Siak river. The country of the Battas forms three independent states,—Sinamora, Bato-Seling-Dong, and Butar. Its principal town is Baroos, on the west coast. Of less size and importance are the states of Indrapura, Passaman, and Jambi, the two former on the west and the latter on the east coast. The rest of the island belongs to the Dutch. Their possessions form six governments, besides two others, which comprise the smaller islands adjacent to Sumatra. The governments are:—1. Sumatra on the west coast, from the equator to 1° 55′ S. Lat., including the district of Menangcabau. The capi-

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tal is Padang. 2. Bencoolen, to the south of the former, and likewise on the west coast, with a capital of the same name. 3. Lampong, occupying the southern extremity of the island. 4. Palembang, north of the preceding, on the east coast, including the town and river of the same name. 5. Indragiri, still further north, extending to the southern entrance of the Straits of Malacca; and 6. Assahan, the most northerly of all the governments on the east coast. Besides these there is the government of Banca, consisting of the island of that name, and that of Rhio, comprising the smaller islands lying south of the Malay peninsula. The extent and population of these various divisions of Sumatra are exhibited in the following table:—

	Square Miles.	Pop. (1857).
Dutch Possessions:—		
Sumatra	46,628	1,499,271
Indragiri	14,327	
Assahan	5,382	
Bencoolen	9,643	112,542
Lampong	10,067	82,974
Palembang	54,216	467,685
Native States:—		
Acheen		600,000
Battas		1,200,000
Other tribes		550,000
Total population.........about		4,512,472

The Dutch are continually by slow degrees enlarging their power and possessions in this island, and year by year are making encroachments on the independent states.

Commerce and navigation.

The trade of Sumatra is carried on chiefly with the neighbouring East Indian countries. The island affords many productions which are exported, especially pepper, gold-dust, camphor, nutmegs, cloves, mace, benzoin, gutta-percha, copper, tin, sulphur, coral, &c., which are generally brought down by the natives to the seaports, and there exchanged for goods of Indian or European manufacture. Besides cotton, muslin, and silk, opium and salt are imported from India; porcelain, hardware, gold thread, and other articles from China; striped cotton cloth, arms, and spices from Java, Celebes, and other islands of the East Indies; and silver, steel, cutlery, broad-cloth, &c., from Europe. There is a considerable trade between this island and Java and Madura, carried on chiefly in native, but partly also in European vessels. In 1854 there entered at the principal ports of Sumatra, from those in Java and Madura, 964 vessels, tonnage 44,446; and there cleared for these ports 871 vessels, tonnage 39,056.

History.

Of the early history of this island we know next to nothing. Mohammedanism is said to have been first introduced in the thirteenth century, when the Arabians were in the habit of undertaking voyages to the East Indies and to China. About the end of the twelfth century the Malays began to spread themselves from their original seats in Sumatra over the peninsula of Malacca and the Sunda Islands, where they continued to be the dominant race until the fourteenth century. When the Portuguese landed here in 1509, they found that the ancient Malay kingdom of Menangcabau had been dissolved; but there was a powerful monarch ruling over Acheen, who endeavoured to exclude the strangers from his country. In 1575 the Portuguese shipping in the harbour of Acheen was destroyed by the natives, and in 1582 an attempt which they made to gain possession of the town proved quite unsuccessful. No permanent settlement was made on the island till 1600, when the Dutch established a factory at Pulo Chinko, on the west coast. The kingdom of Acheen had by this time begun to decline in power, being distracted by internal wars and discords. The success of the Dutch was at first greatly promoted here, as in the other parts of the East Indies, by the fact that they arrived at a time when the natives were bitterly and justly exasperated against the Portuguese, on account of the oppression and cruelty which they in many cases exhibited, and to which the conduct of the new comers afforded a favourable contrast. But it soon appeared that the commercial eagerness of the Dutch was no less grasping and aggressive than had been the Portuguese lust of plunder and conquest. They rapidly increased the number of their factories and settlements, founding one at Padang in 1649, at Palembang in 1664, and in many other parts of the island, and securing to themselves the monopoly of the profitable trade in pepper.

The English followed the Dutch in this island, and founded a colony at Bencoolen in 1685; but they never made so much progress here as their rivals. In 1811, the Dutch settlements in the East Indies fell into the hands of the British; Holland having been at that time annexed by Napoleon to France. But by the peace of 1816 these colonies were restored to the Dutch, who have since retained them. In 1824, they exchanged the settlement of Malacca for the British colony of Bencoolen. A singular war which took place subsequently in Sumatra led to a material extension of the Dutch possessions. It was occasioned by a religious sect called Padries, who first made their appearance here about the beginning of the century. Their principles were at first harmless enough, being simply abstinence from gambling, smoking opium, and drinking intoxicating liquors; and, for about eighteen years they flourished in peace. But about 1815, a society of this sect was formed for the purpose of spreading their doctrines and practices by force; and this speedily roused resistance and opposition. The Malays and Battas made common cause against the Padries; and for a long time a fierce struggle was carried on, which devastated Menangcabau and the neighbouring regions. At length the assistance of the Dutch was called in against the Padries, and with their help the sect was entirely put down. The indirect results of this war were the annexation of Menangcabau to the Dutch possessions in 1835, and the opening up to them of the Batta country, from which foreigners had previously been excluded.

Sumbawa.

SUMBAWA, an island in the East Indian Archipelago, lying between S. Lat. 8. and 9., E. Long. 116. 50., and 119. 10.; bounded on the N. by the Java Sea; E. by the Strait of Sappi, which separates it from Comodo and Flores; S. by the Indian Ocean; and W. by the Strait of Allass, which separates it from Lombok. Length, about 180 miles; breadth from 20 to 50; area, estimated at 7200 square miles. Its form is irregular, and it is almost divided into two by the deep Bay of Sallee, near the middle of the north coast. Along the southern shore a mountain-range stretches from end to end of the island, with a great depression about the middle, opposite the Bay of Sallee. The rest of the island is for the most part hilly, and level plains only occur in a few places, chiefly at the head of the numerous bays which indent the northern coast, and along the Straits of Sappi on the east. One of the most remarkable peaks in the island is the volcano of Tumbora, near the mouth of the Bay of Sallee; it rises to the height of 9000 feet, and there was in 1815 a most terrible eruption, which caused a fearful devastation in the island, and was heard to the distance of 840 miles. Another eruption, much less destructive, occurred in 1836. The soil of Sumbawa is exceedingly fertile. It produces rice, tobacco, teak, and other kinds of timber, &c. Gold-dust and pearls are obtained here. The horses of the island are of a very good breed, and are exported in large numbers. Buffaloes, deer, and swine abound in the island. Sumbawa is divided into six native states, governed by rajahs, all of whom acknowledge the supremacy of the Dutch, who have a small establishment at Bima on the north coast. This town and Sumbawa, also on the north coast, are the only places where there is any intercourse with other countries; but at

these an active trade is carried on in the exportation of native produce, and importations of opium, Indian and European goods.

SUMBULPORE, a district of British India, presidency of Bengal, lying between N. Lat. 21. and 22. 5., E. Long. 83. 6. and 84. 51.; bounded on the N. by the native states of Ryghar and Gangpoor, E. by those of Bonei and Bombra, S. by those of Sonepoor and Patna, and W. by those of Phooljee, Sarunghur, and Burghur. Length, 112 miles; breadth, 60; area, 4693 square miles. It is watered by the Mahanuddy, which divides it into two unequal parts; the eastern portion being mountainous and covered with forests, the western and northern, low and level. The soil of the lower ground is alluvial and rich, producing in abundance and of good quality, rice, wheat, and sugar-canes. It is believed that indigo and opium might also be raised here. The forests afford a rich supply of teak. The most important minerals of the district are diamonds and gold; the former are said to be the finest in the world. The capital of the district is a town of the same name, on the Mahanuddy, containing a fort, several pagodas, and other buildings. There is little or no trade, although the river is navigable. The climate of the town is very fatal to Europeans. Population of the district estimated at 274,000.

SUMMER, the name of one of the seasons of the year, being one of the quarters when the year is divided into four quarters, or one-half when the year is divided only into two, summer and winter. In the former case, summer is the quarter during which, in northern climates, the sun is passing through the three signs Cancer, Leo, Virgo, or from the time of the greatest declination, till the sun again comes to the equinoctial, or has no declination; which is from about the 21st of June till about the 22d of September. In the latter case, summer contains the six warmer months, while the sun is on one side of the equinoctial; and winter the other six months, when the sun is on the other side.

SUMPTUARY LAWS (*Leges Sumptuariæ*), are laws made to restrain luxury. Most ages and nations have had some such laws. Political writers have been much divided in opinion with respect to their utility. Montesquieu observes that luxury is necessary in monarchies, as in France, but ruinous to democracies, as in Holland. With regard to England, whose government is compounded of both species, it may still be a dubious question, says Blackstone, how far private luxury is a public evil, and as such cognisable by public laws.

SUN. See Astronomy.

SUNDERLAND, a large and rapidly-growing seaport-town on the north-east coast of England, in the county of Durham, 268 miles from London. The municipal boundary embraces an area of 1684 acres, and includes the parish of Sunderland-near-the-Sea, the townships of Bishopwearmouth, and Bishopwearmouth Panns, part of the parish of Monkwearmouth, and the township of Monkwearmouth Shore. The River Wear, after running through the centre of the borough, falls into the sea. The first authentic evidence of the existence of Sunderland as a place of maritime commerce is found in a charter granted by Hugh Pudsey, bishop of Durham, in the end of the twelfth century; and there are records extant showing that in the year 674 a monastery was founded at Monkwearmouth, in which the Venerable Bede was educated, and spent the greatest part of his life. The town contains a number of fine streets, the principal of which is the High Street, which extends for nearly one mile from east to west. Throughout the older part of the town, the houses are much crowded together, and to the defective state of the sanitary arrangements in that quarter may be mainly attributed the great ravages committed by cholera, which first broke out in this country at the port of Sunderland in 1832. In 1849 the cholera again visited the town, but since that time many local improvements have been projected and completed. In 1855, a commencement was made with a system of thorough draining of the entire borough, and in March 1860 the works were finished, 52 miles of sewers having been formed at a cost of L.51,000. From September 1854 to April 1860, 75 new streets were laid out; and during the same period 1280 houses were erected. To afford the means of healthful recreation for the inhabitants, 14 acres of land on Building Hill—a picturesque eminence within the borough—were purchased for L.2000, and L.3250 (including a grant of L.750 from Government) were expended in laying out and beautifying the place for a public park and pleasure-ground. Under the new burial acts, 3 cemeteries have been formed outside the borough boundaries, the extent of ground thus enclosed being 54 acres, and the total cost L.37,000. Three public bathing and washing establishments have been set on foot, under the provisions of the Baths and Washhouses Act 1846, the cost of the whole being L.12,750. A water company has also been formed, and, at an outlay of nearly L.160,000, works have been erected which supply daily to Sunderland and South Shields fully one million and a half gallons of water, pumped from the sand underlying magnesian limestone. One of the greatest objects of interest in Sunderland is the well-known iron bridge which crosses the Wear, and connects Monkwearmouth with the south bank of the river. It consists of a single arch of 236 feet in span, having a height of upwards of 100 feet from the surface of the river at low water to the centre of the arch, which enables vessels of 400 tons burden to pass under by merely lowering their topgallant masts. This remarkable structure was finished in the year 1796, having cost L.33,400, of which L.30,000 was subscribed by one of its designers, Rowland Burdon, Esq., then member of Parliament for the county of Durham. In 1856 it was found necessary to strengthen and widen the bridge, as well as to improve its approaches; and the town council having obtained the necessary parliamentary powers, the renovation of the fabric was commenced in the following year, according to plans furnished by Robert Stephenson, Esq., civil engineer. The improved bridge was opened in 1859, the total cost of the alterations having been L.40,000, the repayment of which is provided for by tolls, from which foot-passengers, by a resolution of the town council, are exempted. The leading feature of Mr Stephenson's design was the throwing across of three great tubular girders, one on each side of the east and west ribs, and another in the centre. The cast-iron rings of the original bridge were replaced in the new one, with malleable iron lattice-work. The harbour at the mouth of the river is enclosed by two piers, the north pier, extending 1000 feet, and the south pier 1800 feet. On the north pier there is a lighthouse, which, in 1841, on the lengthening of the pier, was removed a distance of nearly 500 feet without taking down the masonry. The depth of water on the bar varying from 18 to 21 feet at ordinary tides, vessels of a large size can enter and leave the harbour. Docks have also been formed on the north and south sides of the river. Wearmouth Dock, on the north, can accommodate 80 sail of vessels. It was constructed at a cost of L.120,000, and is now the property of the North Eastern Railway Company. Sunderland Docks, on the south side of the harbour, were constructed at a cost of L.720,000. They can accommodate 350 sail of vessels, and have an outlet to the sea independent of the river. This outlet is of great service to large ships, the depth of water at its mouth being greater than that on the bar at the harbour's mouth. Sunderland docks were opened in 1850; in 1859 they passed from the hands of the company that was formed for their construction to the Commissioners of the River Wear, who that

year obtained an act of Parliament authorizing them to purchase the docks. Ship-building, the export of coals and lime, glass-making, the manufacture of anchors and chains, of ropes and sails, and earthenware goods, are the principal industrial features of Sunderland. On the 1st of January 1860, the number of vessels belonging to the port was 1004, representing an aggregate of 232,261 tons. In 1836, the number of vessels that sailed from the port was 994, with an aggregate of 153,415 tons. In 1859, the number of vessels that left the port had increased to 10,736, and the tonnage to 1,712,928. In 1836, the total exports of coal amounted to 971,190 tons; in 1859, the coal exports had reached 2,633,232 tons. Several hundred sailing vessels belonging to the port are solely employed in the coal trade, but this branch of the shipping interest is threatened with gradual extinction, the screw-steamers belonging to the port carrying in the aggregate half a million tons of coals to the London market in the course of twelve months. The custom-house duty paid at Sunderland in 1859 was L.99,115; the expenses of the establishment were L.7721. The port is defended by three batteries, near to the most important of which is the barracks, with quarters for 300 men. Ship-building is carried on to a great extent on the Wear. In 1859, a year of great depression in that branch of trade, 100 vessels were launched at Sunderland, with a total tonnage of 37,184, and an average per vessel of 371 tons. The total value of the vessels built during a year of average briskness in business, when fitted out for sea and ready to receive their cargoes, is three quarters of a million sterling. The glass trade is also of considerable importance. Of window-glass, 6240 tons are manufactured on an average in the year; and 23 millions of bottles are produced in the same period. There are seven firms carrying on both these departments of glass manufacture, and the total annual value of the window-glass and bottles produced by the 1700 hands whom they employ is nearly a quarter of a million sterling. There are a number of charitable institutions in the town, one of which, the Orphan Asylum, opened in 1860, is patronised by her Majesty Queen Victoria, who contributed 100 guineas to its funds. This asylum was founded for the children of deceased mariners of the port, and is principally maintained from the proceeds of the sale of land on the Town Moor for dock and railway purposes. There are several literary institutions in Sunderland; and a museum, with the nucleus of a free library attached, has been established by the town council. There are 2 handsome theatres, with accommodation for 3500 persons. The town is connected by railway with Newcastle-on-Tyne, which is 13 miles north-west of Sunderland; altogether, there are 4 railway termini in the borough. The municipal government is vested in a mayor, 14 aldermen, and 42 councillors, elected by 7 wards. The borough returns 2 members to Parliament. In 1841 the population was 56,607; in 1851 it was 63,897.

SUNIUM, a promontory and demus of ancient Attica, forming the southern extremity of that country. The promontory, which rises steeply from the sea to a great height, was crowned with a temple to Athens, the tutelary deity of Athens. This temple is now in ruins, but many of its columns are still standing, and have given to the promontory its modern name of Cape Colonna. Sunium was fortified in the nineteenth year of the Peloponnesian war, in order to protect the corn-ships in their passage to Athens with supplies, and from that time onwards it was considered one of the chief fortresses of Attica.

SUPERIOR, LAKE. See CANADA.

SUPERLATIVE, in *Grammar*, one of the degrees of comparison, being that inflection of adjectives that serves to augment and heighten their signification. It shows the quality of the thing denoted to be in the highest degree.

SUPPER. See THEOLOGY.

SURAT, a town of British India, capital of a collectorate of the same name, in the presidency of Bombay, on the left bank of the Taptee, 150 miles N. of Bombay, and 130 S. of Ahmedabad. Its form is semicircular, and its circuit is about six miles. It is defended by a small castle on the shore of the river, and by a wall with bastions and battlements. The town is not very prepossessing in its appearance, having narrow, crooked streets, lined with lofty houses, which have frames of timber filled in with brick. Besides the castle, the chief buildings in the town are the Protestant Church, Mosque, Mahometan College, and two Parsee fire-temples. The English cemetery contains many tombs of former governors of Surat, and others; there are also a Dutch cemetery of considerable interest, and a *dukhma*, or Parsee burial-place. The palace of the Nawab of Surat is a plain, unattractive building, remarkable for nothing but for a fine collection of Arabic and Persian MSS. which it contains. Surat has also some ruins of the abodes of the ancient nobility. Outside the walls is the site of the old French factory, now quite deserted; as also is the Dutch factory, which was once the best building about the town. The prosperity which Surat enjoyed in the latter part of last century,—when its bazaars were stored with all sorts of merchandise, and crowded with men of all nations; when its river was filled with shipping, and its streets with the bustle of life,—has quite passed away. Bombay has far outstripped its rival, and withdrawn from it all its foreign commerce; so that its only trade now consists in the exportation of cotton and grain to the less fertile regions of Concass. But, as it is the station of a large number of the British forces, and also of many of the civil officials, it is still a place of some importance, and contains a large proportion of British residents. The inundations of the Taptee have on several occasions been so great as to inflict much damage on the town, but since the last of these, in 1837, some steps have been taken to defend the town against them, and by the construction of a canal in connection with the river, the risk of their recurrence has been lessened. The first mention of Surat in history occurs in 1530, when it was taken and sacked by the Portuguese, but, as it was then a place of considerable size, it must have been in existence for some time previously. In 1612, permission was given to the English to establish a factory here, and the whole possessions of the East India Company were placed under the governor and council of Surat from 1567 to 1692, when the seat of government was transferred to Bombay, on account of its growing importance. In 1664, Surat was plundered by the Mahrattas under Sevajee, but the English factory was successfully defended against their attacks. During the first half of the eighteenth century, Surat was in a state of great confusion between various conflicting powers. At length, in 1759, the Bombay government, in order to put an end to the disorder, took possession of the castle, and in conjunction with the native Nawab exercised the government for forty years. On the death of the latter, in 1799, the British, at the request of the inhabitants, assumed the entire government, which they have since exercised. Pop. (1847) 95,000. The district of Surat has an area of 1629 square miles, and a population of 492,684.

SURGERY.

THE term *Surgery*, or *Chirurgery*, from χειρ, *the hand*, and εργον, *work*, originally signified, as its derivation implies, the manual procedure, by means of instruments or not, directed towards the repair of injury and the cure of disease; in contradistinction to the practice of *medicine*, denoting the treatment of disease by the administration of drugs, or other substances supposed to be of a sanative tendency. Such a meagre description applied but too justly to surgery in its infancy, and still more after its separation from its twin-sister medicine, in the twelfth century. When its practice was denounced by the Council of Tours as derogatory to the dignity of the sacred office of the priesthood, and beneath the attention of all men of learning, the term chirurgery, in its most literal interpretation, was quite sufficient to comprehend the duties of the degraded and uninformed surgeon, who had become a mere mechanic, attached to and completely dependent on the learned and philosophic physician. But the matured progress of the healing art has, fortunately for science and humanity, rendered such a definition of surgery in these days utterly untenable. Its complete separation from medicine would now be attended with the utmost difficulty; nor is it desirable that the attempt should be made, because its success, however partial and imperfect, would be most hurtful to both. They are now, and it is to be hoped will ever remain, one and inseparable. Their principles are the same throughout, and the exercise of their different branches requires the same fundamental knowledge; but their details are so numerous and intricate as to render it most difficult, if not impossible, for any one individual to cultivate all with equal success. The consequence has been, that while the theory and principles of physic and surgery remain united, as constituting one and the same science, the practical parts are now frequently separated into distinct professions, each person adopting that department most congenial to his pursuits, and for the management of which he conceives himself best qualified. The separation however is not that of acquirements, but merely of practice. It should never be forgotten, that the physician, before he can be either accomplished or successful in his profession, must be intimate with the principles, if not with the practice of surgery. And most certainly no one can ever lay just claim even to the title of surgeon, far less hope for eminence or success, unless he be equally qualified to assume both the appellation and the employment of the physician.

Many and laboured have been the attempts to define surgery according to its present state, so as to prevent interference with the department of physic. This example we will not follow. The arrangement as to what is medical, and what surgical, must in a great measure depend on custom, not on fixed and permanent rules. The paths of the practical surgeon and physician are distinct, but in their course they must often cross each other; and these collisions, so far from being avoided, ought rather to be sought, as probable sources of mutual benefit, so long as those enlightened feelings are entertained, and that honourable conduct pursued, which ought ever to distinguish the followers of a liberal, useful, and learned profession.

The limits allotted to this article not permitting us to enter into the details of surgery, we must content ourselves with a sketch of its history, and with some account of its improved condition as it is at present practised.

Origin. That surgery is as old as man himself, that it was coeval with his fallen state, there can be little doubt. The fall entailed the frequent reception of injuries by external violence; and to assuage their pain and remove their inconvenience, the ingenuity and contrivance of the sufferer were powerfully excited. Thus it would seem, that as to antiquity of origin, surgery must take precedence of medicine. And after wars and dissensions began to prevail, and wounds and injuries became both more frequent and more deadly, it is most probable that to these the practitioners of the healing art alone directed their attention, before the nature of disease began to be understood, or its cure was supposed to be within the reach of human means.

Early Egyptians. As to the state of surgery among the early Egyptians, we know but little, except that it was customary, in the time of Joseph, to embalm the dead; a process which appertains closely to both medicine and surgery. There are some grounds, however, for suspecting that they were more conversant with surgery than is generally supposed; for it is said that on "the ruined walls of the renowned temples of ancient Thebes, basso-relievos have been found, displaying surgical operations, and instruments not far different from some in use in modern times." Their medical practice, entirely founded on incantation and astrology, was sufficiently simple. They divided the body into thirty-six parts, believing in an equal number of demons, to whom those parts were intrusted, and to invoke whose aid in sickness was the principal duty of the physician, each spirit being called upon to cure his own peculiar portion.

Jews. Among the Jews, the operation of circumcision was performed, no doubt skilfully and dexterously, though with rude implements, by the priesthood, an order which, for many ages, and in many climes, conjoined the cure of the body with that of the soul.

Greeks. The earliest notice of this art is from the ancient Greeks, who, it is probable, had derived their medical traditions from the Egyptians. They considered medicine to be of divine origin; and its first professors, as they inform us, were no less personages than gods and sons of gods.

Medicine and surgery, at their origin, were conjoined; and both continued to be practised indiscriminately, until separated by the Arabian school. Their complete estrangement occurred, as we have already stated, about the middle of the twelfth century. At first, surgery chiefly occupied the attention of the ancient leech, as the more certain and more obviously useful branch of his profession; but ultimately it became very secondary to medicine when dignified by philosophy and priestcraft.

Chiron. Chiron the Centaur, born in Thessaly, is presumed to have been the father of surgery, celebrated for skilfully applying soothing herbs to wounds and bruises. But his fame is somewhat endangered by that of Æsculapius, the son of Apollo, by some held to be the pupil of Chiron, by others, his predecessor and superior. **Æsculapius.** Æsculapius is supposed to have been deified, on account of his skill, about fifty years before the Trojan war. His very existence however has been questioned. Apollo was the original god of physic among the early Greeks; but he appears to have resigned in favour of Æsculapius, whose temples became the depositories of medical and surgical knowledge; more particularly those of Epidaurus, Cnidos, Cos, and Pergamus.

Podalirius and Machaon, B. C. 1192. Certain it is, according to the testimony of Celsus, that Æsculapius is the most ancient authority in surgery. His immediate descendants, two sons, Podalirius and Machaon, have been immortalized by Homer. They followed Agamemnon to the Trojan war, and there their services were so highly valued as to secure them a not unconspicuous niche among the heroes of the Iliad. Of the two, Machaon seems to have been the more distinguished. When he is wounded by Paris, the whole army is represented as interested in

his recovery. Even the stern Achilles inquires anxiously after "the wounded offspring of the healing god;" and the valiant Nestor, to whose care he is intrusted, is exhorted to unwonted exertion in his behalf; "for a leech who, like him, knows how to cut out darts, and relieve the smarting of wounds by soothing unguents, is to armies more in value than many other heroes." Podalirius enjoys the distinction of being reputed the first of phlebotomists, and probably the most successful, from his time to this; having opened a vein in either arm of the king of Caria's daughter, who had been severely injured by a fall from the house-top, having, after her recovery, been rewarded with the hand of the fair princess, and having been presented by her munificent father with the Chersonese as her dowry. As to medicine, they seem to have been either ignorant, or in no great repute; for, on the breaking out of pestilence in the Grecian camp, Homer neglects them entirely, and applies at once to Apollo. And even their surgical attainments, for which they are celebrated by him, seem to have extended no farther than to the simple extraction of darts and other offensive weapons, the checking of hæmorrhage by styptics or pressure, and the application of lenitive salves. The poet takes notice of his warriors sustaining fracture of the bones; but in such emergencies he adopts the same course as in the pestilence, and invokes the aid of the nonprofessional deities; from which circumstance we may infer, that in those days surgery had made but little advancement.

Asclepiades.

For upwards of 600 years after the Trojan war, there are scarcely any accounts of medicine and surgery. They seem to have remained strangely stationary during the whole of that period. Their practice was confined to the Asclepiades, or reputed descendants of Æsculapius; whose lore was orally communicated from father to son in that family, until they received an extraordinary impulse from the great Hippocrates, himself a branch of the family, and said to have been the fifteenth in lineal descent from the deified founder. The Asclepiades, in the course of their monopoly, established three schools of medicine, at Rhodes, at Cnidos, and at Cos. The last gave Hippocrates to the world, and thus attained a proud and enduring pre-eminence.

Pythagoras, B. C. 600.

Pythagoras was the first who brought philosophy to bear upon the practice of the healing art, and led the way in raising it to the dignity of a science. Democritus, the happy sage, likewise turned his attention to medicine as a branch of general philosophy, and pursued it zealously. He lived in terms of friendship with Hippocrates, by whom he was held in great respect. By Pythagoras a school at Crotona was founded, about the time of Tarquinius Superbus, espousing doctrines somewhat different from those of Cos and Cnidos. It produced Damocedes, a contemporary of Pythagoras, who seems to have practised in Athens, an honoured and successful surgeon. By Polycrates, king of Samos, he was presented with two talents of gold for having cured him of a troublesome distemper. He was afterwards taken captive by the Persians. Their king, Darius, was intrusted to his care for a dislocated ancle, as well as the queen, Atossa, for a cancer of the breast; and he was soon loaded with honour and wealth on account of his wonderful cures, performed after the Egyptian physicians, previously in attendance, had signally failed.

Damocedes.

But we cannot suppose such men as Damocedes and the Asclepiades to have attained any great proficiency in surgery; for the touch of a dead body was interdicted as a profanation both by Jew and Greek, and consequently they must have been almost entirely ignorant of anatomy. They may have understood something of the skeleton, from their practice amongst fractures and dislocations; and they may have formed some general idea of the viscera, from researches in comparative anatomy, and from instruction by the Egyptians, whose practice in embalming afforded ampler scope for observation. But the minute structure of the human body must have been to them a profound mystery. And, knowing that anatomy is, was, and ever must be, the foundation of true surgical knowledge, we cannot evade the conviction that surgery, though occasionally successful and honoured in ancient times, must have been nothing more than a rude, imperfect, and uncertain art. The practice of its professors seems to have been extremely limited, consisting of little more than the binding up of wounds, and the staunching of hæmorrhage by styptics and the cautery; the extraction of darts and other missiles from the wounds which they had inflicted; phlebotomy, both general and local; and cupping by scarification. Whether they practised the capital operations or not, we are not informed; but it is probable that their comparative ignorance of anatomy effectually deterred them from any extensive division of the soft parts, as extremely hazardous and uncertain.

Hippocrates, B. C. 400.

Hippocrates, born in the 80th Olympiad, upwards of 400 years before the Christian era, did more for medicine and surgery than all who had preceded him; and indeed few of those who have succeeded him have been of equal service to the profession. He soon freed medicine in a great measure from the absurdities with which ignorance and superstition had invested it; and through a long, honoured, and glorious life he set a splendid example of persevering industry, philosophical research, and high moral worth. His fame soon raised the Coan school far above its rivals. Though his anatomical knowledge seems little better than a blending of ingenuity with error, yet he appears to have had some indistinct notions of the circulation of the blood; but Dr Pitcairne, in his "Solutio Problematis de Inventoribus," has sufficiently evinced that he was very far from anticipating the great discovery of Harvey. With all his deficiencies, and notwithstanding all the disadvantages under which he laboured, so correct was his observation, and so faithful his chronicling of disease, that many of his descriptions may be fairly inserted in our modern nosologies. Though his attention was chiefly directed towards the improvement and promotion of physic, now begirt with philosophy, and studied as a science, and though his practice was principally confined to the treatment of internal disease, yet he was not wholly inattentive to surgery. And his practice seems to have been tolerably bold and decisive; for, in regard to external disease, it was with him a maxim, that "when medicine failed, recourse should be had to the knife, and when the knife was unsuccessful, to fire;" a substance of which all the ancient doctors seem to have been particularly fond, from Prometheus downwards. Hippocrates employed it not only in a variety of diseases, but in various forms. Sometimes he applied red-hot irons to the part; sometimes he raised a conflagration on it, and of it, by a piece of wood dipped in boiling oil, or by burning a roll of flax after the manner of the modern moxa. He also made use of tents and issues, as more gentle means of counter-irritation. He seems to have performed the capital operations with boldness and success, excepting lithotomy, the practice of which appears to have been confined to a few who made it their exclusive study. He however recommends the removal of calculus, large and firmly lodged in the kidney, by incision; adding, probably in apology for the daring of the procedure, that otherwise there are no hopes of a cure, and that the disease must prove fatal. He reduced dislocations, and set fractures, but clumsily and cruelly; extracted the fœtus with forceps when necessary; and both used and abused the trepan, employing it not only in depression and other accidents of the cranium, but also in cases of headach, and other affections to which the operation was inapplicable. In cases of empyema and hydrothorax, after ascertaining by percussion that fluid was present in the cavity of the chest, he did not hesitate to make an incision between the ribs; and having allowed part of the fluid to escape, he placed a tent in the wound, and by withdrawing it regularly once a day, the whole was ulti-

Surgery. mately evacuated. He seems to have been perfectly acquainted with tetanus and spontaneous gangrene; observing, that even minute wounds of tendinous parts, as the fingers and toes, sometimes produce convulsions which terminate fatally; and that black spots on the feet frequently increase to extensive gangrene and incurable mortifications. Some of his practices have been long and justly exploded, some have been successfully continued, and others have, after disuse, been revived as modern inventions. For example, his method of ascertaining the presence or absence of fluid in the chest was by percussion, and applying the ear to the part, thus anticipating the use of the modern stethoscope. One of his modes of counter-irritation, we have seen, was by burning flax on the part, as in the modern moxa; and he strongly recommends the production of eschars on the back and breast in the earlier stages of pulmonary disease, thus anticipating the supposed valuable discoveries of a celebrated modern charlatan. His writings are elegant, and well repay a careful perusal. By them he made posterity his debtor; his contemporaries were not insensible to his merits, and endeavoured to reward them during his life. The inhabitants of Argos voted him a statue of gold; he was more than once crowned by the Athenians, and, though a stranger, was initiated into the most sacred mysteries of their religion, the highest distinction which they could confer; after his death, universal and almost divine honours were paid to his memory; temples were erected to him, and his altars covered with offerings.

We have already seen that surgery had long been stationary before the time of Hippocrates; and it made but little advancement during many succeeding generations. The Asclepiades had confined the knowledge of medicine among themselves; Hippocrates, however, gave oral instructions in anatomy and the art of healing, and thus disclosed its mysteries to the world. But few of his disciples seem to have profited much by his liberality. One of them, his kinsman Ctesias, we are told, acquired considerable renown for his skill; and having been taken prisoner by Artaxerxes Mnemon, in a battle fought against his brother Cyrus, was successful in curing him of a severe wound, and thus obtained favour with his captor. Plato began to flourish about this time; but though he was connected with medicine, we cannot lay claim to him as eminent in surgery; and he was more famous for his philosophy than his physic. Perhaps the most distinguished in surgery, among the more immediate successors of Hippocrates, was Diocles Carystus. He devoted more attention to anatomy than any of his predecessors, was curious in bandaging wounds of the head, and invented the bellulon, an instrument for extracting darts. Carrying his surgery into the practice of medicine, he was not very happy in the result; from observing that external wounds, abscesses, and inflammations were attended with fever, he supposed that general fever was uniformly occasioned by one or more of these causes operating internally. He followed Hippocrates in practice, and, like him, cultivated his profession, "not for lucre or vain-glory, but from real love of the medical art, and a pure spirit of humanity." Praxagoras of Cos was the last of the Asclepiades who succeeded in leaving a name behind him. As a surgeon he is reported to have been bold in the extreme, incising the fauces freely, and excising portions of the soft palate, in bad cases of cynanche; and making incisions into the bowels to remove obstructions, when milder measures failed. Aristotle, the celebrated preceptor of Alexander the Great, although not strictly in the medical profession, was the promulgator of doctrines which for a long time had a powerful effect on medicine. While he followed out the general principles of the healing art, and was curious in anatomical research, he seems to have disdained to meddle with the practical details, and among the rest those of surgery.

Ctesias.

Plato, B. C. 370.

Diocles Carystus.

Praxagoras.

Aristotle.

On the dismemberment of the vast empire of Macedonia after the death of Alexander the Great, learning took up its chief abode at Alexandria, under the protection of Ptolemy Soter. And here it was that popular prejudice first gave way, and permitted the examination of dead bodies, the greatest possible boon to the medical profession, inasmuch as it removed what had hitherto been the most serious obstacle to its advancement, ignorance of human anatomy. Herophilus and Erasistratus, the two great heads of the Egyptian medical school, were the first who had an opportunity of practising human dissection, the bodies of criminals having been given to them for that purpose; and they consequently not only corrected many errors, but made numerous and important discoveries, in anatomy; thus imparting a fresh stimulus, and affording a new and more solid basis to both medicine and surgery. By some they have been accused of carrying their enthusiasm in this inquiry to such an extent as to "open the bodies of living criminals for the furtherance of their physiological views;" but this is probably a mere exaggeration, originating in the horror with which human dissection was at first regarded; a horror which unfortunately is not even in our day altogether extinguished, notwithstanding the recent legislative enactments in favour of anatomical research. But we find even these privileged men falling into most palpable mistakes; for example, Herophilus plainly confounds the tendons and ligaments with the nerves. Yet the fact that the names which he gave to many parts still remain in use, will of itself remind posterity how much they are indebted to him for his anatomical labours. He was likewise one of the greatest surgeons of ancient times, and, as well as Erasistratus, acquired as much fame for brilliant cures as for anatomical knowledge. The surgical practice of the latter was characterized by peculiar boldness and decision, and strongly marked with the failing of his time and school, a love of multiplying and inventing murderous implements, and the relentless use of them. "In schirrosities and tumours of the liver, he did not scruple to make an ample division of the integuments, and try applications to that viscus itself. He followed the same practice in diseases of the spleen, which he regarded as of little consequence in the animal economy." And perhaps he was right in his supposition, though not in his practice. In cases of retention of urine, he made use of the particular catheter which long bore his name. Xenophon of Cos, said to have been a follower of Erasistratus, seems to have been among the first who arrested hæmorrhage from a member, by encircling it tightly with a ligature. Mantius, a pupil of Herophilus, wrote a treatise on surgical dressings, which he rendered complicated in the extreme. Another, Andreas of Carystus, wrote on the union of fractured bones, and invented several ponderous machines for reducing luxations of the femur. Indeed the surgeons of the Alexandrian school were all distinguished by the nicety and complexity of their dressings and bandagings, of which they invented a great variety. Among them, as in the time of Hippocrates, lithotomy was practised by particular individuals, who devoted themselves exclusively to that operation; and we are told that one of them, Ammonius, employed an instrument, by means of which he broke down stones in the bladder, plainly anticipating Civiale, and furnishing a marked example to the present age of the truth of Solomon's apophthegm, that "there is nothing new under the sun."[1] It is not improbable that some of their other practices might have afforded equally

Egypt.

B. C. 300.

Herophilus and Erasistratus.

Xenophon.

Mantius.

Andreas of Carystus.

Ammonius.

[1] A curious illustration of this is given by Dr James Johnson, in the narrative of his visit to Pompeii. "The Dilator or Speculum, for which Mr Weiss of the Strand obtained so much repute a few years ago, has its exact prototype in the Bourbon Museum at Naples. The coincidence in such an ingenious contrivance would be absolutely miraculous; but unfortunately there is a key to the similitude, which de-

striking examples of this sometimes unpalatable truth; but unfortunately the greater part of the writings of the Alexandrian school perished in the conflagration of the famous national library in the time of Julius Cæsar; a calamity fraught with immense loss to the healing art, as well as to almost every other branch of knowledge.

Rome.

The arts and sciences followed the seat of empire in its transfer to Europe under Julius Cæsar, and Rome became the grand centre of intellectual illumination. Notwithstanding the shrewd sense displayed by the ancient Romans in most matters, it is strange, yet true, that for centuries all ranks of society, from the mere plebeian rabble to the censor, had entertained an abhorrence of all practitioners of medicine and surgery, and trusted for cures to spells and incantations. Indeed public edicts were issued, "discouraging all countenance to the professed exercise of physic, and recommending faith in traditionary prescriptions and religious rites." Cato the censor managed the sick of his own family according to the terms of this edict, and gravely wrote down the words of incantation for curing dislocation or fracture. For nearly the first 600 years of its existence, Rome, accordingly, had no regular practitioner of medicine. The first we read of was Archagathus, a Greek, from the Alexandrian school, who practised in Rome, chiefly as a surgeon, during the consulates of Lucius Æmilius and Marcus Livius. At first his surgical skill obtained for him no inconsiderable fame, but the ancient prejudice soon revived in full vigour. An enraged populace —perhaps not without some reason, for he seems to have been particularly fond of the knife and cautery—compelled him not only to suspend his practice, but, changing his original title of "healer of wounds" to that of "executioner," caused him to be banished from the Roman capital. Afterwards, however, a native of Bithynia, assuming the name of Asclepiades, established himself in tolerable repute by virtue of insinuating manners, shrewd common sense, and the performance of several fortunate cures "tuto, cito, et jucunde." But with him we have little concern, for his sagacity soon taught him that it was essential to his welfare to avoid the unpopular practice of surgical operations, and accordingly he confined himself entirely to the apparently less hurtful administration of medicine. The only important traces of his surgical practice are, that in ascites he practised and recommended discharge of the accumulated fluid by minute punctures of the abdominal parietes; and that for quinsy, which term probably comprehended many of the various acute diseases of the throat now known and distinguished, he not only employed bold blood-letting, local and general, by the lancet and by cupping, but also had recourse to scarification of the fauces, and even attempted laryngotomy. By novel and successful cures in his medical practice, and frequent indulgence in skilful quackery, he obtained great personal reputation, and so far overcame popular prejudice as to establish a tolerably fair field in Rome for future practitioners. He was the contemporary of Cæsar, and the personal friend of Cicero. The latter is eloquent in his praise, and through him seems to have formed a high estimate of the medical character. "Nothing," says he, "brings men nearer to the gods, than by giving health to their fellow-creatures." It would thus seem that, in his time at least, the ancient grudge against the doctors had abated in Rome. Among the disciples and immediate followers of Asclepiades was Cassius, described as Iatro-Sophista, who left behind him several works on anatomical and surgical subjects. In one of the latter he distinctly accounts for wounds on one side of the head producing paralysis on the other, from the decussation of the nerves; a tolerable proof that he was not only a good anatomist for the time, but also an observant practitioner.

Archagathus. Asclepiades, 96 B. C. Cassius.

Celsus.

Rome itself did not produce a single medical practitioner of any reputation before the age of Aulus Cornelius Celsus, although he himself chooses to be complimentary to some of his immediate predecessors, "Tryphon, Euelpistus, and Meges, the most learned of them all." Celsus, the contemporary of Horace, Virgil, and Ovid, likened to Hippocrates for the quantity of his sound practical information, and to Cicero for the elegance of his style, lived in the reigns of Tiberius, Caligula, Claudius, and Nero, in the beginning of the first century of Christianity, upwards of 150 years before Galen.[1] In his celebrated medical work, he places great reliance on Hippocrates and Asclepiades, more particularly the latter, and gives a complete and excellent digest of all the true medical and surgical knowledge of his times, although it is not certain that he himself either practised medicine or operated in surgery. "Of his surgical operations and remarks, many are yet far from being obsolete, and impress us with a high idea of his ingenuity and judgment. His mode of performing lithotomy (on the gripe) has been in recent times warmly defended by Heister, especially as applicable to children. He describes the operation for cataract by depression, and the method of forming an artificial pupil. The whole of his account of injuries of the head is admirable, and evinces wonderful tact and discrimination. His rules for distinguishing fracture, and for the application of the trepan, have been highly eulogized; nor is what he says about contrecoups less accurate. He is the first who has remarked that there may be rupture of a vessel within the cranium without fracture or depression." And he is the first who recommended the application of ligatures to a wounded artery, with the view of arresting its hæmorrhage, after pressure has failed. He improved amputation, an operation then not much in use; and recommended its adoption in cases of gangrene from external causes. He is minute in his details as to the treatment of fracture and dislocation; his description of carbuncle is good, and its treatment similar to that now pursued, namely, free application of the strongest escharotics to the gangrened part. He describes several species of hernia, and gives directions for their reduction. "It would be endless however to particularise. Whoever wishes to know the exact state of surgical knowledge in the world at the time of the Cæsars, may turn to the pages of Celsus, with the hopes of a gratification which will not be disappointed."[2]

Aretæus, born in Cappadocia, practised in Rome, proba-

stroys the charm of astonishment. A crafty Frenchman imitated from memory, and with some awkward deviations, the Pompeian Speculum, and passed it off as his own. Weiss improved upon the Frenchman, and hit upon the exact construction of the original! Many modern discoveries may probably have originated in the same way."

[1] A life of Celsus by Joannes Rhodius is subjoined to the second edition of a work of that learned Dane, entitled "De Acia Dissertatio, ad Cornelii Celsi mentem, qua simul universa Fibulæ ratio explicatur." Hafniæ, 1672, 4to. We must likewise refer our philological readers to "Jo. Baptistæ Morgagni in Aur. Corn. Celsum et Q. Ser. Samonicum Epistolæ, in quibus de utriusque Auctoris variis Editionibus, Libris quoque manuscriptis, et Commentatoribus disseritur." Hagæ-Com. 1724, 4to. The prænomen of Celsus appears to have been Aulus, and not Aurelius, which is a "nomen gentile." See Fabricii Bibliotheca Latina, tom. ii. p. 37. edit. Ernesti.

[2] He relates an interesting anecdote of Hippocrates, illustrative of his abuse of the trepan. "Knowing and skilful as he was, he once mistook a fracture of the skull for a natural suture; and was afterwards so ingenuous as to confess his mistake, and leave it on record." To this he adds, "This was acting like a truly great man: little geniuses, conscious to themselves that they have nothing to spare, cannot bear the least diminution of their prerogative, nor suffer themselves to depart from any opinion which they have embraced, how false and pernicious soever that opinion may be; while the man of real ability is always ready to make a frank acknowledgement of his errors, especially in a profession where it is of importance to posterity to read the truth:" a moral which cannot be too often forced upon the attention of the present generation.

Surgery. Aretæus, A.D. 50–80.

bly about the time of Domitian. He was the first who made use of blisters, using cantharides for that purpose. Dissection in his time was prohibited under the severest penalties: his anatomical knowledge was therefore neither profound nor exact; "nevertheless he had the sound penetration to regard anatomy as the only legitimate basis on which either medical or surgical science could rest." Heliodorus, the celebrated physician of the emperor Trajan, has left some excellent observations on injuries of the head; and Antyllus, almost a contemporary, was a zealous and successful surgeon. He boldly recommends bronchotomy in cases of threatened suffocation induced by disease of the throat; and, in inflammatory affections of emergency, advises arteriotomy in preference to venesection, showing that excessive loss of blood thereby need not be dreaded, it being readily prevented by dividing the artery completely across. He also alludes to the operation for cataract by extraction, which he however recommends very cautiously, and only when the cataract is small. He obtained the radical cure of hydrocele by free incision of the parts. Rufus the Ephesian, who seems also to have lived in the time of Trajan, was a zealous anatomist and surgeon, and has left a treatise on diseases of the kidneys and bladder. About the commencement of the second century, Archigenes the Syrian settled in Rome, and distinguished himself both in medicine and surgery. His writings, which were chiefly confined to the latter subject, are unfortunately lost. Between Celsus and Galen, however, we meet with no great Roman writer on medicine or surgery. These were among the last of the liberal arts that were encouraged by the Romans; and the proud patricians refusing to educate any of their family to such a profession, the medical practitioners of Rome were at first importations from Greece and Alexandria, and afterwards self-educated slaves and freedmen.[1]

Heliodorus. Antyllus. Rufus, A.D. 96–117. Archigenes.

Galen, A.D. 131.

Claudius Galenus was born at Pergamus, in Asia Minor, in the 131st year of the Christian era. After studying at Smyrna and Corinth, he completed his medical education at Alexandria, and ultimately settled in Rome, where he soon obtained a great reputation, both as a successful practitioner, and as a public lecturer on anatomy. Professional jealousy of his talents, however, drove him from Rome, to which he did not return until recalled by Marcus Aurelius. Shortly afterwards he was appointed physician to the young emperor Commodus, with whom, as well as with the public, he rose to great favour. A man of great erudition, brilliant genius, and indomitable industry, he produced works which exerted a most powerful and extensive influence over medical practice. He has the merit of rescuing medical inquiry from the chaos in which he found it, and restoring it to the paths of light and nature. His fame indeed was so great as to prove, in one sense, detrimental to the advancement of the medical profession, inasmuch as his opinions were received as oracular in the schools of all the civilized countries for no less a period than 1300 years, thus seriously retarding further investigation. His works were both numerous and elaborate; but unfortunately he seems to have been debarred from the study of the groundwork of his profession, human anatomy. His dissections appear to have been limited to the simiæ and other mammiferous animals, as most resembling the human structure, though on one occasion "he felicitates himself on the opportunities he had enjoyed of examining two skeletons preserved in Alexandria, and recommends all anxious to obtain a thorough knowledge of osteology to repair to that city." In his early years, he practised surgery at Pergamus with marked success; but in Rome he seems to have confined himself almost entirely to medicine, excepting the occasional performance of phlebotomy: probably the valorous Romans had not yet lost their hatred and dread of the terrible operations of surgery. Like others, however, he was still so much of a general practitioner, as to practise pharmacy as well as medicine, with a little of surgery; and he himself informs us, that he had a drug-shop in the Via Sacra. "He established two general principles as the basis of all surgery—synthesis, or the reunion of parts—diæresis, or their complete division, as by amputation or extirpation. In four cases he detected luxation of the femur backwards, a variety not mentioned by Hippocrates; and records two instances of spontaneous luxation of the same bone. He also treats of more than one species of hernia. But although in his writings we meet with a few bold chirurgical attempts, as in the application of the trepan to the sternum in a case of empyema, yet it must be confessed that by far the greatest part of his surgery seems to have been confined to fomentations, ointments, and plasters, for external affections, together with the art of bandaging, a love for which he necessarily acquired at the Alexandrian schools; and the employment of complicated machinery in fracture and dislocations." His researches were not limited to medical science, but comprehended literature and philosophy.[2]

The early Christians unfortunately appear to have injured medicine and surgery, by attributing to martyrs and their relics the power of healing wounds and curing diseases; "acknowledging the active interference of demons and blessed spirits in the affairs of men, and leaving true philosophy in total abandonment." A Cimmerian gloom was then fast overspreading the world, by which science and art were destined to be long obscured; and shortly after the time of Galen, we accordingly find the medical along with the other sciences encompassed by the dark clouds of ignorance and barbarism. One or two names however occur worthy of notice, but more from having preserved than advanced medical knowledge. Oribasius, a pupil of Zeno, lived in the time of the emperor Julian, whose friendship he enjoyed, and became a celebrated practitioner, as well as of great importance in the state. His works are principally compilations, though judicious and useful. His surgery is marked with timidity, discouraging operations, except in most extreme cases, and is chiefly confined to unguents and embrocations. He abstracted blood locally, by making deep and extensive scarifications, or rather incisions, with the knife; a proceeding somewhat resembling the important modern improvement in the treatment of erysipelas, but adopted under different circumstances, and with other objects in view.

Oribasius, A.D. 350.

During the fifth century the west was repeatedly invaded by the Huns, Goths, Alans, and Lombards. Science greatly suffered in consequence; and no name worthy of remembrance is to be found, until, nearly two centuries after Oribasius, appeared Aëtius, a native of Amida, and a pupil of the

Aëtius, A.D. 500–550.

[1] On this subject, a remarkable controversy took place in England during the earlier part of last century. It was occasioned by Dr Mead's "Oratio Anniversaria Harveiana, in Theatro R. Medicorum Londinensium Collegii habita, ad diem XVIII. Octobris, MDCCXXIII. Adjecta est Dissertatio de Nummis quibusdam a Smyrnæis in Medicorum honorem percussis." Lond. 1724, 4to. This was followed by a publication of Dr Middleton, "De Medicorum apud veteres Romanos degentium Conditione Dissertatio; qua, contra viros celeberrimos Jacobum Sponium et Richardum Meadium, servilem atque ignobilem eam fuisse ostenditur." Cantab. 1726, 4to. To this dissertation Dr Ward of Gresham College published an answer in 1727: Middleton published the first part of a defence in 1728, and Ward having rejoined in the course of the same year, his antagonist prepared a second part, of which Dr Heberden printed a few copies in 1761, eleven years after the author's death.

[2] Here we must refer our classical readers to a most important collection published under the title of "Medicorum Græcorum Opera quæ exstant. Editionem curavit D. Carolus Gottlob Kühn, Professor Physiologiæ et Pathologiæ in Literarum Universitate Lipsiensi Publicus Ordinarius." Lipsiæ, 1821–30, 26 tom. 8vo. Three of the volumes are each divided into two parts. This collection includes the works of Hippocrates, Aretæus, Dioscorides, and Galen. Dioscorides was edited by Sprengel, and the other writers by Kühn.

Alexandrian school. "His surgical writings are copious and valuable. His opinions were guided by experience, and his methods of management and cure are characterised by much caution and discrimination. We find a variety of surgical queries and suggestions which had escaped Celsus and Galen, as well as the description of several diseases which have been omitted by Paulus Ægineta. He recommended and practised scarification of the legs in anasarca, and made free use of both the actual and potential cauteries; he cut out hæmorrhoidal tumours; operated for aneurism; tried to dissolve urinary calculi by the administration of internal remedies; and has given a series of interesting chapters on inflammation of the intestines followed by abscess, on encysted tumours, on the varieties of hernia, on diseases of the testicle and castration, on the pricks of the nerves and tendons, and in fact on almost every important branch of surgical knowledge. If, mixed up with these, we find some things which the matured experience of ages has abolished, it is less to be marvelled at, than that surgery was already enriched with so many valuable facts and observations." He makes no reference to the reduction of fractures and dislocations, whence it has been plausibly inferred, "that in all likelihood quacks were at that time in complete possession of this branch of practice. Better were it for society that it was quite out of their hands now!" He seems to have been the first to open up a field of medical inquiry, which has since been so successfully cultivated,—the nature and composition of urinary calculi. He appears also to have turned much of his attention to diseases of the eye, and is the first who speaks of the dracunculus or Guinea-worm.

Alexander, A. D. 527–565.

Alexander of Trallis, a famous physician in the time of Justinian, about the middle of the sixth century, was an author of more originality than either Oribasius or Aëtius. He wrote on diseases of the eye, and on fractures; but both treatises have been lost, which is the more to be regretted, as, with this exception, he confined himself entirely to internal disease.

Paulus Ægineta, seventh century.

The celebrated Paulus Ægineta, also of the Alexandrian school, lived about the middle of the seventh century, and made both large and valuable contributions to surgery. He frequently performed the operations which he describes, and abandoned the labours of the mere theorist, for the more valuable results of practical observation and experience. "His sixth book has been considered by many, and not without reason, as the best body of surgical knowledge, previous to the revival of letters." He recommended bleeding from the immediate neighbourhood of the part affected, in preference to general blood-letting, because more effectual; and, for the like reason, opened the temporal artery in cases of very severe ophthalmia. He had recourse to copious venesection, with the view of accelerating painful descent of calculus in the ureter. He opened internal abscesses by caustics, and defined the points at which he thought it advisable to perform paracentesis in the different alleged species of ascites. In lithotomy, having first endeavoured to ascertain the situation of the calculus by the rectum, he made his incision, not in the centre of the perineum, as recommended by Celsus, but to one side of the raphe, as is now practised. Of the impropriety of extensive incision of the bladder he seems to have been well aware, directing that the external wound should be much freer than the internal, and that the latter should be in extent merely sufficient to admit of the passage of the stone. While Celsus limited the operation to patients between nine and fourteen years of age, he sanctions its performance after the age of puberty, but admits that the chances of success increase with the youth of the patient. He described more than one variety of aneurism, pointing out those cases in which he thought it advisable to attempt a cure by operation; and extended this to the aneurisms of the head and joints, excepting only those of the groin, arm-pit, and neck, instead of confining it to the tumours of the arm alone, as had been done by Aëtius. All aneurisms, excepting aneurism by anastomosis, which he clearly and accurately distinguished, he conceived to originate in rupture of the coats of the artery. He performed extirpation of the mamma by crucial incision, and practised both laryngotomy and tracheotomy. He is the first who seems to have performed the latter operation as a means of carrying on respiration during occlusion of the larynx, but naturally enough falls into the error of transverse instead of longitudinal incision. He describes different species of hernia, and did not hesitate to operate when the tumour became strangulated. He is also the first who treats of fracture of the patella. He was pre-eminent as an accoucheur, and was the originator of the obstetric operation of embryotomy.[1]

Actuarius.

From the time of Paulus, we find no Greek or Roman surgeon of note, until the appearance of Actuarius, a Greek, who practised with great distinction at Constantinople, probably about the beginning of the twelfth century, but at what exact period it is impossible to ascertain. Among his writings are found several surgical treatises, which however possess no greater merit than as compilations from previous authors.[2]

Arabia. A.D. 640.

Having thus traced surgery from its origin, through the Egyptian, Greek, and Roman dynasties, we come to notice the prolongation of its feeble existence in Arabia.[1] From Alexandria, captured by the Saracens under Amrou in 640, knowledge was gradually communicated to Arabia. Its people became acquainted with medicine through the medium of translations of the Greek authors; and the "seat of learning was transferred, for a time, from beneath the shadow of the cross to the empire of the crescent; from the classic shores of Italy and Greece, to the warlike followers of Mahomet, and the fiery descendants of Ishmael." Many valuable manuscripts, rescued from the savage destruction of the Alexandrian library, were carefully transcribed, or translated into the Syriac or Arabic languages, and dispersed in various directions. The first Arabic translation was made about the year 683, by Maserjawaihus, a native of Syria; but the most eminent in this labour was Honain, called, by way of eminence, "the translator," a Christian, born at Hira in 764. Towards the end of the eighth century, a college was founded at Bagdat by the Caliph Almanzor; and there medicine obtained a permanent footing, under the fostering care of the far-famed Caliph Haroun al Raschid. Public hospitals and laboratories were founded by him for the benefit of students, who are said to have amounted at one time to no fewer than six thousand, consisting chiefly of Christians banished on account of their religion; and the Caliph Almamon surpassed even his predecessors in munificent patronage, extended to every department of art and science, and in unwearied exertions to restore and propagate the various branches of learning. By supplication he prevailed upon the Grecian emperors to send him many works in philosophy; and, employing the best interpreters that he could find, ordered all these books to be translated, and encouraged the industrious study of them by his own personal example. The medical school at Jondisabour, the

[1] Mr Francis Adams, a very erudite surgeon practising in the vicinity of Aberdeen, has published the first volume of "The Medical Works of Paulus Ægineta, the Greek Physician, translated into English: with a copious commentary, containing a comprehensive view of the knowledge possessed by the Greeks, Romans, and Arabians, on all subjects connected with medicine and surgery." Lond. 1834, 8vo.

[2] Le Clerc, Histoire de la Médecine. Geneve, 1696, 8vo. Amst. 1723, 4to. Freind's History of Physick, from the time of Galen to the beginning of the sixteenth century. Lond. 1725–6, 2 vols. 8vo. Le Clerc only continues the history till the age of Galen. The literary history of the Greek physicians may be sought in the *Bibliotheca Græca* of Fabricius.

capital of Chorassan, established by Sapores the First as early as the end of the third century, had by this time risen to great celebrity; and from it Rhazes, Hally Abbas, and Avicenna derived their medical education. Mesue lived during the caliphate of Haroun al Raschid, in the end of the eighth century, and Serapion during that of Almamon, about a century later; both eminent medical men in their time, but both pure physicians. The first Arabian worthy in the surgical department was the celebrated Rhazes, who presided over an hospital at Bagdat in the end of the ninth and beginning of the tenth centuries. His works are not remarkable for anatomical knowledge, which is not surprising, since the study of anatomy was strictly forbidden by the Mahommedan religion, and consequently the Arabians had to rest contented with the writings of the Greeks on that subject. "One of their religious prejudices against dissection was, that the soul did not instantly forsake the body, but lingered in some particular portion of it for some time after apparent dissolution, so that the dismemberment of it might be a species of hideous martyrdom;" a very sufficient reason why a professor of such a belief should strenuously object to the anatomization of himself and his friends. Rhazes is the first who has described spina ventosa and spina bifida. Of the real nature of the latter, however, he does not seem to have had any clear idea. Regarding cancer, he advised that the knife should never be used except when the disease was limited, and the whole tumour could be completely removed; condemning the opposite procedure as cruel and unavailing; an opinion which after-experience has shown to be most just and true. In bites from rabid animals, he first cauterized the wounds, and then prescribed emetics to expel the "black bile;" an evacuation considered most essential to the cure. His account of hernia is better than any to be found in the Greek writers. His works on surgery, however, are little more than compilations from Hippocrates, Oribasius, Aëtius, and Paulus. His confidence in oculism does not seem to have been great; for, having in his old age become blind from cataract, he could not, though urged, be prevailed upon to undergo an operation for its removal. In his time lithotomy, and some other operations, seem to have been entirely in the hands of juggling impostors. Hally Abbas, surnamed the Magician, on account of the extent of his knowledge and acquirements, lived in the end of the tenth century. His great work, the Al-meleky, written about the year 980, is, in its anatomical and physiological department, a mere transcript from the Greeks; and his surgery possesses but few peculiarities. "From the idea that caustics were efficacious when a redundancy of the humours flowed to a particular part, he recommended their application for the cure of hydrocele. In the management of dropsical affections his attention was always directed to the remote causes; and he preferred puncturing in the linea alba, a little below the umbilicus, for the relief of ascites." Avicenna, who divides with Rhazes the honour of having first introduced chemistry into physic, flourished later than the two preceding Arabians. He was termed, in his day, the Prince of Physicians, and seems to have been regarded as almost miraculous for the extent and variety of his knowledge. He was born in 980, and died in 1036, without a rival, either in the medical profession, or in general science. In his great medical work, the Canon, the surgical department is not altogether forgotten, but holds a second place to physic; indeed, before the appearance of Albucasis, surgery seems to have been all but extinct amongst the Arabians. He has distinguished between closure of the pupil and cataract, and in operating for the latter recommends depression; extraction he considers a very dangerous experiment. It is probable that to him we owe the first use of the flexible catheter. His works are said to have remained the oracles of medical knowledge for nearly six hundred years.

Rhazes, A.D. 852-932.

Hally Abbas.

A.D. 980.

Avicenna.

A.D. 980-1036.

Albucasis, who died in 1122, exerted himself more than his predecessors in behalf of surgery, which, by his own account, he found in a most deplorable condition; and he is chiefly distinguished as a surgical writer. Cauteries and caustics seem to have been his favourite remedies; and he becomes enraptured when speaking of the "divine and secret virtues" of fire surgically employed. The actual cautery he looked upon with veneration, and describes more than fifty affections in which his experience had found it beneficial. He is minute in his directions for its application, and forbids its use, "except by persons acquainted with the anatomy of the frame, and the position of the *nerves, tendons, veins, and arteries;*" from which latter circumstance some idea may be formed of the extent to which he himself was in the habit of roasting his unfortunate patients. He checked arterial hæmorrhage by his favourite method of cauterization, but also employed styptics, as well as complete division of the vessel, and ligature. He is supposed to have been the first to remark, that it is by the formation of a coagulum in the orifice of an artery that its calibre is closed and hæmorrhage arrested. He has described a particular instrument of his own for the cure of fistula lachrymalis, and the needle used by the surgeons of Irak for cataract. He speaks of operating for the relief of hydrocephalus, but the success of the practice does not seem to have been greater then than in its revival in our own time; for he confesses that he knew of but one successful case, and therefore does not recommend the operation. He seems to have been conversant with the mode of removing tumours by ligature when the knife is inexpedient; he advises amputation in gangrene of the extremities; and is the first who has described the mode of extracting calculus by incision in the female. His method of lithotomy resembled that practised by Paulus Ægineta; and, like him, he seems to have been bold in puncturing and excising the tonsils, removing the uvula when obstinately relaxed, and extracting polypous tumours from the fauces. He mentions bronchocele as occurring most frequently among women; but, fond of the knife and cautery as he was, he does not seem to have employed either for the removal of that tumour; indeed he tells us of "an ignorant operator who," in attempting extirpation of a bronchocele, "by wounding the arteries of the neck, killed the patient upon the spot." He invented the probang, for dislodging foreign bodies from the gullet; and in wounds of the intestines practised union of the divided parts by suture more than once with success. Though thus bold in his operations, and, like all the Arabians, too fond of the employment of instruments, he was not however without judgment and caution. For example, he condemns tracheotomy as worse than useless when the inflammatory affection of the windpipe is acute, and has extended to the bronchi; an opinion which is acknowledged as true, though unfortunately not always followed in the present day. And he exceeds even Rhazes in his dislike to operative interference with cancerous tumours, declaring that he never either cured, or saw cured, a single instance of that disease; a conclusion too nearly consistent with the history of that most implacable malady in all succeeding ages. His remarks on abscesses are most judicious; directing particular attention to their situation, and recommending their being early opened, whether "matured" or not, when in the neighbourhood of joints or other important parts, which would be injured by their continuance; a rule of practice which, if more faithfully followed, would materially diminish the number of diseased joints and bones. He also advised what has since been so much insisted on by Mr Abernethy, that when the abscess is very large, its contents should be evacuated by degrees. He is the only one among the ancient writers on surgery who has described the instruments used in each particular operation. Avenzoar, a Spanish Arab, practised physic with distinction, about the beginning

Albucasis, A.D. 1122.

Avenzoar.

Surgery.

of the twelfth century, at Seville in Andalusia. He describes inflammation and abscess of the mediastinum, from which he had himself suffered; and mentions a case of abscess of the kidney, from which fourteen pints of matter were evacuated. He speaks of bronchotomy as expedient in dangerous cases of inflammation of the tonsils: and in stricture of the gullet proposes three modes of treatment; the occasional passage of a tin or silver tube; the use of a milk bath, that nutritious particles may be taken up by the pores on the skin; and the injection of nutritious fluids by the rectum. He also details cases of "rupture, fracture of the hip-bone, wounds of the arteries and veins, tumours, and other varieties of surgical disease, which he appears to have understood well, and treated with discretion." He does not complain, like Rhazes, that lithotomy was in the hands of mountebanks, but tells us that the Arabians then reckoned such operations "filthy and abominable, and unfit for any man of character to perform;" and held that "no religious man, according to the law, ought so much as to view the genitals." The brightest name in the history of Arabian philosophy is that of Averrhoes, the pupil of Avenzoar, born at Cordova about the middle of the twelfth century, and said to have died in the year 1206. But he cultivated the study of medicine only as a branch of general philosophy, and surgery he seems to have altogether neglected.

Averrhoes, A.D. 1206.

Such were the Arabians. Of these, Albucasis was the most famous in surgery, as Celsus had been among the Romans, and Paulus Ægineta among the Greeks. But even he could not escape the unfortunate failing of the Saracenic school; endless invention of manifold and complicated instruments, attaching far too much importance to the mechanical part of their profession, and mistaking the inspiration of terror and infliction of cruelty for energetic and judicious surgery. In order, for example, to arrest hæmorrhage from a wounded surface, if time pressed and assistants were scarce, it was not uncommon to dip the part into boiling pitch, a liquid which was then dignified with the appellation of a styptic. They however systematically divided physic, surgery, and pharmacy into three distinct professions; and so, by commencing the division of labour, may be considered as having done something not unimportant towards the ultimate advancement of medical knowledge. "The last traces of their intellectual illumination appeared among the Spanish Moors in the thirteenth century, when the Christian arms having become more and more powerful, they were compelled to substitute the field for the study—the sword for the pen—and, before an overwhelming opposition, were at length driven from a region whose fields they had tilled, and whose olives they had gathered, for a thousand years. With the decline of the Saracenic school, the daylight of science went down over the nations; and an intellectual darkness, which endured for three hundred years, enveloped the general face of society. All the fountains of science were dried up, and the world seemed retrograding into the unillumined chaos of ignorance."[1]

School of Salerno.

A knowledge of the Greek and Arabian systems of medicine was introduced into Italy, at Salerno, in the beginning of the eleventh century; and this school soon rose to celebrity as a seat of medical learning. In the time of the Crusades, Salerno was a place of great resort for warriors of all nations passing between Europe and Palestine; and by these wanderers, on their return, the light of medical science was thence slowly conveyed over Europe. It obtained the privileges of a university; but the medical school of Salerno did not long retain its high reputation. In modern times, it is chiefly remembered on account of the *Regimen Sanitatis Salernitanum*, a singular production, of which more than one hundred and sixty editions are known to have been published. Though written in the name of the *Schola Salernitana*, it has generally been ascribed to Joannes de Milano. The English king to whom it is addressed is supposed to have been Robert of Normandy, whose claims to the English crown were recognised by some of his contemporaries. The poem opens with these lines:

> Anglorum Regi scripsit Schola tota Salerni.
> Si vis incolumem, si vis te reddere sanum,
> Curas tolle graves, irasci crede profanum,
> Parce mero, cœnato parum, non sit tibi vanum
> Surgere post epulas, somnum fuge meridianum,
> Non mictum retine, nec comprime fortiter anum.[2]

In the twelfth century, the Jews practised medicine, not only among their own tribes, but also among the Moors and Christians; and though, like all others of this age, merely treading in the beaten track of the Greeks and Arabians, yet, from their superiority in such learning, they came to be reputed the most skilful practitioners. About the middle of that century, as has already been stated, surgery was completely separated from physic, by the edict of the Council of Tours prohibiting the clergy,[3] who then shared with the Jews the practice of the healing art in Christian Europe, from in any way causing the effusion of blood, at least as a means of curing bodily ailment. Surgery was in consequence abandoned to the uneducated laity, and sunk to a deplorable state of prostration; it became a mere matter of plasters and unguents; and if any thing happened to be written on the subject, it was but a bad compilation from the Arabians.[4] We shall however notice some of the more remarkable events in connection with it during its temporary abasement. In the year 1271, the foundation of the College of Surgeons at Paris was laid by Pitard, a surgeon of eminence in those days, and whose enthusiasm effected something towards raising his humbled profession. About the same time lived Gulielmus de Saliceto, a professor at Verona, said to have been "a powerful man" in both surgery and medicine. He seems to have earnestly dissuaded men from the copying and study of books in preference to practical experience, and he himself set a better example. In our own country Gilbertus Anglicanus is the first name connected with surgery; but he seems to have been little more than a compiler from the Arabians. He lived about the beginning of the fourteenth century; and shortly after him appeared John of Gaddesden, author of the *Rosa Anglica*, and said to have been an erudite and ingenious man, as well as a skilful practi-

A.D. 1271.

Fourteenth century.

[1] Moir's Outlines of the Ancient History of Medicine. Edinb. 1831, 16to. Of this work we have not scrupled to make free use in the course of the preceding observations.

[2] *Regimen Sanitatis Salernitanum*; a Poem on the Preservation of Health, in rhyming Latin verse, addressed by the School of Salerno to Robert of Normandy, son of William the Conqueror, with an ancient translation; and an introduction and notes by Sir Alexander Croke, D.C.L. and F.A.S. Oxford, 1830, 12mo.

[3] The early clergy claimed the practice of medicine as their peculiar privilege, and, using it chiefly as a means of personal power and gain, disgraced it by ignorance, charlatanry, and imposture. It was to check this that the Roman council assembled by Pope Innocent II. in 1139, threatened with the severest penalties those monks and canons who applied to the practice of medicine, "neglecting the sacred objects of their own profession, and holding out the delusive hope of health in exchange for ungodly lucre." But even this, though followed by the more peremptory edict at Tours in 1163, where Alexander III. presided, did not make them altogether forego what they found so convenient and profitable. It was necessary to repeat the edict in 1179 and 1216; but notwithstanding, the monks continued still to practise physic, and it was chiefly by their evil influence that the school of Salerno was brought to decay.

[4] The writers of that age were aptly termed by Severinus, Arabistæ.

tioner. About the middle of the fourteenth century, Guy de Chauliac practised with renown at Avignon, and is "accounted one of the revivers of the languishing art." In his *Chirurgia*, a history of the state of surgery in his day,[1] we find the first mention of the Cæsarean operation. Contemporary with him was John of Ardern, an English surgeon. He wrote with simplicity and honesty, and may be regarded as a reviver of surgery in that country. In his practice he was peculiarly successful in the treatment of fistula in ano, and thereby acquired a great reputation. Valesco de Taranta, a Portuguese, practised at Montpellier, and wrote on surgery in the beginning of the fifteenth century. He was the first who proposed the cure of cancer by the application of arsenic. About the middle of the same century, lithotomy, the practice of which had hitherto been confined to itinerant and ill-informed operators, was restored to the regular profession by Germain Colot, a French surgeon, high in favour with Louis the Eleventh. He first contrived to witness the operation by the itinerants, then practised it on the dead body, and at last performed it successfully on a condemned criminal who happened to be afflicted with stone, and who consented to undergo the operation on condition of being pardoned if he survived. His success, in having thus doubly saved life, obtained for Colot much renown; and lithotomy ever after continued a regular part of surgical practice.[2] The fifteenth century contains other two events important to surgery;

1450. the discovery of the art of printing, about the year 1450, which gave a new impulse to science and literature, by rendering the accumulated stores of knowledge more accessible; and the importation of the venereal disease from America, by the first discoverers of that continent, giving the *small* pox as if in exchange, about the year 1492.[3] In this century also the Turks captured Constantinople, thus overthrowing the last remains of the eastern empire; and by the multitude of Christians who fled from that city many manuscripts of the Greek medical writers were brought to Italy, and their contents thence slowly disseminated over Europe.

Hitherto surgery can scarcely lay claim to an actual revival. Occasional attempts had been made to raise it from its low

Sixteenth century. position, but all proved abortive. At length, however, in the beginning of the sixteenth century, the practitioners of the healing art were happily convinced that the observation of nature was superior to compilation from the ancients, whether Arabian, Roman, or Greek; they consequently ceased to tread blindly and servilely in the footsteps of their predecessors, and a new era arose to the

1539. profession. About the same time Vesalius gave birth to anatomy, properly so called;[4] illuminated by which science, surgery became a worthy object of pursuit to men of talents and education, and under their cultivation it was gradually raised to an enlightened and liberal profession.

A. Paré.

The most conspicuous name in this new era of surgery is that of Ambrose Paré, a Frenchman. In this country surgery was then sadly depressed, having retrograded since the time of John of Ardern. Its list of practitioners comprised barbers, farriers, sow-gelders, cobblers, and tinkers; and it is not matter of surprise that from among these no name has been handed down as worthy of remembrance. The combination of the practice of surgery with the more harmless manipulations of the barber, was not confined however to this island, but existed also in France, and continued in both countries for upwards of 200 years. The great Paré does not reject the appellation of barber-surgeon, as applied to himself; nor does he seem to think that there is any thing derogatory in the title. He was surgeon successively to Henry the Second, Francis the Second, Charles the Ninth, and Henry the Third, of France; and followed the French armies in all their campaigns down to the battle of Moncontour in 1569. His consequent experience of gunshot and other wounds, on the field of battle, naturally directed his attention to the subject of hæmorrhage; and it is to him that we owe the revival and improvement of the method of arresting bleeding from arteries by ligature, and discontinuance of the canteries and styptics, which, to the disgrace of surgery, had hitherto been in exclusive use for this purpose. Yet so averse are mankind to abandon their ancient customs, that the improvement of Paré was not sanctioned till after much abuse and persecution, directed both against himself and his discovery; indeed so bitter and unrelenting were his jealous brethren, that he was compelled for his own safety to adduce garbled and incorrect extracts from Galen and other ancients, in proof that to them, and not to him, the invention was to be referred. So far he was less in error than he himself supposed, for we have already stated that he has merely the merit of reviving the use of the ligature.[5] Celsus distinctly advises its employment when pressure fails to stop arterial hæmorrhage; and Albucasis sometimes condescended to use it instead of his favourite cautery and cruel styptics. Paré, however, was amply repaid by future fame for the opposition which he had at first sustained. He rose to an unparalleled height of popularity with the army, by whom he was absolutely adored. On one occasion, his mere presence among the garrison of a beleagured city about to capitulate, re-animated the troops to such an extent, that their resistance became more energetic than before, and the besieging army perished beneath the walls. By his sovereigns he was also highly esteemed. From the general massacre on the fearful night of St Bartholomew he was rescued by the personal exertions of Charles the Ninth, his great merits being appreciated even by that weak and cruel monarch. But he was not content with the respect and praise of his contemporaries; his writings, the result of great experience and accurate observation, freed from the

[1] Some idea may be formed of the languishing state of surgery at this time, from his division of the surgeons into the following five sects. The first applied cataplasms indiscriminately to every description of ulcer and wound. The second in similar cases employed wine only. The third used emollient ointments and plasters. The fourth, chiefly military surgeons, promiscuously employed oils, wool, potions, and charms. The fifth, "consisting of ignorant practitioners and silly women, had recourse upon all occasions to the saints; praised each other's writings perpetually, and followed each other in one undeviating track, like cranes."

[2] In the beginning of the sixteenth century, cutting upon the staff was introduced by Johannes de Romanis and Marianus Sanctus, and very successfully followed by Laurence Colot, a descendant of Germain.

[3] The first author who clearly describes the venereal disease is Marcellus Cumanus, who wrote in 1495. It was not till 1530 that Fracastorius wrote his celebrated poem *De Morbo Gallico*, in reference to which it has been said that the chaste and classic elegance of its language was worthy of the best days of imperial Rome, and the mellifluence of its versification hardly surpassed by the bard of Mantua himself. By G. Torella, physician to Pope Alexander the Sixth, we are informed that the insane abuse of mercury as a means of cure was not quite a universal practice on the outbreak of the disease; for, in describing some particular forms of mercurial ointment, he himself states that "they destroyed an infinite number of people, who in this case did not die, but were downright killed; and these bold empirics must give an account, if not in this, in the next world, of their practice, and be drowned in the pit of repentance." It is but very lately that the "pit of repentance" ceased to be useful under very similar circumstances.

[4] A little later in the century, Fallopius taught anatomy at Pisa, and Eustachius at Rome, and to their efforts, as well as to those of Vesalius, the advancement of that science is much indebted. Fallopius died in 1563; Eustachius in 1574.

[5] As an example of how little the hint of Celsus was attended to, we may mention, that Procopius relates how Artabazes perished of a wound in the neck, "the artery of the neck having been cut through, so that the blood *could not be stopped.*" Their cauteries and styptics had no effect on the carotid, or its larger trunks.

yoke of authority, and digested by genius of a high order, have rendered him immortal. His works, first published in 1535, and afterwards more fully in 1582, exerted a most powerful and beneficial influence upon his profession. The influence was not however immediate; for at his death the light he had shed was for a time obscured, surgery reverting to the state of degradation in which he found it, in consequence of its baneful association with barberism. Pigrai was his successor, but an unworthy one: endeavouring to follow the footsteps of his master, he obscured and almost effaced them. The most interesting of Paré's surgical treatises is that on gunshot wounds, a class of injuries then of recent introduction, and little understood: the murderous cannon and firelock had not long been in use.

Seventeenth century. C. Magatus. Tagliacotius. Severinus. F. Aquapendente.

In the seventeenth century surgery again revived, resuming the impulse which the genius of Paré had imparted. Italy produced Cæsar Magatus, who simplified, and consequently must have improved, the treatment of wounds; the never-to-be-forgotten Tagliacotius, with his rude repairs of the human face; and Marcus Aurelius Severinus, a skilful and intrepid operator. At the end of the sixteenth and beginning of the seventeenth centuries, Padua was favoured with Fabricius ab Aquapendente, the preceptor of Harvey, a most distinguished physiologist, and the most eminent surgeon of his time. His *Opera Chirurgica* passed through no less than seventeen editions, and contain not only an excellent digest of surgery as it then was, but also many improvements of his own.

Wiseman.

About the middle of the seventeenth century arose the true father of British surgery, our own Wiseman, the Paré of England. One or two English names are to be found before him: William Clowes, a military surgeon of some eminence, attended the Earl of Leicester's army in the Low Countries, and wrote on gunshot wounds; and Lowe, a Scotchman, gave to the world a Discourse on the whole Art of Chirurgery, dated 1612: but Wiseman doubtless is the first Briton worthy of note in surgery. He was serjeant-surgeon to Charles II., and amidst the horrors of the civil wars had ample scope for the study of his profession. His surgical works, consisting of eight treatises, dated 1676, contain much information, at that time most valuable, and still amply rewarding an attentive perusal. In military practice he strongly advocated immediate amputation, "while the patient is free of fever," in the case of such injuries as rendered preservation of the member improbable, of course allowing the primary shock of the accident to be past; a point of practice which long discussion in after years served to confirm. It was not till his time that surgeons ceased to believe that gunshot wounds were necessarily envenomed by the powder and ball, and had to be treated accordingly with potent and cruel dressings.

Harvey. A. D. 1628.

The immortal Harvey, contemporary with Wiseman, cannot perhaps be classed among the eminent surgeons, having principally confined himself to anatomy and physiology, yet he is inseparably connected with that science by his discovery of the circulation of the blood; a discovery which has done so much for the advancement of all medical knowledge, but of surgery in particular.

Young.

James Young, a surgeon in Plymouth, may be said to have been also contemporary with Wiseman, having written in 1679. He is the first who proposed amputation by a flap, an improvement to which two French surgeons, Verduin and Sabaurin, lay claim; and he is also the first who recommends limited compression of the main artery in amputation.

F. Hildanus. Scultetus. Purmann. Heister.

Germany boasts of several eminent surgeons of this time; Fabricius Hildanus, a most successful practitioner, and author of a surgical treatise dated 1641; Scultetus, author of the work, celebrated for its horrid array of lethal weapons, called *Armamentarium Chirurgicum*, 1653; and Purmann, who displayed too great an attachment to the dangerous representations of Scultetus. Heister, a professor in the university of Helmstädt, wrote a system of surgery, which has been translated into most of the European languages, and is still in high repute.

Rau.

Holland likewise possessed successful practitioners of surgery, but tainted with an unworthy concealment of their methods of cure. Rau, a native of Germany, though a professor at Leyden, was perhaps the most successful lithotomist that ever lived, but he kept his method of operating a profound secret, and made it a mystery even to his own pupils; as appears from the circumstance that his two favourites, Heister and Albinus, of a more liberal spirit than their master, in attempting to divulge his secret for the benefit of the profession at large, have varied most materially in their statements. This illiberal spirit pervaded the other branches of medicine as well as the surgical. The famous anatomist Ruysch preserved inviolate the secret of his wonderfully minute injections, although really the discovery of his friend De Graaf; and Roonhuysen the accoucheur worked stealthily with his invented lever. The succeeding generation however removed this stigma from the Dutch; and their great Camper was equally celebrated for the number of his discoveries and the zeal with which he made them known.

Dionis. Eighteenth century. Petit.

From the time of Paré, France produced no surgeons of great eminence until the eighteenth century. In the seventeenth, we find the names of Dionis, Belloste, Saviard, and a few others of some renown, but not at all equal to their contemporaries in other nations. Some idea may be formed of the then feeble condition of surgery in France, from the fact, that Louis XIV. was not cured of a simple fistula in ano, until after his life had been in no small degree endangered by repeated abortive operations. That the French can boast of surgeons of the first class in the next century, however, is indisputably shown by the simple mention of Petit and Desault; names that must ever occupy a proud place in the annals of surgery. The former, adding to the most powerful talents great industry, and an innate love of his pursuits, rose rapidly to eminence, though not without much envious opposition, which seems to be the portion of nearly all those who occupy a pre-eminent place in the profession. On general surgery, he has left a work of much value; and his treatise on diseases of the bones, though produced at an early age, entitles him to be called the father of that branch of pathology. For many years it remained the best work on the subject. He was the inventor of the screw-tourniquet, and the first who operated for fistula lachrymalis by transfixion of the sac. He contributed largely to the Memoirs of the Royal Academy of Surgery; an institution which has done much for the advancement of surgery, not only in France, but throughout the world. Its Memoirs, containing the result of the labours of many eminent men, constitute a work of the greatest value.

Desault.

Desault, also of high reputation, both as an anatomist and as a surgeon, was the first who taught surgical anatomy, and gave clinical lectures on surgery. His improvements on the apparatus for fractures were most important; and a splint invented by him is still in use for fractures high in the femur. His modifications of cutting instruments were also good; among others, changing the amputating instrument to a straight knife, instead of the old curved weapon. He was the first who contemplated the cure of artificial anus, resulting from strangulated hernia; and he further improved Paré's revival of ligature of the arteries. The proposal of curing aneurism by ligature of the vessel on the distal side of the tumour originated with him; a proceeding, however, of which the merit is still dubious. His writings are both valuable and extensive. After the great names of Petit and Desault, not a few French surgeons of the same century, though less eminent, yet deserve mention; Le Dran, a copious and excellent author; Sabatier, famous in the department of operative surgery; &c.

Le Dran, &c.

Surgery.

Garengeot, Louis, La Motte, Frère St Cosme,[1] Portal, Pouteau, Lecat, Chopart, Morand, Moreau, &c.

America.

It is about the middle of the eighteenth century that our attention is first attracted to our transatlantic brethren. In 1763, lectures on anatomy and surgery were delivered in Philadelphia by Dr Shippen; and in 1791 the medical school of that city was completely established, under Benjamin Rush, the Hippocrates of Colombia; a school which has since lent invaluable aid to the progress of both medicine and surgery.

Pott.

Our own country was at this time by no means barren in surgery. Percival Pott and John Hunter are names which occur, the one in the middle, the other in the end, of the eighteenth century, and are fully equivalent to Petit and Desault; indeed Hunter may be justly ranked as the greatest man that ever graced the profession. Pott, the best author, operator, and practical surgeon of his time, greatly improved the practice of surgery in England, both by his writings and by personal example. Like Desault, his attention was particularly directed to the treatment of fractures, of which he had some painful experience in his own person, having sustained a severe compound fracture of the leg. He has left a justly celebrated treatise on the subject. On amputation his observations are most important, clearly discriminating between those cases, of injury more particularly, which demand the operation, and those which do not; at the same time marking the period most advantageous to its performance. Regarding injuries of the head, he wrote with more precision, and at the same time with more originality, than any previous author, and will ever remain a valued authority upon that subject. The same may be said of his description of vertebral disease, he having been the first who clearly distinguished between those curvatures of the spine depending on mere change of form in the bones, and those occasioned by caries or abscess: the latter formidable affection is still known as "Pott's disease" of the vertebræ. He greatly improved the treatment of fistula in ano, and abscesses in general; and by simplifying the whole art of surgery, discarding the cautery and escharotic unguents, or rather limiting them to their proper place and use, employing also the cutting instruments with caution and reserve, and placing more implicit trust in, and showing more respect for, the powers of nature than had hitherto been the custom, he achieved a most important and beneficial reform in surgery. Until his time, the maxim "Dolor medicina doloris" remained unrefuted. The actual cautery, for example, was in such general use, that "at the time when surgeons visited the hospital, it was regularly heated and prepared in the wards, and in the presence of the patients, as a part of the necessary apparatus. Mr Pott lived to see these remains of barbarism set aside, and a more humane and rational plan, of which he was the originator, universally adopted."

Hunter.

John Hunter, a native of Scotland, the pupil, first of Cheselden, and afterwards of Pott, though not remarkably distinguished as an operator, was the most gifted surgeon of which the medical profession can boast, and no less eminent as an anatomist, physiologist, and general philosopher. His researches comprehended a wider range than those of Pott, but arrived at the same end, the improvement of surgery. The knowledge obtained by his vast inquiries into physiology, pathology, and human and comparative anatomy, was, with all the power of his genius, brought to bear upon the practice of the profession, and with the happiest success. The doctrines of adhesion, granulation, ulceration, and inflammation with its various results, were, until detected and explained by him, comparatively obscure and uncertain; and no one is ignorant how much the successful treatment of disease, either by surgery or medicine, must ever depend on an accurate and familiar knowledge of these rudiments. To him we are indebted for the simplification of more than one operation, the discovery of the vitality of the blood, important advice as to the treatment of gunshot wounds, the enforcement of excision of bitten or poisoned parts, many new facts as to the physiology and pathology of teeth, and other valuable additions to practical surgery. But these assume an unimportant place among his deeds, when placed beside the two with which his name is indelibly associated—the cure of popliteal aneurism by ligature of the femoral artery, and the elucidation of the venereal disease; his work on the latter subject still remaining standard, and in many respects unsurpassed. His improvement of the operation for aneurism marks an era in the history of surgery, being one of the most important of its advances. Dissatisfied with the cruel, formidable, and unsatisfactory operation for popliteal aneurism, by incision of the tumour and ligature of the vessel at its diseased part, he made himself aware of the causes of failure by the old system, contemplated the plan of cure which bears his name, satisfied himself of its practicability by diligent study and experiment, successfully brought it to the test of actual practice; and then, extending the principle to all aneurisms, effected for surgery a great triumph over that formidable disease.[2] His first operation was performed in 1785, and was successful; proving that permanent removal of the force of the circulation in the aneurism is sufficient for its cure, by permitting consolidation and ultimate obliteration of the tumour. Since his time the method of applying the ligature has been considerably improved, and the certainty of success consequently increased. But "the more brilliant a discovery, and the more beneficial its results, the more certain is its author of becoming the butt of envy and the object of detraction." And accordingly we find that Hunter has not been permitted to remain in undisturbed possession of his discovery. Its merit has by some been claimed as due to Aëtius: others, with better hopes of success, support the pretensions of Guillemeau (a pupil of Ambrose Paré), Anel,[3] and Desault; but a candid inquiry into facts and dates will ever result in ascribing the honour to our illustrious countryman. Had he even been deprived of this, his name must still have been immortalized by othe and more palpable labour of his mind and hand—his books and museum.

A. D. 1785.

In the same century with Pott and Hunter, Britain also produced White, an excellent practical surgeon and lucid writer; Cheselden and Douglas, two eminent lithotomists, the former peculiarly successful; Sharp, famed for his Critical Inquiry into the State of Surgery; and Monro, a name indissolubly united with the birth and fame of the Edinburgh medical school.[4]

White. Cheselden. Sharp. Monro.

In Italy, where, during the times of Pott and Hunter, several eminent surgeons lived, Lancisi, Morgagni, Bertrandi, Troja, &c.,—the labours of Hunter in aneurism were ably followed up by Scarpa, who still further elucidated the doctrines regarding the new treatment of that disease, and established the success of the operation. He was also eminently successful in his researches as to the anatomy and patho-

Scarpa.

[1] Frère Jean de St Cosme, although a monk, had been educated as a surgeon. He was the inventor of the Lithotome Caché, and with it obtained wonderful success and celebrity as a lithotomist.

[2] "So discouraging were the results of the old operation, that many surgeons preferred performing amputation of the aneurismal limb."

[3] Guillemeau and Anel placed their incisions and ligatures in the immediate neighbourhood of the tumour.

[4] Dr Monro was appointed professor of anatomy to the company of surgeons in 1719, and during the ensuing year he was appointed to a similar chair in the university. Several other professors in the same faculty had previously been nominated; Sir Robert Sibbald, Dr Halket, and Dr Pitcairne, so early as the year 1685. But Dr Monro was the first who regularly delivered public courses of lectures, and he may in a great measure be regarded as the founder of the medical school of Edinburgh.

Surgery. Haller. logy of hernia, a subject which he has made peculiarly his own. The same century saw in Germany, Schmucker, Richter, and the great Haller, whose *Disputationes Chirurgicæ* bear, equally with his other works, the impress of both labour and genius of a high order.

Nineteenth century. Abernethy, &c. The nineteenth century will not yield to any former era in a numerous and bright array of names dear to surgery. It has seen the fall of Abernethy and Dupuytren, Cooper and Roux, Liston and Lisfranc, brilliant stars in the galaxy, and mourns others highly valued; but vast and powerful is the host who are still labouring, with distinguished success, in their noble calling. In all civilized countries, the dark days of the profession have, we trust, for ever passed away; and many are the illustrious names in which it now exults, more particularly in France and Germany. But we hesitate not to assert,—and we cannot think that national prejudice exerts any influence in leading us to the conclusion,—that no country can boast of a better crowd than that by which Britain, in the present century, has been and still is adorned.

Modern surgery. Having followed surgery thus far, from the earliest times, in its most notable points of history, we shall proceed to inquire briefly into the practice of the present day. And,

Operations. first, of the art of operating. It is a favourite phrase by which operations are stigmatized as the "opprobria of surgery." Nothing can be more unjust. So long as injury and disease are permitted to afflict mankind; so long as bones are crushed, and flesh bruised and torn; so long as tumours grow, and gangrenes spread—and we know nothing short of direct divine interposition that can wholly prevent such accidents—it is only by operation, dexterously executed and skilfully timed, that the human frame can be kept in repair, and life prolonged. To be able safely and expeditiously to remove parts which accident has rendered totally useless, and which would prove highly injurious if longer attached to the body; to take away diseased formations, or other noxious substances, and at the expense of but brief suffering, to dispel torture which had rendered existence a burden for previous weeks, months, and years; to accomplish such results, though it be by blood and pain, is alike creditable to the operator and beneficial to the sufferer. It is not a disgrace to the profession that certain injuries and diseases are of so grievous a nature as to be incurable but by operation, for such is the dispensation of Providence; it is the surgeon's boast to have recourse to the knife as seldom as possible; but it is also his pride to be able by it, as a last, and, to both parties, painful resource, to ward off suffering, deformity, and death. It is not, to operate, but to operate unseasonably, unnecessarily, unskilfully, that can ever bring disgrace; and to refrain from performing an operation when it is loudly and plainly called for, would carry not only opprobrium to surgery, but guilt and shame to the surgeon. We are speaking of surgery as it now is, not as it was. In former times operations were its disgrace. Knives, hot irons, screws, files, and saws, were employed with cruel and ignorant recklessness; but of late years, it has been the object of each truly good surgeon to simplify and diminish the number of instruments, and at the same time to use them as seldom as possible. He does not hesitate to employ them when his knowledge and experience tell him they have become indispensable. On the contrary, he will probably be urgent in their application, knowing that an early wound may save much after-suffering; but, in the first place, he will exert all his skill and all his powers, by milder measures to counteract injury and restrain disease, so as to supersede the necessity of operating. To effect this is doubtless the true triumph of his profession; and this triumph he often attains. But he must be Utopian indeed who can seriously hope that the period will ever arrive when operations shall have altogether ceased to be required. In the progress of surgery, many a murderous weapon, at one time in frequent use, has grown thick with rust, and become almost unknown; those retained are few, effective, and never employed without good cause. The growth of science and experience is bringing the ravages of disease more and more under control; operations are not only less frequent, but more simple and less dangerous in the performance; and it is the pride of the modern surgeon to witness and promote this great improvement of his profession. But there are, and ever must be, diseases which we cannot expect to cure, and injuries against which we cannot hope to strive successfully, so as to preserve life, by any measure short of operation. Modern surgery, accordingly, while anxious to limit the necessities for operation, is not the less aware of its importance as a means of cure; and has not only directed attention towards its improvement, but also extended its application, and with the happiest result, to diseases formerly unopposed. Many patients, for example, are now by the knife freed from morbid growths and natural deficiencies, who were formerly left an unprotected prey to deformity and disease.

The necessity for an operation having been clearly established, our object then is to perform it as safely and expeditiously as possible. We now no longer hear, as we did even so lately as fifteen or twenty years ago, of a poor patient being tortured for the space of an hour, by cruelties misnamed lithotomy: in a few minutes the bladder is cleared of extraneous matter; and almost the like number of seconds will suffice for amputation.[1] With this celerity, the safety of the patient is not only equally, but more secure; for rapidity is still held subservient to, though conjoined with, excellence of performance; and the mere absence of protracted pain confers a most important advantage on the reparative powers of the system.

But for the mitigation of pain, the surgeon is not now dependent solely on his quickness of hand. Anæsthesia, by vaporous inhalation, places the patient, temporarily, in a most blissful Lethe; not only abrogating all sense of suffering, but also contributing greatly to the system's power of enduring the operation. (Vide Chloroform.)

A prominent cause of improvement in the art of operating is an increased simplicity of the instruments, their arrangement, and use. On this subject, one who stood *facile princeps* among the operators of his day,[2] observes: Our armamentaria should contain simple and efficient instruments only; the springs, grooves, notches, and curves, seeming to be chiefly intended to compensate for want of tact and manual dexterity. The apparatus, though simple, ought to be in good order, and should always be placed within easy and convenient reach of the operator, so that he may be in a great measure independent of the lookers-on, who, owing to anxiety or curiosity, hurry and agitation, are apt to hand anything but what may at the instant be required. He will consider well what place he himself will most conveniently occupy during the operation; and having obtained proper assistants, he will make sure that they all understand what is expected of them. In short, before he ventures to begin, he will ascertain that everything is arranged, and in proper order; more particularly, that the cutting instruments have good points, that their edges are keen, and that the joints of forceps and scissors move freely and readily. The

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[1] Nor are there many now, who, alluding to their operative powers, would be likely to express themselves as did the preceptor of the immortal Harvey, first surgeon of his time though he was: "If it be a movable tumour, I cut it away with a red-hot knife, that sears as it cuts; but if it be adherent to the chest, I cut it without bleeding, with a wooden or horn knife, soaked in aquafortis, with which, having cut the skin, I dig out the rest with my fingers!"

[2] Mr Liston.

principle on which the instrument is made to cut should be well considered. Every knife is to be looked upon as a fine saw; the teeth of some are set forwards, and these cut best from point to heel, as does a razor; but the greater number are set in the opposite direction,—for example, the common scalpel and bistoury,—and act efficiently only in being drawn from heel to point. The cutaneous tissues, and in many instances the subjacent parts, should be divided at once and completely, by a single incision made lightly and rapidly; for the pain experienced is in proportion to the pressure and tardiness of movement in the instrument applied. The pain of partial division of the skin, in tails left at each end of an incision, is very great; and, besides, such wounds are not so available, as they would otherwise be, for the intended purpose of evacuating fluid, for permitting the extraction of foreign bodies, or for the dissection of morbid growths. Also, the pausing of a surgeon in the midst of a dissection, and the resort to fresh and more extensive incisions of the surface, is not only always awkward, but attended with much additional and unnecessary pain to the patient. Every cutting instrument should be well balanced, and placed in a steady smooth handle; the point should either be in a line with the back, which ought then to be perfectly straight, or both edge and back should be so far convex, the point being in the middle of the blade. The form and size of the instrument ought always to be in proportion to the extent of the proposed incisions, both as regards their length and depth: nothing can be imagined more cruel and reprehensible, for example, than an attempt to remove the lower extremity of a full-grown person with a common scalpel or dissecting-knife. If an extensive incision is necessary, an instrument should be employed possessing length of edge sufficient to separate the parts smoothly and quickly. Should the operator be required to cut on important parts, to perform a delicate dissection of the living tissue, he will choose a short-bladed instrument, with a handle rather long and well rounded; and after the superficial incisions have been effected, he will hold it as he would a writing pen, lightly but firmly, so that he can turn the edge, and cut either towards or from himself, as occasion may require. A small well-made scalpel, with a good point, and less convexity than those usually employed, is the instrument best adapted for such a purpose. Grooved probes and directors should be used as little as possible. With a little practice, incisions may be made upon the most delicate parts, without risk, by the hand unsupported, one layer being cut after the other. If any instrument is wanted to make the proceeding more safe—if the closely investing fasciæ of a hernial tumour, for example, are to be cautiously raised—dissecting forceps will be found the most convenient instrument for elevation previous to incision. In dividing the skin, the knife, whether a scalpel or a bistoury, is to be held and entered with the point and blade at right angles to the surface. It is carried with a decisive movement down to the subcutaneous cellular tissue; the blade is then inclined towards the part to be divided, and by a rapid and slightly sawing motion—as little pressure being applied as possible—the division is effected to the desired extent. The incision is finished by withdrawing the knife in a position perpendicular to the surface, so as to divide the entire thickness of the skin at the extremity as well as origin of the wound. For dexterously effecting such manipulations, the "fingers must be educated;" and diligent practice in the dissecting-room will be found the best foundation for surgical dexterity, as it is for sound surgical knowledge: "it is only when we have acquired dexterity on the dead subject, that we can be justified in interfering with the living." By practice the pupil will be enabled to use either hand almost equally well, and none should neglect to attain this power, for an ambidexterous surgeon possesses a great advantage as an operator. An ordinary degree of expertness is within the reach of any one who will industriously seek for and improve the opportunities for its acquirement; but yet a certain combination of natural qualifications is undoubtedly necessary to the attainment of pre-eminence in operative surgery; for a great operator in one respect resembles a great poet,—"nascitur, non fit." The importance of these natural gifts did not escape Celsus. "He must be young, or at most but middle aged," says he, "and have a strong steady hand, never subject to tremble. He must be ambidexterous, and of a quick, clear sight. He must be bold, and so far void of pity that he may have in view only the cure of him whom he has taken in hand, and not, in compassion to cries, either make more haste than the case requires, or cut less than is necessary, but do all as if he were not moved by the shrieks of his patient." The coolness and courage thus inculcated are the most valuable natural gifts of the surgeon; and it would be well did every patient remember that they are equally important in himself, for on his steadiness and patience under suffering much of the celerity and success of an operation depends. Expert skill in operation contributes greatly towards perfect self-possession; for the dexterous surgeon, like an adroit master of the sword, "will not enter rashly into difficulties, but being engaged from necessity or conviction, will bring himself through with courage." He who has what is strangely termed "*common* sense," enjoys another of nature's choicest gifts; and to no possessor does it prove more valuable than to the surgeon, as by its judicious application the want of more than one of the prominent qualifications considered as essential to his success may be fully compensated.[1] But a combination of the natural essentials for an eminent operator, as may readily be imagined, falls to the lot of only a small number; and to that gifted few it were well, when circumstances will admit of it, to delegate the performance of the more dangerous and difficult operations. Every surgeon, however, should be ready to undertake the greater number of surgical proceedings without hesitation or delay; for though, as we have already stated, operations do not form the most important part of surgery, they still are, and ever must be, inseparable from its successful practice.

Hæmorrhage.

Hæmorrhage, the most prominent accompaniment of surgical operation, is now in much better command, both temporarily and permanently, than it used to be, and consequently is less dreaded by the surgeon. During the operation, complicated machines, encircling the whole limb —very painful from the great and general pressure, and increasing the loss of blood by swelling the venous torrents and retarding retraction of the minor vessels—are now superseded by the skilful application of the "educated" and steady hand of an assistant, compressing the trunk of the main artery, and it alone. This change is particularly advantageous to amputation, admitting of its performance with greater dispatch, and with less hæmorrhage. In more tedious proceedings—the cautious extirpation of tumours, for example—the surgeon commences his incisions where he knows the principal vessels enter the part about to be the scene of operation; they are consequently divided at once; an active and steady assistant secures their orifices

[1] The ancient Athenians had a law, that no slave or woman should study medicine; probably fearing want of education in the one class, and deficiency of common sense in the other. Perhaps it were well if a similar protection to the practice of the profession were in present force, as was proposed by the late Mr Alexander Wood of this city. In addition to the usual examination for the diploma of surgeon, he wished to establish a jury to determine on the common sense of the candidate, stating as his reason, "If they have not *that*, I would not give a —— for *the rest of* their medical knowledge."

by the pressure of one or more fingers, and the proceedings are completed with comparatively little loss of blood, and without the hindrance of applying ligatures to any arterial branches until all the knife-work has been completed. Sometimes, when the part is unusually vascular, and important vessels come from all sides, this rule cannot be followed, and ligature must be applied to each important branch as it is divided; but this necessity for delay does not often occur. The ligature,—a firm hempen thread, well waxed,—ought in all cases to be applied very carefully, and made to enclose the orifice of the artery alone, which for this purpose is pulled out by the spring-artery forceps, or, when the parts have been much consolidated by infiltration, by a sharp tenaculum. A double knot, carefully secured, having been made upon the isolated orifice, one end of the ligature is cut off close to the knot, the other being left protruding from the most dependent part of the wound, that the ultimate separation of the ligature and its enclosed slough may thus be watched and made certain. It was at one time recommended, and is still practised by some, to cut away both ends of the ligature close to the knot, in the belief that the union of the wound by the first intention would thus be favoured, and in the hope that the noose would become encysted in its original situation, and produce no further annoyance; that hope, however, has been disappointed. It was then thought, that by making the ligature of an animal substance, as catgut, it might be slowly removed by absorption, and thus be prevented from becoming a source of future irritation; but that plan also failed. No doubt, ligatures in such circumstances have long remained quiescent, but that has been seldom; sooner or later, perhaps after the cure has been thought complete, they occasion the formation of abscess after abscess, and produce much irritation, until they themselves are expelled; and thus recovery is in the end much protracted. The usual practice therefore now is, to leave one end of each ligature a little protruding from the lips of the wound, in order to secure their complete expulsion at the proper period. These remarks of course apply only to wounds which are approximated soon after infliction, with the hope of their adhesion. When the cut surface, on the contrary, is left open, in order to suppurate, both ends of each ligature should be removed close to the knot, the practice being then unexceptionable. Another innovation lately practised, was the substitution of torsion for ligature of the arterial orifice, thereby imitating the natural means of suppressing bleeding. The method has only been found to succeed well with vessels of the second and third class, such as those of the fore-arm and lip—being inapplicable to the smaller twigs, and not safe in the case of the larger arterial trunks. In every extensive wound, therefore, some ligatures must be applied; and that being the case, it has been found more convenient and satisfactory to apply ligatures to each orifice requiring artificial closure. Hæmorrhage from veins usually ceases spontaneously when the position of the part is attended to, and all pressure removed that might prove an obstacle to the venous return. If it should be found obstinate, pressure applied to the orifice will be sufficient. Under any circumstances, cauteries and caustics are now seldom if ever required for arresting hæmorrhage.

Wounds.

These remarks naturally lead to the consideration of incised wounds, and here we again find that simplicity and improvement in surgery are synonymous. "Hot dressings, filthy unguents, greasy poultices, stimulating plasters, and complicated bandages, have given place to light water-dressing, unirritating plaster sparingly applied, and careful position of the part."[1] To no one does a larger share of merit belong in this, than to him from whom we have made the above quotation; and we cannot do better than continue to glean from him a little more on this subject. "Formerly (and they are even still) wounds were put together without delay, and their edges squeezed into apposition, and retained by various means, such as sutures, plasters, compresses, and bandages. They were carefully covered up, and concealed from view for a certain number of days. Then the envelopes of cotton and flannel, the compress-cloths, the pledgets of healing ointment, and plasters, were taken away, loaded with putrid exhalations, and a profusion of bloody, ill-digested, fetid matter. A basin was forthwith held under the injured part, and the exposed and tender surface was deluged with water from a sponge, and then well squeezed and wiped. Then came a re-application of retentive bandage, of the plaster, of the grease mixed with drying powder, all surmounted by some absorbing stuff, as charpie or tow, to soak up the discharge. This was not unaccompanied by pain, often more complained of than that attendant on the original injury or operation. This process was repeated day after day, the patient was kept in a state of constant excitement, and often, worn out by suffering, discharge, and hectic fever, fell a victim to the practice. The wound was, as it were, put into a forcing bed, excited action beyond what was required was hurried on, and the consequence was, that immediate union seldom if ever could or did take place. A suppurating surface, on the contrary, with bad profuse discharge, and a very tedious cure, if any, were obtained." This was an uncomfortable state of matters, but there is now a change. Surfaces are not disposed to unite for some time after the division and separation have occurred. So long as there is oozing of blood, no good end is to be attained by their close apposition. Should this be attempted, the blood which continues to be discharged from the smaller vessels is necessarily prevented from escaping; and the consequences are, infiltration of the loose cellular tissue, distention of the cavity of the wound, and separation of the surfaces probably throughout their whole extent; unless, indeed, this be counteracted by well-adjusted pressure on every part. Then ensues a congested state of the surrounding vessels, with perhaps a troublesome hæmorrhage from branches that would otherwise have become sealed up; at all events, constitutional disturbance, a heated swollen state of the injured parts, profuse, bloody, and putrid discharges, must occur; and this will certainly be followed by suppuration from a foul cavity, which may be long in assuming a healthy state. It is when re-action has occurred, when gentle vascular excitement has taken place in and around the solution of continuity, and when plastic matter begins to be secreted and thrown out, that the process of adhesion can be expected to commence in earnest. The edges of a large wound, as that resulting from amputation of the extremities, may be approximated in part, either by position, or by a few points of interrupted suture (the metallic almost always preferred), as soon as bleeding from the principal vessels has been arrested. But the close apposition, and application of all the retentive means, had better be delayed for some time longer. In the interval, sensibility will be abated, the oozing moderated, and the chance of secondary hæmorrhage much diminished, by lightly covering the parts with lint dipped in cold water, and frequently renewed; or a piece of lint may be placed between the cut surfaces, and a constant irrigation kept up by threads passing from a vessel containing cold water. When all oozing has ceased, and the surface become glazed, the surrounding skin, previously shaved, is made thoroughly dry; coagula are removed, the edges are put carefully and neatly in contact, and retained by narrow slips of adhesive plaster placed at intervals. The plaster commonly in use does not retain

[1] Liston's *Practical Surgery*.

Surgery.

its hold sufficiently long, is loosened by discharge, heats the surface, and often gives rise to erythema. A better kind is made by spreading a strong solution of isinglass in spirit on the unglazed side of oiled silk, cut into slips of the necessary length and size; this plaster is quite unirritating, and often retains its hold until the very completion of the cure. Being transparent, it does not prevent any untoward process that may be going on underneath from being observed; and if any fluid collects under it, an opening can be made for its escape. If sutures have been previously employed for the partial approximation of the wound, they can be removed by cutting the thread, shortly after the fixing of the plasters, should these alone prove sufficiently retentive. No other dressing need be employed in the first instance; no compress, no pledget, no bandage; for in general they will not promote union of the wound, and may do harm. The slight discharge that oozes out is from time to time wiped from the surrounding skin, and from the glazed cloth on which the part is laid. In some cases of amputation, after a few days a roller may be applied, to encourage the subsidence of any slight œdema that may have arisen, and to bring the stump into a good form. By such simple treatment, a great deal of suffering is saved to the patient, and he enjoys much comfort and cleanliness; besides, the surgeon is relieved from a load of most unpleasant and harassing duty. In certain circumstances it may be expedient to deviate from this system of dressing, and to bring the wound at once into apposition. In such cases the use of lint-compresses are quite essential, arranged over the entire extent of the incision so as to keep the surfaces in apposition, and prevent inward accumulation of the blood that may continue to ooze.

Wounds produced accidentally are almost always attended with more or less bruising of the parts, and can unite only by the second intention. After bleeding has been suppressed by the method recommended for incised wounds, the cold applications are to be superseded by those of an agreeable warmth, such as poultice of bread and water, or, what is much to be preferred, from its simplicity, and lightness, lint of thick texture, and of sufficient size to cover the wound, soaked in tepid water, and overlaid by an ample piece of oiled silk to prevent evaporation. Heat and moisture, by which qualities a poultice produces its soothing and beneficial effects, by which the surface is relaxed, its capillary circulation encouraged, and discharge promoted, are thus amply afforded without any of the weight, putrefactive fermentation, stench, and filth not easily separable from common poulticings. The edges of the wound are approximated as much as possible by attention to position; and by the same means the return of blood is favoured, and engorgement of the vessels and inflammatory swelling prevented to a very great degree. If the wound run across the fibres of the skin and muscles underneath, these are to be relaxed by flexion or extension, as may be, of the neighbouring articulations. Rest of the injured parts is also essential, and to obtain this it is sometimes proper to apply splints. Contraction of the wound takes place naturally, and generally with sufficient rapidity; should the surface, however, from any cause become weak and flabby, the lint is to be wet with a gently stimulating solution, as of zinc, instead of tepid water. Support, by bandage or plaster, may for a like reason sometimes be required. But healing is often retarded by the plasters and bandages which are inconsiderately employed to hurry it on; the granulations are absorbed, the surface of the sore becomes foul, the discharge thin and offensive, perhaps inflammation of the surrounding skin takes place, with extension of the sore by ulceration. Sometimes adhesion and suppuration may be happily blended in the cure. Thus, when, in a suppurating wound, whether accidental or incised, the discharge begins to thicken, and diminish in quantity, when the granulations are florid, small, and accuminated, and when the surrounding parts are sufficiently lax to admit of easy approximation, the granulating surfaces may then be brought into close apposition, with every prospect of immediate union taking place.

When the wound is superficial throughout, and when the means used for effecting apposition are capable at the same time of preventing the interposition of blood, the dressing may be always completed at once; as, for instance, in penetrating wounds of the mouth; in division of the lip, as for harelip; and in repairing some deficiencies of the genital organs. In such cases, either the twisted or quilled suture is used, usually the former, and no other dressing should be applied. To put on strips of plaster, to cover the part with lint smeared with ointment, to interpose dossils of lint between the skin and end of the pins, to support the wound by a uniting bandage—all this is mischievous, and a remnant of the old meddlesome surgery. Any kind of application collects and retains the secretions, heats and excoriates the surface, promotes suppuration, and interferes with the process of union.

Such is an outline of the simple treatment of wounds now employed, with the happy effects of saving the patient from much pain, and the surgeon from much trouble; obtaining a more frequent occurrence of adhesion in incised wounds; shortening the process of suppuration, and depriving it of much of its inconvenience. It is almost needless to observe, that this, as well as every other treatment, will, however, prove of little avail, unless accompanied with a careful attention to the general health: in other words, the surgeon, not hesitating to encroach thus far upon the duties of the physician, must ever be employing his medical science.

Diseases of the joints.

In no class of diseases is the operating knife now more happily in abeyance, in comparison with former practice, than in affections of the joints. Many a limb is now saved, with its usefulness little if at all impaired, that would, in days not long passed, have been doomed at once, and with very little ceremony, to amputation.[1] This important saving of life and limb is mainly attributable to the advance of pathology. The cultivators of that science, among whom the name of Brodie deserves prominent notice, have shown with great perspicuity the various changes which morbid processes induce in the structure of articulations, and established a wonderfully accurate diagnosis of each affection. We can often tell in what tissue of the joint disease originated, of what nature the morbid change is, and can predicate almost with certainty the actual state of the parts, as to extent and manner of degeneration. According to the principle that "the knowledge of a disease is half its cure," great advantage is thus obtained in adopting and regulating the treatment suitable to the circumstances of each case. Besides, we can tell at once, and with tolerable accuracy, in what cases we shall probably succeed; and in those in which we are made aware that the disease is of such a nature, or has proceeded to such an extent, as to baffle all attempts to cure, we are enabled to save valuable time,

[1] John Hunter himself seems to have been in the habit of making very unwarrantable abbreviations of living limbs, as the following anecdote abundantly proves. "He once had a patient whose leg he considered it necessary to remove. He had got on his *dress*, and a profound silence reigned in the theatre. The surgery-man disappeared. In two minutes he returned alone, with a face as long as the leg. 'Why do you not bring in the patient?' demanded the expectant operator. 'Because, sir,' said the astonished surgery-man, 'because, sir, he has run away!'" It is to be hoped that the custom of amputating legs that are able to "run away" has fallen into complete desuetude.

and thereby to save life, by proceeding at once to the only cure available, by the knife. In whatever part of the joint disease may have originated—bone, cartilage, bursæ, or synovial apparatus—if not arrested, it soon extends to all, converting the whole joint into one mass of disorganization, It is of the utmost consequence, therefore, to be early in the employment of the appropriate means of cure. The first and most important object is to secure absolute want of motion in the diseased parts; and here it is that the greatest improvement has taken place in the treatment of joints. "If perfect repose and quiet of the affected parts be omitted, all other means are found nugatory, and were as well untried. Nothing but disrepute can accrue to the profession, if hot irons, moxas, and issues continue to be used inconsiderately, to the neglect of more powerful and less appalling means. Instant relief invariably follows the securing a state of perfect rest; other means, local and constitutional, are thus afforded a fair chance of doing good, and the natural efforts towards a cure are no longer thwarted and interrupted. But, above all, the effect on the general health is most remarkable and cheering. Even in very complicated and bad cases, in which sinuses communicate with the cavity of the joint, and the heads of the bones are ascertained to be in a state of ulceration, or partially necrosed, the good effects of perfect quietude of the joint will soon be manifested by cessation of pain, diminution of discharge, and speedy improvement of the general health. A cure of the local mischief may not be possible by this means alone, but much will often be gained, as regards the success of ulterior proceedings, by the rapid and certain amendment of the patient's condition." This salutary rest is the first part of the treatment of all diseased joints, and is continued, in general, throughout the whole period of cure; it is obtained by the application of splints, varied in form and construction according to the particular joint affected.

Disease of the soft parts of the joint usually commences in an inflammatory form, requiring depletion; when acute, the antiphlogistic treatment, local and general, must be very active, so as at once to arrest the morbid process; and hot fomentation and poultice will generally be found more soothing than cold applications. When the more violent symptoms have subsided, the disease giving way, a determination to the surface, with discharge, lends powerful aid towards its final extinction. For this purpose vesication may be produced, by cantharides or by nitrate of silver; or an eruption may be established by friction with a liniment of croton oil, or an ointment of tartrite of antimony, their strength proportioned to the nature of the part and age of the patient. In chronic swelling of a joint, whether the effect of inflammatory change, or slowly and gradually supervening after injury, the disease must not only be arrested, but absorption also procured of the deposit and effusion within the synovial capsule and bursæ. To obtain the former indication, local depletion and counter-irritation are employed, according as the circumstances of the case require; and to obtain the latter, uniform pressure of the whole swelling, and gentle irritation of the surface, are combined with the means of securing the all-important rest of the joint, according to the method first recommended by Mr Scott. The limb having been uniformly supported by a roller, from its extremity up to the diseased articulation, the surface of the swelling is covered by lint spread with some gently stimulating ointment—soap cerate with camphor, for example, or that with a greater or less proportion of the unguentum hydrargyri; and the whole articulation is then surrounded by long strips of adhesive plaster, drawn with moderate and uniform tightness, so as to support and gently compress the parts, without producing absolute pain or uneasiness. Above all, splints are applied to secure total immunity from motion; and they may be of leather or wood, or gutta-percha, as most suitable to the joint affected. When this dressing has become loose from subsidence of the swelling, it is re-applied as often as may be necessary. Should fresh inflammatory accession occur in the joint, from any accidental cause, during this treatment, the apparatus must be discontinued, until such accession has been subdued by the usual means already described; and when the pressure is resumed, it should at first be very moderate. During the treatment the limb must be kept or gradually brought into the most advantageous position for ultimate use, particularly if, from the duration, nature, and extent of the disease, there is reason to expect permanent impairment of the joint's motion. Thus, by steady extension with splints, the knee-joint may be brought into nearly a straight position, so that it shall be serviceable in progression; and the elbow may be bent, to form such an angle with the humerus, as shall be most convenient for prehension. But such alterations of stiffened limbs must be proceeded with very cautiously, otherwise they may rekindle the inflammatory process, with consequent renewal of disease in the joint.

The preceding treatment will be found applicable to almost all joints, the hip not excepted. In morbus coxarius, for example, it is useful for securing immobility of the articulation, an object of such paramount importance towards arresting the progress of that formidable disease; and in its advanced stage it is productive of at least relief. The joint is placed extended, that being the preferable position, in case of anchylosis, and surrounded by "soft lint soaked in a strong solution of gum acacia, which is laid on in strips over the side and pelvis, from the short ribs to the knee, and made to embrace the limb fully. A layer of dry lint is first applied, and then two or three others, soaked in the mucilage, follow; these are covered by a fold or two of coarse calico, and the whole is retained by a roller." Sometimes it is necessary to preserve the limb steady in position by a wooden splint, as in fracture, until the composition has dried, and the splint, so formed, adapted itself closely to the parts. "This gum-splint can be made of any form, so as to allow of its being taken off, trimmed, lined with wash leather, or protected with a layer of oiled silk, and re-applied with a clean bandage. It can also be fashioned so as to leave any part exposed: the discharge from issues and abscesses can thus be allowed to escape, and the parts can be dressed, and otherwise attended to, without disturbing the limb. In fact, the apparatus can be varied as circumstances demand, and is applicable in a great variety of cases, and to any articulation." A similarly useful splint is made "of leather dressed without oil, cut to a proper form, moistened in hot water, and applied with a roller. It soon becomes firm, and forms a case which fits the part accurately; it is then pared, fashioned neatly, and lined. In many chronic cases such splints answer admirably; but the gum-splints can be applied with less disturbance of the limb, which in many instances is a great recommendation."

"In the painful and dangerous affections of the articulations, when the cartilages are extensively absorbed, and when the cancellated texture of the bone is more or less diseased, good effects may yet follow judicious treatment. Besides following out the principle of preventing all motion, great relief will often be experienced from establishing a permanent discharge from the neighbourhood of the diseased tissues. This can be done simply and effectually, without causing alarm, or exciting much pain, by confining a small piece of caustic potash on the skin near the diseased joint. The sore thus formed is deepened, and made to discharge freely, when disposed to heal, by a few hours' application of the antimonial ointment. A seton may be preferred in some situations; certainly discharge can be thus kept up, and derivation obtained from the affected parts,

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fully as well as by actual cauteries, moxas, pea-issues, or other farrier-like practices. Great care must be taken in the placing of issues; they should be near to, but not upon a joint. Serious results have sometimes followed their careless application; diseased action has been increased, they having reached, or even penetrated, the synovial capsule."

By the careful and judicious employment of such treatment, many affections of joints which resisted the less simple modes of cure formerly in use, are now successfully combated; and many limbs are saved which our forefathers would not even have attempted to cure. But still there are too many cases which baffle all efforts to arrest the progress of morbid change; and it becomes necessary, in order to relieve the labouring constitution, and preserve life, to remove either the diseased parts alone, or the remainder of the limb along with them by amputation. The former operation is termed resection, and is the preferable, because the less mutilating and severe, when the case is such as to promise a tolerable certainty of success. Should it fail, amputation then becomes necessary; but by the failure the chance of the patient's ultimate recovery is very much diminished. The cases for resection, therefore, should be carefully selected. The general health must not have been too much impaired; the disease must be almost entirely limited to the articulating surfaces; and the patient must be of that age and constitution most favourable to the reparation of injury. The articulating extremities of the bones are exposed by free incisions, planned according to the circumstances of the case, and the diseased portions are removed by suitable saws, or by cutting pliers. The soft parts are then replaced, and the cavity treated as a suppurating wound, the intention being that it should heal by healthy granulations from the bottom; and motion of the part is encouraged during the cure, with every prospect of the new articulation becoming both free and strong. The elbow-joint is the one to which the operation is most applicable, and to which these observations chiefly refer. The shoulder, too, is often operated on with perfect success. The hip, though not excluded from the benefits of such conservative surgery, is less favourably circumstanced; and it is only in few cases, specially affected as to either injury or disease, that here resection is advisable. The knee, of late years, has been subjected to the experience somewhat freely; and the general result seems on the whole favourable to well selected examples, except in the case of the young, the operation in them being apt to arrest growth in the limb, so that at the adult period of life the stunted member hangs loosely as a mere appendage, neither useful nor ornamental. Anchylosis is always sought. The wrist has been successfully operated on occasionally; and good practice in the region of the tarsus may be every day made on the principle of resection. This operation is founded on sound surgery, and ought in all practicable cases to take the place of mutilating dismemberments.

Resection of joints.

Amputation.

When, however, all milder means have failed, and resection is inapplicable, amputation must not be deferred until the disease has grown riotous in its progress, and the general health has been seriously impaired. When the surgeon is satisfied that amputation has become absolutely necessary,—that nothing else can save life,—the sooner it is performed the greater is the chance that this severe remedy will not fail in its issue; and it is consolatory to reflect that modern improvement has greatly mitigated its evils, and increased the probability of its success. It is performed more rapidly, more skilfully, and more successfully. The tedious dissection of a limb, called the "circular method," has now given place to the "flap-operation" by transfixion; the only valid objection that can be brought against which is, that perhaps a greater surface of wound is made; but this is much more than counterbalanced by the many benefits which it otherwise insures. The operation is more rapid; the cut surface is smooth and regular; adhesion, or union by the first intention, is more frequent; whether union be by the first or second intention, the cure is more speedily completed; the end of the bone is better covered, and the stump consequently more useful; and if the flaps have been skilfully formed, there will seldom be exfoliation of the end of the bone protruding through ulcerated integuments, or the formation of excruciating neuromata in the cut extremities of the nerves, rendering a renewal of operation necessary for final cure. The manipulations of the flap-operation are simple and well known, so need not be here detailed; but some rules necessary for its dexterous accomplishment are not always sufficiently attended to. The first regards transfixion; and it is, that after the first flap has been formed, the knife should not be again entered close to the top of the wound, but about an inch below, as thus cross-cutting of the integument is avoided. Another is, that in sawing the bone, the surgeon must not trust the distal portion of the limb entirely to an assistant, but, grasping it in his left hand, must himself regulate its support, and so avoid splintering the bone. Pressure to command the bleeding need not be severe, but must be true. As was formerly stated, the tourniquet is seldom if ever used when the fingers of an assistant can be obtained who is cool, steady, and well conversant with the course of the vessels. The pressure is not applied until the instant the incisions are commenced, and then only on one point; the limb consequently is not gorged with blood, as it would have been by the ordinary tourniquet; less blood therefore is lost, and besides, the flaps are much more easily retracted from the bone. When skilful assistants cannot be obtained, or when it is probable that many vessels will require ligature, and that consequently pressure must be long continued, a strong metallic spring may be used, each extremity terminating in a pad, one placed over the course of the vessel, the other resting on the opposite part of the limb; the assistant preserves its just application, and regulates its pressure, and the risk is avoided of his fingers giving way from cramp or fatigue. When the surgeon, from want of other means, is compelled to use the ordinary screw-tourniquet, its principal pressure should never be applied until the moment before incision; and as soon as the larger vessels have been secured, the whole apparatus should be removed, as thus the loss of much blood by regurgitation, and particularly from veins, will be avoided. The arterial orifices are secured by ligature, according to the method already mentioned; and should the venous trunks continue to pour out their contents, notwithstanding the removal of all constriction of the limb, pressure by the fingers of an assistant, though for only a short time, usually suffices to arrest the hæmorrhage. The wound is treated according to the principles formerly explained; and thus adhesion is not only favoured, to the saving of time and pain, but the occurrence of secondary bleeding is also made much more improbable; for no warm coagulum is bound up in the wound, to act as a sponge, and encourage escape of blood from all the untied vessels; and even when it does take place, the bleeding point is much more easily secured than when the stump is bound up tight and close from the first. Should the stump bleed seriously, six, eight, ten, twelve, or fifteen days after the operation, in consequence of sloughing or some other unhealthy state having supervened, the ununited wound is to be laid open, all coagula removed, and direct pressure applied. But should this fail, the surgeon ought instantly to secure the trunk of the vessel whose branches are at fault, at some distance above the stump—in amputation below the knee, tying the femoral, for example—at the same time supporting the stump by bandage.

Amputation is also less frequently resorted to in cases of severe injury than formerly. In fractures, skilful and careful management preserves many a limb useful and but

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little out of shape, which before would have been considered too seriously injured to retain its vitality. Nor are compound luxations regarded with the same dread. In compound dislocation of the ankle-joint, for example, with protrusion of the bones, instead of at once amputating the limb, the dislocation is reduced, the protruding portions of bone having been removed in whole or in part, if so injured as to render that proceeding necessary; the limb is retained in a favourable position, and in a state of complete rest; the wound is treated by the simple soothing plan; inflammation is warded off or held in subjection by the usual means; if abscesses form they are early evacuated; the parts are uniformly and gently supported; the surgeon's *medical* acquirements are kept constantly on the alert; and thus, in very many cases, the limb is retained, with the injured joint, though stiff, exceedingly useful. The ordinary simple dislocations are now at once detected by the observant and well-educated surgeon, and as readily reduced if recent; so that branch of the profession promises to be soon rescued completely from the maltreatment of ignorant empirics. In both diagnosis and reduction, but especially in the latter, vast benefit is found from the use of anæsthesia. The patient lies without pain throughout the whole manipulations, and every muscle is as passive as in death.

Compound dislocation.

Fractures.

The whole treatment of fractures has been simplified and improved; the process of reparation in disunited bone is better understood, and the means which favour it are more skilfully and effectually adopted. In fractures, whether compound or simple, of the smaller bones, more particularly of the upper extremity, the gum-splint will be found very suitable. By the employment of these or other light splints—of wood, pasteboard, leather—well padded, so as not to fret the integument, and always of sufficient length to command the neighbouring joints, the bones are not only kept accurately in their proper place, but perfect quietude and freedom from all motion are likewise secured,—a point all important here, as in the treatment of diseased joints. Broken limbs are no longer laid out in state on pillows, altogether unrestrained. Absolute rest, following early reduction of the bones, and combined with strict attention to the workings of the general system, usually succeeds in preventing interruption of the cure by inflammatory mischief in the neighbourhood of the injury. Should this nevertheless occur, the retentive apparatus can be so arranged as to admit of the part in fault being attended to as freely and as often as is necessary, without disturbance of the rest of the limb; for example, blood may be abstracted locally, fomentation or poultice applied to a particular part, abscesses opened, and wounds dressed, without undoing all the retentive apparatus, and so jarring the fracture. In severe compound fractures this advantage is particularly important. The soft parts can be looked after as well as if no apparatus at all were applied; and the untoward results likely to follow such a serious accident can consequently be sometimes averted, and always moderated, while the hard parts are uniformly kept in the condition most favourable to their union. For many simple fractures an immovable retentive apparatus, by starch bandaging, is very suitable; always taking care, during the early period of its application, that no undue tension of the parts occur. In fractures of the lower extremity near the hip-joint, Desault's splint is still in use, somewhat modified; and with simple yet efficient means to maintain as much permanent extension as shall prevent shortening of the limb. When the break is lower in the limb, an improvement of Macintyre's double inclined plane is in many cases a most suitable apparatus, combining in an eminent degree the advantages of complete rest of the whole limb, with ready and convenient dressing of particular parts. The patient is also able, with safety, to be out of bed at an early period of the cure; a circumstance very favourable to the preservation of the general health.

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Gangrene.

When, notwithstanding care and skill, gangrene occurs after severe fracture, either immediately or in consequence of greater inflammation having taken place than the hurt parts are able to bear, amputation must be had recourse to, and the period of its performance is now no longer a subject of dispute. Should the state of system permit, it is done immediately in sound parts, at a distance from the gangrene, without waiting for a line of separation, as in chronic gangrene, else the surgeon will expect the opportunity in vain, and meanwhile his patient sinks and dies.

Disunited fracture.

Sometimes, either by the carelessness of the surgeon and inefficiency of his treatment, or from the fault of his patient or defect of his constitution, union of the fracture fails to take place. In recent cases of such disunion, adjustment of the broken ends in accurate apposition, and undisturbed rest of the fracture and of the whole limb, as by starch bandaging, will occasionally effect a tardy union. But usually it becomes necessary to rouse the parts, and this may be done in various ways. One method is the introduction of a seton between the fractured extremities, gradually increasing the size of the tape, but taking care to remove it altogether as soon as it appears that excitement has been produced sufficient for establishing the regenerative process. A few days are usually enough; when permitted to remain for a long period, the mere presence of the foreign body, and more particularly the constant discharge which it maintains, tend to prevent the result in favour of which it was employed. After removal of the seton, the limb is placed in the proper position, and must be preserved in a state of most complete rest. Another and gentler mode of procedure is by subcutaneous puncture. A strong tenotomy knife is introduced and moved about freely, even roughly, so as to make raw both ends of the bone, and break up completely the intervening tissue; reducing the parts to a state somewhat resembling their condition at the time of the original injury. Then the retentive means are applied with great care, to be readjusted from time to time, with perhaps a repetition of the puncture, should the results of the former one seem to prove imperfect. This method of treatment, being milder than the seton, is to be preferred in the first instance; but in the event of it failing, then the seton may be used, or ivory pegs may be driven into the ends of the bones, with the view of producing callus, as advised by Dieffenbach. (Vide Miller's *Principles of Surgery*, p. 695.)

Fractures of the cranium.

In fractures and other injuries of the cranium, the trephine is now used with better judgment than formerly; more sparingly in most cases, more readily in others. It is not considered necessary to convert every fissure of the skull into a chasm, by following it out with the trephine; in depressed fracture with urgent compression of the brain, the application of the trephine is imperative, but no more bone is taken away than is necessary for the raising of the depressed portion, and the removal of what is so injured by the accident as to render its retention of vitality improbable; and to bore one or more holes in the cranium in search of extravasated blood, is generally regarded as a proceeding equally mischievous and unprofitable. But in punctured fracture the necessity for the trephine is absolute; it must be used freely and at once; and as this important point of practice is perhaps not yet sufficiently attended to, we shall be a little more explicit on the subject. The punctured or star-like fracture is occasioned by a sharp body striking the head with considerable force. The integuments are divided, and the surface of the bone presents an appearance of injury somewhat resembling what is often seen in ice when struck in a similar way. But this is a very slight extent of damage compared with what the inner table suffers, when the puncturing weapon has

Punctured fracture.

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passed through the diploë, as is usually the case. The inner table, being by much the more vitreous, is shivered into numerous fragments, which being driven inwards by the force of the blow, perforate, or at all events grievously irritate, the coverings of the brain, producing inflammation, which, if not arrested, proves speedily fatal. After the infliction of such an accident, therefore, even should the patient be at the time so little affected as to walk to the surgeon to have his wound dressed, the trephine should be immediately applied to the punctured point, in order that a portion of the bone may be removed, sufficient to allow extraction of all the displaced portions of the internal plate. In no other way can we avert intense inflammation from the wounded dura mater, extending in all probability to the brain and its more immediate investments. Even should the practitioner be in some degree successful in moderating the more immediate mischief by antiphlogistics alone, the necessity for trephining will still remain, on account of abscess under the bone, occasioned and kept up by the fragments; the matter must be evacuated, and the cause of its formation must be removed. It is surely infinitely better, therefore, to operate in the first instance, and so avert all such calamities.

Abscess of the dura mater.

Abscess sometimes forms between the dura mater and the bone, as a consequence of mere contusion; its occurrence, and usually its site, are indicated by constitutional disturbance, peculiar œdema of of the scalp, unhealthy discharge from the wound, and a pale necrosed appearance of the bone. In such cases, also, perforation of the skull should not be delayed; for it alone can succeed in evacuating the matter and relieving the patient. But, on the whole, "trepanning of the skull, which with our forefathers appears to have been an every-day occupation, is an operation now very rarely resorted to." After its performance, from whatever cause, there is now no rasping of the bone, or cutting away of the integuments; the edges of the circular aperture are denuded of their periosteum as little as possible, and the soft parts, having been carefully replaced, are treated as a suppurating wound; the deficiency of the bone is filled up by a ligamentous expansion, which slowly ossifies as the patient lives on. When a large portion of the skull has been removed, it is well to afford support to the cranial contents by the application of a compress and bandage externally.

Erysipelas.

There is no more successful caterer to the amputating knife than erysipelas inertly treated; destruction of bones and joints has been too often its result. The improved treatment by incision, however, now in general use, saves many a limb entire and unscathed. So soon as tension of the surface indicates that the cellular substance is so infiltrated as to threaten destruction of the tissues—in that intense and peculiarly asthenic form of the disease which is called the phlegmonous—free incision must be immediately had recourse to; the knife is used not only to evacuate matter, but to anticipate its formation, and prevent its baneful consequences. In the milder cases, sufficient relief is obtained by making, with the point of a lancet, numerous punctures in rapid succession, effusion from which is encouraged by hot fomentations. In most cases, even when severe, division of the integument and subjacent cellular tissue suffices; but if the infiltration has extended to the inter-muscular tissue, the knife must follow: its free use may appear harsh, but is in reality a valuable kindness. The burrowing of matter is prevented, and consequently also sloughing of the soft parts, the opening up of bursæ and articulations, and the denuding of bones by destruction of their periosteum, ending in necrosis more or less complete. Museums were at one time copiously enriched with splendid specimens of necrosis of the long bones, throughout almost the whole extent of the limb, all the result of neglected erysipelas; but the bistoury has superseded the amputating knife, and such preparations fortunately are now become valuable by their rarity. The free internal administration of iron is of vast value in all cases of truly asthenic erysipelas, whether slight or severe, not only mitigating the symptoms at the time, but also preventing those secondary abscesses which otherwise are so apt to prove troublesome, especially in hospital practice.

Abscess.

In opening abscesses, "pointing" is not now waited for; before that takes place, irretrievable mischief may have been done. The *tactus eruditus* having acquainted the surgeon with the existence of purulent formation, it must be reached by his bistoury, at whatever depth, if it be in the neighbourhood of joints, bones, or vessels, and more particularly if close to important cavities or canals. The mere contact of purulent matter will not injure these, but its pressure will, and from it they must be relieved, lest their functions be interfered with or their structure destroyed. For example, purulent collections in the fauces are evacuated by the bistoury before the patient is threatened with suffocation; and abscesses in the perineum, and neighbourhood of the anus, are drained by an external opening before they have become troublesome fistulæ.[1] The knife must of course be used cautiously when the abscess is deep, lest the vessels and other important parts be wounded; but let not the fear of this deter the surgeon from relieving abscesses in their immediate neighbourhood; for "the vessels and nerves are displaced by the morbid accumulation, and the knife is passed safely, in their course, to such a depth as would greatly endanger them in the healthy state of the parts." The opening should in all cases be made sufficiently large to afford a free exit to the matter; it should be placed in the most dependent part of the cavity, with which view the prevailing position of the patient should be considered; and sometimes more than one opening should be made at once, to prevent the necessity for future counter-openings, or the formation of sinus,—as when the abscess extends over a considerable surface, and cannot be made to discharge through one aperture. After evacuation, in assisting which no pressure or squeezing should be employed, fomentations and the water-dressing are applied. Chronic abscess, when small, may be treated as the acute, by direct and free incision; but when large, there is risk by intense inflammation of the pyogenic membrane following; and it is better to empty the cavity by subcutaneous puncture from time to time, till the size has so far diminished as to admit of a direct wound being made with safety.

Improved seton.

In establishing an artificial abscess, or issue, the modern caoutchouc seton is a great improvement on the skein of silk or cotton formerly used, requiring no renewal on account of decay, and absorbing no discharge.

Ulcers.

Ulcers, like wounds, are now treated more simply and better; and better because more simply. The healthy suppurating sore is covered, like a suppurating wound, with the plain and light water-dressing; simple in the first instance, afterwards medicated by gentle stimulants or not, according as the progress of the sore may seem to require.

[1] Dr Radcliffe has probably few imitators at present in his clumsy though ingenious method of emptying abscess of the fauces. "He was once sent for into the country to visit a gentleman ill of the quinsy. Finding (supposing) that no external or internal application would be of service, he desired the lady of the house to order a hasty pudding to be made; when it was done, his own servants were to bring it up. While it was preparing, he gave them instructions how they were to act. When the pudding was set upon the table, the doctor said, 'Come, Jack and Dick, eat as quickly as possible; you have had no breakfast this morning.' Both began with their spoons; but, on Jack's dipping once for Dick's twice, a quarrel arose. Spoonsful of hot pudding were discharged on both sides; handsful were pelted at each other. *The patient was seized with a hearty fit of laughter, the quinsy burst, and the patient recovered.*" A moment's use of a straight sharp-pointed bistoury would have saved both time and the pudding.

When stimulants are used, their solution is at first weak, and is increased in strength very gradually, lest the discharge should be suddenly suppressed and the sore consequently inflamed; the object is simply to moderate discharge, and check weak exuberance of granulation. An inflamed ulcer is subdued by the hot-water dressing, combined with antiphlogistic regimen, rest, and elevation of the part. An irritable ulcer is soothed by the water-dressing, and occasional slight application of the nitrate of silver to the jagged angry edges of the sore; or the lint may be dipped in a bland anodyne solution. In all such dressings, the lint is kept constantly invested by a portion of oiled silk, larger than itself, to prevent evaporation of the fluid in which the lint has been soaked. When granulations prove exuberant, the surface may be compressed by dry lint and bandage, so as to produce recedence either by absorption or by ulceration, according to the degree and duration of the pressure applied. An indolent ulcer is stimulated to healthy action by pressure and support, combined, if necessary, with a direct stimulant application. This last description of sore is perhaps the most common, and is usually found afflicting the labouring classes, to whom the restoration of a limb is of more importance than to any other class of patients; a speedy cure is therefore of no little consequence. It is well effected by the method first recommended by Mr Baynton. When the patient applies for relief, there is usually considerable excitement around the sore, and this may, of itself, be the means of removing the indolent characters in the surface and edges, and restoring the ulcer to a healthy state, on subsidence of the inflammatory process from its destructive stage. But in the purely indolent condition, the foot and lower part of the leg, for it is the part commonly affected, having been uniformly supported by bandage, the sore is compressed by adhesive plaster, applied in strips encircling the whole girth of the limb, and with their extremities crossed over the sore; if this is large, and pouring out much discharge, it is well to cut a small hole in the plaster where it covers the ulcer. The application having been made to extend about an inch on each side of the sore, a little fine tow is placed above it, to absorb discharge, and the whole is retained by continuation of the bandage which supports the lower part of the limb. This dressing is removed at the end of forty-eight hours, or sooner if necessary. The sore itself is not to be washed or rubbed, for its own secretion is its natural and best protection; but the surrounding skin is wiped clean, and, if excoriated by the pressure, bathed with a spirituous lotion; the dressing is then re-applied as before. By such manipulation, repeated as often as is necessary, the indolent surface of the sore is stimulated to the formation of healthy granulations for raising its depressed surface, while at the same time the swelling of the surrounding skin and cellular tissue is diminished by absorption; and thus, the sore and its margins having been brought to one level, cicatrization proceeds. After the ulcer has in this way been converted into the simple suppurating sore, either the same dressing may be continued, exerting less pressure, or it may be superseded by the medicated lint and oiled silk. When nearly closed, all dressing may be discontinued; the natural secretion forming a crust, under which cicatrization is speedily completed. Of course healing will be materially assisted by rest and elevation of the limb; but the labouring man cannot always afford this; and the treatment by plaster, just described, possesses, in addition to its other virtues, this advantage, that with it the patient can continue in the erect posture with much greater impunity then when using any other application. For some considerable time after cicatrization, the limb should continue to be supported by a bandage or laced stocking. Another frequent ulcer is the scrofulous sore, with the areolar tissue infiltrated by tubercular matter, and crumbling down under a chronic disintegrating process, which yields a copious, thin, and mixed discharge. Such generally form in clusters, and can be brought to heal only after the unsound parts have been destroyed by the potassa fusa, so as to obtain a sound foundation on which the reparative granulation may arise. This description of sore, however, being combined with and dependent on the strumous diathesis, is healed only to break out afresh, unless constitutional means be diligently employed to rectify the state of the system.

Sores, however, are often changing their character and appearance, though perhaps but slightly; and consequently demand as frequent a change in the treatment. "A judicious practitioner, by varying his applications according to the appearance and disposition of the sore, will serve and benefit his patient much more efficiently than by trying empirically this or the other new specic, or blindly applying one remedy for every sore, because he has seen its good effects, or been informed of its answering miraculously in one or two instances." Be it likewise remembered, that in no class of diseases is attention to the general health in all cases more requisite.

Hospitals.

We may here allude to the general improvement in hospital arrangement and practice, in consequence of which the hospital sore, so long and so frequently a scourge in those valuable institutions, is now comparatively unknown. The ventilation, cleaning, and general arrangement of the wards, the diet, clothing, and classification of the patients, are all improved; but probably nothing has tended more to the disappearance of this formidable disease, than the substitution of tow for sponge in the dressing of sores; a change apparently simple and insignificant, but in reality most important. Formerly both nurses and dressers were in the habit of using one sponge for the sores and wounds of a whole ward, and if in one patient unhealthy action supervened, the vitiated discharge was soon afforded an opportunity of inoculating all. Now, sponges are not seen but in the operating theatre; washing of wounds and sores has been discontinued, because found to be prejudicial to cicatrization; and when the parts around require cleansing, this is effected by means of tow, which, when used, is immediately thereafter destroyed or thrown away.

In the management of hospital sore, and other affections of that class, the energetic application of nitric acid, or other suitable escharotic, to the edges of the sore, after they have been thoroughly dried, is found preferable to the expectant treatment by poulticing or other inert appliances.

Aneurism.

In aneurism, the discovery of Hunter has been most successfully extended. Further investigation in arterial pathology, especially as to the effects of ligature, has produced the most important results. The accumulated knowledge and experience, applied to practice by the talents and courage of Scarpa, Abernethy, Astley Cooper, Liston, Stevens, and Mott, have achieved most triumphant advancement in surgery; for thus the means of cure have been happily extended to cases of aneurism, formerly regarded as irremediable. There are many aneurisms, and not of unfrequent occurrence, on which the surgeons of the last century were content to look until the tumour burst, and their patient perished under their very gaze, which are now fearlessly encountered, and with the best hopes of success. In aneurism of the neck, Hunter and Scarpa led the surgeon to believe that a ligature placed on the carotid, between the tumour and the heart, might effect a cure, and Cooper proved that it did so. This arresting of the cephalic circulation is no longer looked upon with insurmountable dread, for experience has shown that even both carotids may be tied, with but a short interval between the operations, and without any untoward result. The surgeon's knife and ligature have, in the cure of aneurism, ventured even so near the heart as the arteria innominata,

Surgery.

but hitherto unfortunately without ultimate success; indeed it is doubtful whether the operation on this vessel can ever prove successful, there being so many inevitable obstacles to complete consolidation by ligature; as yet, ulceration has always supervened, occasioning fatal hæmorrhage. The subclavian has been deligated on account of axillary aneurism. Mr Liston had the honour to be the first who did so with success, and an equally happy result has not been unfrequent since. Ligature of the axillary and humeral arteries, though sometimes difficult, is regarded as scarcely unusual. The aneurisms of the groin and hip were left to run their course unmolested until Abernethy and Stevens showed that the Hunterian operation could be extended even to them. "The common, external, and internal iliacs are now tied without much difficulty, and very often with a successful issue. These operations are quite justifiable, provided always there has been no mistake in diagnosis, and that there is nothing in the state of the patient's health or in the condition of the arterial system to contra-indicate interference." The original operation on the femoral, on account of aneurism in the ham or in the lower third of the thigh, is now looked upon, when skilfully executed, as at once the simplest, most beautiful, and most successful interference with the larger arteries. Thus we see that all aneurisms of the extremities are within the reach of our art, and that a certain degree of success has attended the approaches towards the trunk, as far as the common iliac and arteria anonyma.[1] It is to be feared that "the force of (operative) surgery can no further go." It is indeed a triumph that it has gone so far; and we cannot reasonably expect that ligatures, placed nearer the great centre of circulation than either of the above-mentioned vessels, can ever be productive of a successful result. Surgical invention and enterprise have not, however, been easily baffled, and in those cases of aneurism too deep to admit of the Hunterian method of operation it has been proposed to reverse the procedure, and place a ligature on the distal side of the tumour. The operation has been put in practice, and in a few cases with some temporary advantage. Great difficulty, however, has sometimes been experienced in discovering the vessel destined for the ligature, in consequence of displacement by the tumour, or more or less obliteration of its calibre. In false aneurism from wound, as at the bend of the arm, if pressure methodically and firmly applied—the whole limb below the wounded point being duly supported—fail to arrest the formation of tumour, recourse is had to the ligature. If the tumour be recent, soft, and superficial, and the parts around not much infiltrated, the wounded point may be exposed at once by incision, and ligature placed above and below the aperture. But if the tumour be of considerable duration and size, ligature of the trunk, between the tumour and heart, may be the preferable and equally successful proceeding.

The more important steps in effecting deligation of the larger arteries, whether for true or false aneurism, may here be briefly mentioned. The incisions are made with a small, finely-edged scalpel, used lightly and cautiously; neither directors nor blunt knives should be employed, for they must bruise or tear to a certain extent, and the simpler and smoother the cut is, the greater is the probability that both wound and artery will assume a healthy action. The vessel having been exposed, its sheath is opened on the anterior aspect, to the extent of about an inch, and the point of a blunt aneurism-needle is gently passed beneath and around the artery, great care being taken to exclude nerve and vein from its circuit. A strong silk ligature having been thus passed, its loop is cut, and one half withdrawn along with the needle; the other is firmly secured on the artery, its effect on the tumour having, by previous pressure, been ascertained to be satisfactory. "All this must be done without disturbing the position of the vessel, without detaching it from the sheath, or breaking up its fine cellular connections laterally and behind, further than is barely sufficient for the passage of the needle. There must be no lifting of the vessel on the handle of the knife, or on the director, as if in triumph, for ulceration of the arterial coats, and secondary hæmorrhage on or about the separation of the ligature, are the almost inevitable consequences of such proceedings." If by accident the vessel has been disturbed from its connections, two ligatures are to be applied, one at each termination of the separated portion, but in general one single ligature is much preferable. Both its ends should never be cut away close to the knot, for, in addition to the ordinary disadvantages found to belong to this plan, there is no slight risk of abscess, caused by the deserted knot, inducing secondary bleeding by ulceration of the arterial coats. And indeed the surgeon will feel more comfortable in such anxious cases if he leave both ends pendant from the wound. For a like reason, separation of the ligature should be throughout its whole course spontaneous; rash pulling at its ends may be productive of the most serious results. The wound is brought together and otherwise treated according to the principles formerly detailed. Should secondary bleeding unfortunately occur, the vessel must be exposed and tied above the source of hæmorrhage. But if the original operation have been judiciously as well as dexterously performed, and the after-treatment carefully conducted, such an untoward result need scarcely be dreaded. Should pulsation return in the tumour to an undue extent, on the complete establishment of collateral circulation, pressure well applied will usually suffice to perfect the obliteration of the sac.

So much for the knife. But modern surgery has successfully revived the use of pressure, not seldom superseding the ligature, with success. The pressure is made not directly on the tumour, but at a distance from it; at the same point, in fact, where the Hunterian ligature would lie. It is not intense, so as to arrest the flow of blood completely, and it need not be constant in its application. Consequently, it is not intolerable to the majority of patients; and such moderate use of it has been found, in experience, to be sufficient in many a case for satisfactory cure of the aneurism. Being a minor procedure, it well may be employed in all suitable cases in the first instance, seeing that while the prospect of success is good, the risk of hazard scarcely exists at all under careful and judicious management, and, in the event of failure, the patient is still left in a favourable condition for the operation by ligature. Its great advantage over the latter is, that it avoids direct læsion of the arterial coats, which in all cases of idiopathic aneurism must be more or less diseased, and consequently prone to the casualty of secondary hemorrhage.

Veins.

In dilatation or varix of the veins, if methodical pressure and attention to the bowels fail to remove the disease, or at least its inconveniences, a radical cure is obtained by obstruction of the calibre of the main trunk, on the cardiac side of the dilatation, and this is effected either by the application of potass, or by including about an inch of the vein at that part, between two points of twisted suture, the needles being passed beneath the vessel, and removed as soon as sufficient change has been produced in the venous coats and contents. Either method is effectual in obtaining obliteration of the vein's calibre at the selected point; the latter is, perhaps, in most instances the preferable, but

[1] The aorta has been tied, but with a result which does not warrant repetition of the experiment; unless, indeed, circumstances be such as to render the protraction of life for but a few hours eminently desirable.

in both the procedure must be cautious, and the after-treatment watchful, in order to guard against hæmorrhage and extension of phlebitis.

Venesection.

The operation of phlebotomy has always been simple and of easy execution; in regard to it, the only modern improvement which we have to notice is the comparative rarity of its performance. It was too much the custom to bleed, so as to appear to be doing something active in treatment, not only when the proceeding has seemed to the ignorant practitioner likely to do no harm, but also when a wiser head could have told that it must do irremediable mischief. The good fortune of the first phlebotomist, Podalirius, seems to have produced in his successors an unfortunate attachment to the operation, which has been communicated from generation to generation, and from which our day is not yet wholly exempt. In some cases it is doubtless the only certain means of relief, and must be employed readily and boldly, but in fully as many it had better be done with a sparing hand or altogether omitted. What can be worse, for example, than to find a patient who has just sustained a severe accident—still labouring under the shock which the injury has produced, pulseless, and with the powers of the system all but extinguished—robbed by an ignorant or reckless man, unfortunately called to his aid, of those very powers of which he is at the time most in need, and without which the syncope must soon pass into death. Such a case is too frequent even now, but it is consolatory to know that the folly of such proceedings is becoming more and more extensively known, and that the thoughtless, mischievous practice of indiscriminate venesection is more and more abandoned.

Bruise.

A similarly absurd practice prevails in regard to the treatment of bruise. Leeches are instantly applied, in order that they may suck out the extravasated or "bruised blood," as it is called. These little animals drink only from the running stream, drawing for themselves from the blood-vessels, and therefore fail to perform what is expected of them by their employers. At the same time, their bites, admitting the external air to the extravasated blood, may induce suppuration of an unheathy kind in the cellular tissue. They are of use simply as a mode of local depletion, in order to moderate or avert an inordinate inflammatory process occurring as a secondary result of the accident.

The practice of blood-letting in inflammatory disease has undergone a great revolution within the last thirty years. Instead of being the ordinary treatment, it is now quite exceptional. And this change seems to depend on several circumstances: mainly these—a better acquaintance with the pathology of the disease, an alteration in the type of the disease itself, and a more skilful handling of the other and simpler antiphlogistics.

Hernia.

In the treatment of hernia, the advancement of anatomical knowledge has rendered operative procedure more simple, safe, and effective. And pathological experience having now fully established the great danger of delay after the taxis, fairly tried, has been found unavailing, the operation is had recourse to at once, with a much more certain prospect of success. In the greater number of cases the taxis will prove successful, when employed early and with skilful perseverance. But as soon as the surgeon is satisfied that his unarmed hands, assisted by his medical skill, are incapable of reducing the tumour, each moment of delay is culpable until he assumes the knife, and by it relieves the constricted parts, for by its keen edge the patient is infinitely less endangered than by even brief continuance of the incarceration—more especially if, as is often the case, the constricting cause can be removed by limiting the incisions to the outside of the sac, and so largely tending to prevent all risk of peritonitis. This principle, now generally acted on, saves many a patient who formerly would either have perished in excruciating torture, or lingered on with artificial anus, noisome to others, and a burden even to himself. But this is a subject too extensive to be here more fully considered.

Calculous disorders.

In the treatment of calculous disorders, modern improvement has effected much. Chemistry, happily combined with pathology, has taught the surgeon, in many cases, to anticipate cure by prevention, detecting the tendency to deposit in the secretions of the kidney, ascertaining the exact nature of that deposit, and then applying, according to its nature, the suitable corrective. When there is reason to believe that calculus has actually formed in the bladder, its presence is to be ascertained by careful sounding. Many affections—for example, diseased kidneys or fundament, worms or other causes of irritation in the bowels—occasion all the ordinary symptoms of stone; and it is only after the surgeon has distinctly heard the stroke of his sound on the foreign body, that he can be certain that a stone exists. The most convenient instrument for exploring all parts of the bladder is a sound, steel throughout, with a sharp and sudden curve. When, by its cautious and patient use, the presence of a calculus is no longer doubtful, and some estimate has also been made of its size and form, the question then arises between patient and surgeon as to the preferable mode of its summary extrusion; for removal by chemical solvents, though sanctioned by act of Parliament, is no longer trusted to in practice. It is only within these twenty years that a power of selection has existed; till then, the knife alone presented hopes of relief. Now, however, *cutting* is often superseded by *crushing*, and rightly. Indeed it is a *questio vexata* among many as to whether lithotomy or lithotrity be the better adapted for general use; and each has its zealous and uncompromising advocates. As is usual in such cases, we shall probably find that truth lies in the middle, and that both operations are to be practised, each finding cases to which it is peculiarly applicable. Lithotrity was at first a very imperfect art, difficult and complicated in performance, often failing in the attainment of its object, and not seldom followed by the most untoward results. Its practice was likewise in a great measure confined to a particular set of operators, not the best qualified for such undertakings, who, regarding it as a means of gain alone, were not long in bringing discredit on its reckless and indiscriminate use. Thus a great advantage was given to the old operation, over its imprudently managed rival. But the instruments and procedure of lithotrity have of late been greatly improved, and have become, as is usual in such improvements, more easy and simple, and at the same time more effective. They now receive the attention of every well-educated surgeon; the student applies to lithotomy and lithotrity with equal care and attention, and endeavours to perfect himself in the manipulations of both; and in consequence, the latter operation has been rescued from the empirical professor, and placed in the better qualified hands of the regular practitioner. There is not now, as in the time of "the invasion of professed stone-grinders," some years ago, an indiscriminate performance of one operation, in all cases, simply because the operator knows no other. The circumstances of the case had then very little influence in determining the nature of the operative procedure. If a surgeon was applied to, the knife was recommended; and "if the patient fell into the hands of the professed stone-grinder, he was certain, under all circumstances, of being subjected to the hammering and boring processes." Now, application being made to the regular practitioner, at least in the first instance, he, equally acquainted with either mode of operating, conscientiously advises the one which circumstances require, either operating himself, or employing one whom he may consider more dexterous and equally skilful. Lithotrity can only be safely performed by those "who understand well the healthy anatomy of the urethra and

bladder; who are acquainted with their sympathies, vital actions, and pathological changes, and who understand and practise the treatment of their deranged functions." And by such it is now performed, in the cases to which it is applicable. In patients above the age of puberty, when the symptoms have not been of very long duration, when the stone has been ascertained not to exceed a chestnut in size, when the urethra is free from contraction, when the bladder is capacious, tolerably healthy in its coats, and free from irritability of its lining membrane, and when the individual is of an easy, patient disposition; under a combination of such circumstances, lithotrity is the preferable operation. It is thus apparent, that possibly lithotrity may in time almost entirely supersede lithotomy in the adult; the chief thing necessary being, that the patient apply to a well-qualified surgeon at the very commencement of his ailments. But until wisdom shall pervade mankind to this extent, very many cases must occur in which the old operation, well performed, is much to be preferred; and this need not be greatly regretted, for the actual difference between the two operations as to suffering and danger is perhaps not so great as is generally supposed.

The simple instrument of two branches, as made by the Messrs Weiss, has superseded all the more complicated and less effective apparatus for lithotrity, as well as Cooper's forceps for removal of small stones by the urethra. The instrument having been introduced into the bladder, tolerably distended, is brought in contact with the stone; its blades are opened, and the stone brought between, great care being taken that the mucous membrane is uninjured; the blades are then approximated by the screw, and the interposed stone crushed more or less completely. When the stone is single, small, and friable, one such proceeding will suffice; if not, the fragments are seized and bruised in succession, either at the time, or at one or more subsequent sittings. The screw-power is preferred to that of the hammer, as equally efficient and more safe, not endangering the twisting or breaking of the instrument. Diluents are freely exhibited, to promote and facilitate passage of the detritus with the urine. Should the pain and irritation thus occasioned prove severe, opiates, hot bathing, &c., may be required. But, in general, if the case have been judiciously selected, and the operation skilfully performed, the subsequent irritation will be but slight; and, after a few days, examination of the bladder may be resumed, to ascertain whether or not all the fragments have been extruded. This exploration cannot be too minute and careful, for the greatest stumbling-block to the advancement of lithotrity in the confidence of the profession has been the uncertainty as to whether or not the bladder has by such proceedings been completely freed from every fragment, it being well known that but a very small portion of foreign matter remaining will become the nucleus of further deposit, and speedily re-establish the disease. The advantage of lithotomy is, that, for final exploration of the bladder, it has the finger, which, if at all experienced, can seldom be deceived. Lithotrity has but the sound for the same purpose, and must endeavour to make patience, dexterity, and care, compensate for the inferiority of the instrument.

But when the stone is large, and has been long resident in the bladder, this viscus has its cavity contracted, its coats fasciculated, and its surface irregular, affording receptacles for the fragments, from which the most careful manipulations may not dislodge them. Besides, such a bladder will not bear the annoyance of instruments often introduced; indeed the mere change of a tolerably smooth stone into angular fragments, may be sufficient to excite even fatal disturbance of the viscus and of the system. In all such cases, therefore, lithotomy is the preferable operation; it not only insures, with common care, complete removal of the source of irritation, but also by suspending the functions of the diseased viscus, gives it the advantage of rest, as well as the relief caused by loss of blood from the neighbouring vessels. Even when the bladder is tolerably sound, a large stone of ordinary consistence is unfavourable to lithotrity; for the fragments must also be large, until after much manipulation; and attempts to pass such fragments must be attended with much pain and some danger. The immediate result of lithotrity in such cases is, " like the partial delivery of a pregnant woman," very unsatisfactory. The fragments may become firmly impacted in the urethra, causing retention of urine, and all its direful consequences. When this happens, and the impacted portion will not yield to an attempt to push it again into the bladder, it must at once be reached and removed by incision in the mesial line; and then the surgeon may take the opportunity of extending the wound a little farther, and with his finger and a scoop effectually clear the bladder of all remaining detritus. Lithotrity is not very applicable to young subjects; the parts are not sufficiently capacious, and the concretion, usually of oxalate of lime, may be too hard to be easily pulverized. This is the less to be regretted, as in them well-performed lithotomy seldom proves unfortunate. Among them, therefore, and " those of mature age who are so foolish or so ill informed as to permit the stone to attain an inordinate bulk," lithotomy must still prevail. It is an operation certainly more alarming to the patient, and to the surgeon may be more difficult and perplexing; but when dexterously and skilfully executed, we doubt much if its average risk exceeds, or even equals, that of promiscuous lithotrity; its efficiency is indisputably greater. The mode of operation pursued by Mr Liston, the most dexterous, elegant, and successful lithotomist of recent times, is similar to the method of Cheselden. For its details, we beg to refer to Mr Liston's work on *Practical Surgery*, where the modern lithotriteur is also minutely described. He attributes much of his success to limited incision of the prostrate, so as to preserve the internal cellular tissue of the pelvis from infiltration of urine; and to the insertion of a gum elastic tube in the wound, so as to afford a free exit to the urine, and diminish the risk of its poisonous infiltration, while at the same time it facilitates the arresting of hæmorrhage, should this occur. " The operation of lithotomy," says he, " if performed in the easy and simple method recommended, is effected with much less pain than is supposed; it is completed, with perfect safety, in a short space of time, and offers very favourable results. It is, however, an operation which ought never to be undertaken without due consideration of all the circumstances that may arise; and the surgeon who does undertake it must have resources within himself to meet and overcome difficulties in all the various stages of the proceeding."

Stricture. In the treatment of stricture of the urethra, all armed bougies have been laid aside, in favour of the plain metallic catheter and bougie. The milder cases are easily overcome. A metallic bougie, selected of such a size as will with no great difficulty pass the constricted part, is gently insinuated along the urethra. After two, three, or four days, the introduction is repeated. Then at each farther re-introduction, at an interval of a few days, the size of the instrument is gradually increased, until it completely fills the orifice; a sign that sufficient distention of the canal has been achieved. After this, it is right to pass a full-sized instrument occasionally, at long intervals, to counteract any tendency towards return of the contraction. Soft pliable bougies may sometimes be useful for mere exploration of the canal, but are not of much use otherwise; it being difficult to guide their points, or ascertain the exact direction which they assume. During the cure, the state of the urine should be strictly attended to; for its acridity—one of the causes of stricture—may, by irritation of the urethra, materially retard progress. Should the bougie cause seri-

ous irritation of the urethra, as sometimes happens, the interval between its introductions must be increased, allowing the painful effects of each to subside before another is attempted, else much more harm than good will accrue from the use of the instrument.

It is important to remember that it is not necessary always to pass the bougie completely through the contracted part of the urethra in order to obtain its remedial and relaxing effect. To pass the instrument down and partially into the stricture is often enough; repeating this from time to time, till at length the instrument slips through into the bladder; and a medium-sized instrument, as No. 5 or 6, is often, in cases of tight stricture, safer, as well as more expeditious, thus employed in what has been called the "tunnelling method," than a small instrument, such as No. 1, thrust through, or attempted to be thrust through, at each introduction.

For the penetration of tight unyielding strictures, a firm silver catheter is the most appropriate instrument, its size being proportioned to the extent of contraction. For very obvious reasons, great caution must be observed in its use; steady, cautious, patient, and gentle pressure, in the right direction, must never be superseded by sudden and daring force, or irreparable mischief may ensue. "Lightness of hand, and gentleness of manipulation, will often enable a surgeon to overcome difficulties which to others may have proved insuperable. The operation of introducing a catheter through what has been called an impermeable stricture, is without doubt the most difficult in the whole range of surgical practice, and demands all the prudence, science, and skill of a master. The art can only be acquired, and that gradually, by frequent practice." When the stricture is very tight, and has afforded much opposition to the passage of the catheter, and more particularly when the operation has been undertaken on account of retention of urine, it is well to retain the instrument secured in the strictured part for twenty-four or eight-and-forty hours. The cure is thus much expedited, as well as recurrence of the retention prevented. The presence of the foreign body in the stricture calls up a natural effort for its extrusion, resulting in relaxation of the part, with profuse discharge; and so remarkable is the dilatation thus effected, that on withdrawing the instrument at the end of the time already specified, it is found "lying quite loose" in the passage, although at its introduction it had been grasped most tightly, and firmly fixed in the stricture. Immediately after its withdrawal, a much larger instrument can usually be introduced with ease, and the cure is then proceeded with as in ordinary cases. Sometimes the parts so strenuously resist the presence of the foreign body, that it is prudent to remove the instrument in less time than we have mentioned. Under no circumstances should it be retained beyond two days. It is apt to become coated with calculous deposit; and, besides, there is danger of its irritation proving excessive; ulceration may take place in the urethra, or abscess form along its course.

Thus many a bad stricture may be overcome, and the urethra restored to its healthy functions and dimensions. But, as already said, prudence and experience are inseparable from the safe use of the small catheter; with these, it is a most valuable instrument, and saves many a patient who might otherwise have become the victim of dangerous operation. It is seldom, indeed, that we now hear of puncture of the bladder, even by the rectum. And we as seldom hear of the catheter producing tears and wounds of the urethra, followed by abscess and fistula, or urinary infiltration, ending in the death of the patient, or at least in the destruction of a large portion of his genital integument and cellular tissue. When from any cause urine has escaped into the cellular tissue of the perineum, free and deep incision, so as to afford ready escape to the poisonous fluid, cannot be too early resorted to.

Should it happen that the surgeon, notwithstanding skill and perseverance, is foiled in passing the catheter, and relieving distention, then, instead of puncturing the bladder, he may proceed to "make a free opening in the perineum, directly upon the obstructed part; to cut upon the end of the catheter, carrying the knife forwards; to open the dilated portion of the urethra, and then to pass the catheter on to the bladder." Thus the viscus is relieved, and a sure commencement made of the cure of the stricture, while no permanent inconvenience ensues, as is apt to be the case after puncture of any part of the bladder.

In passing the catheter to relieve retention caused by prostatic disease, it should never be forgotten that the urethra is in such cases much elongated, and that in consequence the instrument ought to be three or four inches longer than those in ordinary use. The treatment of the enlargement of that gland is entirely palliative; proposals for its removal by excision cannot be ranked among the modern improvements.

There is a class of strictures, tight, irritable, relapsing, and sometimes associated with great tendency to untoward sympathy of the system, in which the ordinary modes of treatment prove unsatisfactory at the best, and sometimes altogether abortive. Fortunately, these are comparatively few. For their cure incision is advisable; dividing the whole of the constricted parts, and subsequently maintaining due dilatation by means of bougies. The incision may be from without, or from within; the former preferable, in most cases, as being exact in its operation, and avoiding risk by urinous infiltration of the tissues. The safest mode of performance is on the grooved staff, as recommended by Mr Syme.

Diseases and injuries of the windpipe.

Diseases and injuries of the windpipe are better understood, and more successfully treated, than formerly. In the latter, the surgeon is less meddlesome, and his patient is benefited accordingly. In wounds of the throat it was formerly the custom, after having secured the larger arterial branches, to proceed at once to closure of the wound, dragging it together by stitches and plasters, and covering all by lint and bandage, as if the principal object were to conceal the horrid gash from view. The consequence was, that the blood, which continued to ooze, finding no ready outlet externally, collected in the air-passages, and suffocated the patient, provided, as was most probable, he had not at the time sufficient energy for forcible expectoration; or if this danger was escaped, it was shortly succeeded by one equally imminent, closure of the windpipe at the injured part, from inflammatory swelling of the wound. Now the intelligent surgeon is less precipitate; he knows the danger of the old system, and avoids it by treating cut-throat on the same principles as he would an ordinary wound, making no approximation until all oozing has ceased, and then only drawing together the corners, trusting the centre to the more gentle apposition by bending the head forward, and by bandage retaining the chin approximated to the top of the sternum. Thus a free outlet is left to the discharges which must form; for the transverse nature of the wound, and the constant motion of its edges in respiration and deglutition, render union by the first intention impossible. Immediate risks are thus avoided; and if the patient's energy prove sufficient, the wound will gradually close by granulation. But too often, at least in attempted suicides, a low fever ensues, against which all efforts toward cure are unavailing. The patient should be kept in a comfortably warm and equable temperature, and the fore part of the neck should be protected by some loose covering, that the inspired air may be, as nearly as possible, of the same temperature as in natural respiration. Thus the occurrence of bronchitis is so far obviated; and so long as

air passes through the wound, no other dressing need be applied. When the pharynx is involved, nourishment is given from time to time through a tube introduced by the mouth; not through the wound, lest contraction of the tracheal opening should be interfered with, and its edges cicatrize separately, leaving the patient in a very miserable plight. Sometimes respiration becomes obstructed by swelling of the mucous membrane and accumulation of viscid mucus, so as to endanger suffocation, and render it necessary to open the windpipe longitudinally below the obstructed part. Tracheotomy has also been proposed as a preliminary part of the treatment, so as to permit immediate and accurate approximation of the wound, with a chance of primary union taking place. The tracheotomy, in this case, acts as a safety-valve, preventing untoward consequences.

In injuries of the interior of the throat, tracheotomy is sometimes necessary. When the glottis has been injured, for example, by the swallowing of acids, or hot water, or by the inhalation of steam, should the ordinary active treatment fail to arrest the urgent symptoms, tracheotomy must be had recourse to without delay, otherwise the patient will perish, either by immediate suffocation, or by effusion consequent on imperfect pulmonary circulation. A simple blow on the larynx may so completely paralyze the parts, as to render opening of the windpipe necessary for restoring the respiration. And the operation is also required when foreign bodies have lodged in the air-passages, and cannot be expelled by expectoration. If allowed to remain, they are productive of the greatest annoyance; perhaps suffocation is immediate; and if they do not speedily induce inflammatory accession of the most serious nature, they are certain ultimately to occasion phthisis, or other chronic disease of fatal tendency. If the foreign body is loose, it will be spontaneously ejected from the opening; if fixed, it must be dislodged by forceps.[1]

In diseases of the air-passages, tracheotomy often becomes necessary, on account of obstruction at the top of the windpipe preventing free entrance of air into the lungs. In acute inflammatory affections, croup, for example, its employment is open to difference of opinion. In the early stage, it has been said, on high authority, that "whilst active antiphlogistic remedies are indicated, and considered likely to afford relief, it could not with propriety be proposed; in the latter stages, after lymph has formed, when the lungs are gorged, and effusion has commenced at the base of the brain, no good purpose can be answered by an operation." Sometimes, in adults, a favourable opportunity for the operation may be selected between these stages; all the more as, in them, the morbid change of the lining membrane is more frequently confined to the larynx. And even in children, when the case is advanced, urgent, and apparently incapable of further benefit by simple remedial means, it comes to be a question whether the chance of relief by tracheotomy, doubtful though in many cases it must necessarily be, ought not to be afforded. To the chronic affections the operation is more applicable. Even in phthisis laryngea, the most intractable of these, advantage may be derived from it when performed at an early period; the diseased parts above the opening being set at rest, and an opportunity afforded of making direct application, through the wound, of the suitable remedies to the ulcerated surface. But it is in œdema of the glottis, whether as a primary affection, or supervening on previous disease, that its beneficial results are most frequent and most apparent; the patient is at once relieved from impending suffocation; the swollen parts are put to rest, and in time subside; and after a while they so far recover their healthy condition, as to admit of closure of the wound and re-establishment of the natural course of respiration. In all cases where opening of the windpipe is required, whether on account of accident or disease, tracheotomy is preferable to laryngotomy, and though a little more difficult, is equally safe in performance. An opening in the cricothyroid membrane will not always suffice for detection and removal of a foreign body; and being placed in the ordinary site of laryngeal disease, will usually fail to afford relief when undertaken on that account. The incisions in tracheotomy are made very carefully, so that stray vessels may be pushed aside in safety; the trachea is pierced during the act of deglutition, when the larynx is elevated and the windpipe elongated; a silver tube is immediately introduced, of calibre proportioned to the object in view, and of such a form as to prevent oozing from the wound by compression of the edges. After a short time all irritation from the presence of the tube ceases; but during the whole cure great attention must be paid that it be kept clear of the vitiated mucus. It should also be protected by some loose covering, in the same manner and for like reasons as in cases of cut-throat. In the treatment of all affections of the throat, the possibility of tracheotomy becoming requisite should always be kept in view; and the curative applications should consequently be confined as much as possible to the sides of the neck, leaving the fore part free, otherwise much difficulty may be thrown in the way of the operator.

Diseases of the rectum. The treatment of diseases of the rectum has become simplified and improved along with the rest of surgery. "Many attempts have been made to mystify the subject of diseases of this region, and to separate them in a great measure from general surgery. There is no such difficulty as has been supposed in understanding their nature; the principles which should guide their management are simple, and the means, operative and otherwise, easily enough applied." Of late a variance of opinion has arisen in regard to the treatment after operation on the rectum; one party maintaining that in all cases little or no dressing is required; the other, that in every case stuffing and compression of the wound are essential to the safety of the patient. As is usual when opinions are in extreme opposition, we find that truth occupies a middle place. In slight cases of operation, for fistula, hæmorrhoids, &c., no more dressing is required than what is sufficient to prevent immediate union of the divided parts, especially when the good general rule is followed out, of always tying every artery that springs, however small, in this quarter; while in others, a degree of compression must be made on the divided surface, proportioned to the extent of the incision and the probability of hæmorrhage by oozing. It would be very unnecessary to cram the wound in the first class of cases; in the second, it would be equally unwise to leave the parts wholly unsupported.

Tumours. As the pathology of tumours has become more and more understood, operative procedure has been withdrawn from some and extended to others. Diagnosis having become both more easy and more accurate, we can now more readily distinguish between those of a benign and those of a malignant disposition. In regard to the latter, experience has taught us usually to forbear from operative interference, unless at the very first accession of the disease; for though the more simple tumours, even when of large size and long duration, may be removed with every prospect of permanent cure, yet in those of a malignant nature, immunity from recurrence of the disease can be hoped for only when the removal is early; when the local affection is still limited and loosely attached; when there is a certainty of being

[1] A most interesting case of foreign body in the bronchus, successfully removed by operation, is detailed by Mr Liston in his *Practical Surgery*, p. 371.

able to remove, not only the morbid structure itself, but some portion of the unaltered tissues which invest it; before any affection of the neighbouring lymphatics can be detected; and before the general system seems to have been both largely and permanently involved. Among the more benign tumours, perhaps the most remarkable extension of active surgery is in regard to the solid tumours of the jaw. Thirty years ago these formidable formations were looked upon with horror and dread, as one and all of the most malignant tendency, and were consequently left to their own course. But now we have been taught that such is not, and ought not to be, the case; that many doubtless are most malignant, and must not be interfered with; but that others, and sometimes even those of the most formidable appearance, are sufficiently local and apathetic to warrant the adoption of active interference with the most sanguine hopes of success. Both the upper and lower jaws, involved in large and frightful tumours, have of late years been removed by operation; and when the case has been judiciously selected, good success has been invariable. In the soft medullary tumour of the upper jaw, commencing in the antrum, an opportunity warranting interference can seldom occur; for before the morbid formation has appeared externally in the mouth or nose, it has not only completely involved the bone in which it originated, but also included in the diseased mass the palate-bone, the ethmoidal cells, the orbit, and even the sphenoidal sinuses. It is only when such a disease, at an early period of its existence, is confined to the antrum, that removal of the superior maxillary bone can be of service; but unfortunately its true nature is seldom discovered until a portion of the tumour has become apparent by the giving way of the parietes; and when that has occurred the case is hopeless, for its extension backwards very far exceeds the outward protrusion. In its first stage the prominence of the cheek has the same smooth glistening appearance as in chronic abscess of the antrum; but the parietes of the tumour are hard and unyielding; they soon thin at one or more points, there communicating a pulpy feeling to the finger; and when they have completely given way, the ravages of the disease are as rapid as uncontrollable. The more benign tumour in this situation—originating in the bone, and usually the result of injury—is, on the contrary, slow in its progress and of very firm consistence; its surface is lobulated, and if ulcerated by accident, soon heals again; the internal structure, of a firm fibrous character, is limited by a dense cellular cyst; and the neighbouring bones are either simply displaced, or removed more or less by interstitial absorption; the progress of the tumour is in consequence almost entirely towards the surface. It is in such cases that the surgeon does not now hesitate to remove the superior maxillary bone; for with it he knows that he can take the whole diseased formation. It is doubtless a formidable operation, and not unattended with danger; but the risk is insignificant when compared with the ultimate benefit likely to accrue. It is, therefore, evidently of the highest importance to distinguish accurately these two classes of tumour, the treatment suitable to each being so widely different; in the one case operation is usually inadmissible, while in the other the sooner it is had recourse to the greater is the probability of a successful result. Care should also be taken not to confound either with the more simple affection of accumulated fluid in the enlarged antrum; for it has happened that a surgeon, after having made up his mind to attempt removal of the superior maxilla, has, "on trying to divide the connections of that bone, had his hands covered with purulent matter, and himself with shame and confusion." The same general description applies to tumours of the lower jaw as to those of the upper, with this difference, that the relative position of the former somewhat prolongs the favourable opportunity at which tumours even of malignant tendency may be removed. That very many tumours of the jaws are attributable to disease, or even faulty position, of the teeth, and to unskilful dental operations, is a fact as true as it is important, and should direct both surgeon and patient to greater and more frequent attention to those influential little portions of the osseous system. After the operation on either jaw, an unseemly void of course remains; but nature, assisted occasionally by the dentist, does wonders in repairing this, and the actual deformity is in many cases surprisingly slight.[1]

In operations for the removal of tumours in the soft parts, we have elsewhere stated that the incisions should be so planned as to divide the principal vessels at the outset, as thus both time and blood are saved. If the vessels implicated are large, temporary pressure on the trunk may be made by the assistant; but it can seldom if ever be necessary to practise a preliminary operation for the securing of that trunk by ligature. In most cases the dissection of the tumour should be made as rapidly as is consistent with the safety of important parts in the neighbourhood. But when the tumour is suspected of a malignant tendency, the duration of the proceeding must not be considered; the dissection must be methodical and deliberate. As it proceeds the parts must be examined carefully by both the finger and eye; and on its completion, the removed mass must be minutely surveyed, lest any shred of morbid formation be left in the wound. No successful result can be hoped for, unless the whole altered structure is completely and freely removed. Another point in regard to operations on tumours ought never to be forgotten, namely, that the most simple and best dispositioned formations may, in the course of time, degenerate into the malignant and intractable, and therefore should not be exposed to this contingency; they should be early removed, while yet simple, and auspicious of successful results.

Vascular tumours, of erectile tissue, are now safely and efficiently removed by ligature. Formerly they were usually left undisturbed. Sometimes attempts at excision were made, but the results were truly discouraging, the hæmorrhage proving most alarming, and not unfrequently fatal. In minor cases, obliteration of the vessels may be safely effected by vaccination, pressure, acupuncture, injection, seton, or the application of escharotics. But such treatment is inapplicable to the erectile tumours of large size. These are best managed by ligature, arresting their circulation, and so producing sphacelus of the adventitious structure. When the formation is of a broad base, several ligatures are required, passed beneath the tumour by needles; and when the integument is free, or but slightly involved, it should be reflected by preliminary incision, so that these ligatures may be the more effectually applied.

By similar procedure, even enlargement of the thyroid gland may be removed. Of course no one would think of attacking the whole tumour on account of the mere deformity; but it sometimes happens that enlargement of the isthmus occasions difficult respiration, congestion of the cerebral vessels, and other alarming symptoms; and in such cases the offending part has been successfully removed by a combination of incision with ligature, using the knife as deeply as the hæmorrhage will permit, and then completing the isolation of the lobe by strong ligatures applied by transfixion.

In the treatment of venereal affections, mercurial supre-

[1] For details of the operation we again refer to Liston's *Practical Surgery*, a work of great value, from the perusal of which both practitioner and student will derive much profit, and to which, we beg to acknowledge, we have been not a little indebted in the course of the present article.

Surinam || Surplice.

macy has gradually given way to the influence of common sense, and the disease has consequently become more mild and tractable, particularly in its secondary forms. When the exhibition of mercury seems advisable, little usually suffices; it is used, not abused as formerly.

Venereal disease. Hydrocele.

Hydrocele, which was at one time the apology for very severe surgical proceedings, by knife, setons, and escharotics, is now under very simple treatment; the palliative—is mere tapping of the cavity; the permanent—injection of it, after tapping, by some stimulating fluid, such as tincture of iodine, or port-wine; the former is usually preferred, injected in small quantity, and allowed to remain. But great care must be taken during injection that none of the fluid enter the cellular tissue of the scrotum, otherwise violent inflammation must ensue in the infiltrated parts.

Restorative surgery. The nose.

Restorative surgery, in former years scarcely attempted, is now making rapid progress. Noses are made and repaired most adroitly, not according to the old inconvenient system of the European father of rhinoplastics, but by a modification of the plan practised by the Koomas, a caste of Hindoos, and first introduced into this country by Mr Carpue. This decorative operation was at one time very successfully practised by Mr Liston, the author of an important change in the procedure—not bringing the columna from the forehead, but waiting till the new apex and alæ so obtained are consolidated, and then fashioning a column out of the upper lip. By this little operation a more vigorous and substantial support is obtained for the new parts; and, besides the lip, which formerly hung tumid and pendulous, is at the same time very much improved. Some of these nasal constructions are scarcely to be distinguished from the natural feature at a little distance, are quite sufficient for the ordinary uses of that organ, and sometimes have been brought to desiderate and enjoy the questionable accomplishment of snuff-taking.

By an operation conducted on similar principles as the rhinoplastic, the lower lip is renewed from beneath the chin; the ear, or rather portions of it, from the integument behind; and deficiencies in the urethra can be closed by adaptation of a portion of either the prepuce or loose neighbouring integument. Such proceedings some may affect to disregard as trivial; but they are not looked upon as such by the unfortunate individuals to whom they are applicable, and really constitute a most interesting and useful department of operative surgery.

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Great improvement in both looks and usefulness may also be achieved for the lip, by means of incision alone, without any transplantation of parts; the knife being so directed as to loosen existing relations, and admit of new position and play.

Harelip.

Harelip, one of the most disagreeable of the congenital deficiencies, can be very perfectly remedied by paring the edges of the fissure, and securing them in close and accurate apposition by two or more points of twisted suture. According to the principles already detailed, no further dressing is applied; and if the patient be otherwise in good health, and the parts protected from external injury, adhesion will seldom or never fail to occur. The most important part of the operation, as regards restoration of the lip's natural appearance, is complete removal, by the paring of the rounded margins where the membrane that covers the edge of the fissure joins the true prolabium. If this be not attended to the operation is imperfect, for a most unseemly notch remains in the lip; in fact, the fissure is merely diminished, not obliterated. But when these rounded portions are completely removed, and the operation is in other respects well conducted, a mere line of cicatrization is all that remains of the deformity.

Clubfoot.

Club-foot, a most inconvenient as well as unseemly malformation, may sometimes be remedied in children by simple means, merely applying the necessary retentive apparatus, until the parts become fixed in the normal position in which that apparatus places them. But, in most cases, division of tendon is also required; which can be freely and safely effected by subcutaneous incision, so as to slacken the abnormal bonds completely, and admit of entire restoration to the normal state. To other deformities the principle of subcutaneous section has been happily applied with the best success; a field much too wide, however, for consideration in detail here.

We have thus briefly and imperfectly sketched some of the subjects which naturally occur to us as prominent examples of the modern advancement of surgery. It were easy to swell the list, in both number and illustration. But our assigned limits have already been attained, if not exceeded; and enough has probably been said, both to convey a general idea of the improvement recently effected, and to encourage a hope that such progress will still continue, year after year, bringing the practice of this useful, enlightened, and noble art closer to perfection. (J. M—R.)

SURINAM, a river of the colony of Dutch Guiana, which is sometimes called by its name, rises in a mountain-chain in the south of the colony, and flows northwards through its centre into the Atlantic, which it enters near Paramaribo, after a course of about 300 miles. Its chief tributaries are the Commewyne, Errewyne, and Para. Large vessels can ascend the river for 30 miles. The banks are in general well wooded; but below Paramaribo they are laid out in plantations. The mouth of the Surinam is defended by forts.

SURPLICE, the habit of the officiating clergy in the Church of England. By Can. 58, every minister saying the public prayers, or ministering the sacrament or other rites of the church, shall wear a decent and comely surplice with sleeves, to be provided at the charge of the parish. But by 1 Eliz. c. 2, and 13 and 14 Car. II., the garb prescribed by act of parliament, in the second year of King Edward VI. is enjoined; and this requires, that in the saying or singing of matins, and even songs, baptizing and burying, the minister in parish churches and chapels shall use a surplice. And in all cathedral churches and colleges, the archdeacon, dean, provosts, masters, prebendaries, and fellows, being graduates, may use in the choir, besides their surplices, such hoods as pertain to their several degrees; but in all other places every minister shall be at liberty to use a surplice or not. And hence, in marrying, churching of women, and other offices not specified in this rubric, and even in the administration of the holy communion, it seems that a surplice is not necessary. Indeed, for the holy communion, the rubric appoints a white alb plain, which differs from the surplice in being close-sleeved, with a vestment or cope.

Boundaries, extent, and description.

SURREY, one of the smallest of the English counties, has the Thames for its northern boundary, Berkshire and Hampshire on the west, Sussex on the south, and Kent on the east. Its form is nearly that of an oblong quadrangle; its utmost length, from east to west, about 39½ miles; its breadth, 25½ miles. According to Parliamentary returns its superficial area is 789 square miles, or 485,760 acres; though Stevenson estimates it at 519,040 acres. It lies between 51. 5. and 51. 31. N. Lat., and 3. E. and 51. W. Long.

That portion of it included in the valley of the Thames is exceedingly rich and fertile; and the scenery is there diversified by leafy dells, waving corn-fields, picturesque ascents, and prolific woodlands. The western and southern

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districts exhibit, on the contrary, wide barren heaths and gorse-covered commons, so that Fuller's quaint description is not altogether exaggerated. "The county of Surrey," he says, "is not improperly compared to a cynnamon-tree, whose bark is far better than the body thereof; for the skirts and borders bounding this shire are rich and fruitful, whilst the ground in the inward parts thereof is very hungry and barren, though by reason of the clear air and clean wayes, full of many gentile habitations." Aubrey speaks of it in very similar language:—"It has been likened by some to a coarse cloth with a rich bordure or fringe, the inner part being less fruitful than the skirts." A range of chalk-hills, often attaining a considerable height, traverses the shire from east to west; the northern slopes clothed with verdure, and affording many noble prospects; the southern, barren, precipitous, and rugged, but noteworthy for their elevation and romantic character. Among the North Downs may be particularised Cooper's Hill, rendered famous by Denham's vigorous verse; St Anne's Hill, associated with the memory of Charles James Fox; the wooded heights of Norwood; Banstead Downs; Box Hill, and Sanderstead Hill. Of the South Downs, most worthy of notice are Leith Hill, so celebrated for the richness and extent of the prospects which it commands; the road from Albury, which affords a view of the whole extent of the Weald; Tilburstow Hill, near Godstone; and Anstie-bury Hill, overlooking a landscape of the utmost beauty.

The Surrey hills.

Its geological aspect.

The geological characteristics of the county have been identified by Dr Mantell with three principal groups, namely, the Wealden, which is the lowermost and most ancient; the Chalk, which overlays it; and the London Clay, filling up the depressions or basins of the chalk. Upon these last-named strata have accumulated, in many places, those drifts of sand, loam, and gravel known as post-tertiary detritus, or diluvium. In the neighbourhood of London, on Richmond, Tooting, and Wandsworth Commons, may be found the blue and tenacious London clay, yielding occasionally the bones and teeth of extinct mammalia; of birds, serpents, and crocodiles; fishes, crustacea, nautili, and other marine shells. Epsom and Bagshot Heath lie upon the Bagshot Sand. The North Downs are entirely of the chalk formation, affording ammonites, nautili, and belemnites; corals and other zoophytes; echini, crustacea, and the bones of saurians and turtles. The Shanklin, or lower green sand, occasionally rising to a considerable elevation, may be found at Reigate, Dorking, Godalming, and Tilburstow Hill. The Wealden occupies almost the whole of the southern portion of the country. The district between the Thames and a line running through Croydon, Sutton, Epsom, Leatherhead, and Guildford exhibits Bagshot Sand; between the boundary just indicated and the northern slopes of the Surrey Downs spreads the chalk formation. Shanklin Sand lies between the latter and the range of Tilburstow Hill, Bletchingley, and Leith Hill, a range which separates it from the Wealden.

Climate.

The face of the county being so varied, it is easy to understand that there will prevail extraordinary differences of temperature. The northern and southern districts are somewhat damp; in the former from their vicinity to the Thames, in the latter from the flatness of the surface and the luxuriance of the woodlands. The air on the chalk hills is, on the contrary, of a dry and bracing character. But, on the whole, Surrey may justly be regarded as a healthy county. Its climate is usually bland and genial, encouraging a quick vegetation and an early harvest. The popularity of its towns among fashionable places of resort is, in a great measure, due to their salubrity; and for different classes of invalids, the faculty constantly appreciate the advantages of Richmond, Dorking, Esher, and Reigate.

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Products.

In the neighbourhood of London the cultivated land is principally devoted to the production of those esculents required for the metropolitan markets. Acres of market-gardens are there in continual cultivation. Chertsey and Godalming produce yearly a large supply of carrots, a vegetable first introduced by the Flemings when driven into England by the persecutions of Alva; but potatoes and cabbages are more generally and more extensively raised. Mitcham is famous for its flower-farms, devoted to the culture of medicinal herbs, such as lavender, mint, chamomile, penny-royal, rosemary, and hyssop. Farnham is celebrated for its hops, which flourish abundantly on its calcareous soil. Though now a principal staple of the district, the hop culture does not date farther back than 1597, when, according to Aubrey, it was introduced by Mr Bignell, a Suffolk gentleman. The varieties chiefly cultivated are the "white-bine grape hop," the "red-bined orchard hop," and the "never black." Red clover is extensively grown in the meadow-lands of Surrey, and sainfoin upon its extensive chalk-hills. Sir Richard Weston is said to have introduced the cultivation of the trefoil and turnip about the middle of the seventeenth century. Wheat and barley are largely produced, but not oats or rye.

Manufactures.

Surrey possesses no manufactures of an *indigenous* character; for the tanneries of Bermondsey, and the potteries and bone-factories of Lambeth belong rather to the metropolis than to the county. On the banks of the Wandle there are some important mills, especially those of copper, snuff, silk, and paper. Near Wandsworth are the extensive works of Price's Patent Candle Company, and Watney's Distillery: Beaufoy's Vinegar Distillery, the Breweries of Barclay and Perkins, and Goding; and Doulton's Potteries are seated on the southern banks of the Thames. Apsley Pellatt's well-known Glass-works occupy large premises in Holland Street, Blackfriars.

Live stock.

Surrey is not associated with any particular breed of domestic animals. The horses employed are chiefly of the large black kind, found at the great fairs of Croydon, Ewell, and Kingston. The breeds of sheep most esteemed are the South Downs, the Upland-Merino South Down, the large Wiltshire, the Dorsetshire, the Mendip, and the Romney. Near the metropolis the cows, chiefly kept to supply South London with milk, are of the short-horned or Holderness kind, though the Alderney, the Suffolk, the Galloways, and the Welsh are also encouraged. Dorking is noted for a peculiar breed of fowls.

Rivers, canals, and railroads.

To carry its products to the London market, and to maintain a communication between its principal towns, as well as to facilitate the frequent visits of tourists, there exists in the county a complete net-work of rivers, railroads, and canals. Of the Thames, which forms its northern boundary, we need not speak. "The chalky *Wey*, that rolls a milky wave," enters the shire near Frensham, flows through the vale of Farnham, passes Moor Park and Waverley Abbey, proceeds eastward through fertile meadows and agreeable valleys to Godalming and Guildford, and swollen by several streams, washes the town of Weybridge before emptying its waters into the Thames a mile distant, at a point called Ham Haw. It is rendered navigable for twenty miles from its mouth by means of locks and auxiliary canals. The *Mole*, characterised by different poets from the peculiarities of its career as the "nousling Mole," the "sullen Mole that hides his diving flood," and the "silent Mole," enters Surrey in several small rivulets which unite near Gatwick, and runs onwards to Betchworth. Near Box Hill it flows into the numerous apertures in its banks and bed called *Swallows*, which in summer reduce its waters to an almost imperceptible channel, and have given rise to the fiction that at this part of its course it runs underground. Through the vale of Mickleham it winds to Leatherhead, and thence, with numerous meander-

ings, past Stoke d'Abernon, Cobham, and Esher Place to East Moulsey, where it joins the Thames. The *Wandle* (or Vandle—Pope's "blue transparent Vandalis") rises at Croydon, and increased by several springs which well up from the meadows of Carshalton, runs northward by Mitcham and Beddington to Wandsworth, where, after a brief but useful course of ten miles, it flows into the Thames. A small but pellucid stream, the ***Hogg's Mill or Ewell River***, rises at Ewell, flows northward past Maldon, and runs into the Thames at Kingston.

Weybridge and Basingstoke are brought into communication by a canal, the Basingstoke, completed in 1793, which has a course of 37 miles, and is on an average 5 feet in depth. The Grand Surrey Canal, from its great basin near Adlington Square, Camberwell, to its junction with the Thames, opposite the Shadwell Docks, is 4 miles and 6 chains in length. It was commenced in 1801. The Wey and Arun Junction Canal connects the two rivers, whence it derives its name, at a point near Stone Bridge, 2 miles from Guildford, and New Bridge, on the Arun, in Sussex. Its course is about 18 miles. The act of Parliament authorising its construction was passed in 1813.

Few parts of Surrey are now without the advantages of railway communication. The London and Brighton line, from London Bridge, traverses the suburban districts to Croydon, and is thence continued to Reigate, Merstham, and Horley, with branches to Caterham, and through Cheam and Ewell to Epsom; while a short line of 6 miles in length unites Croydon with Wimbledon. The London and South-Western Railway, from Waterloo Bridge, crosses the western division of the county to Guildford and Godalming, with branches to Kew and Twickenham, and a short line between Guildford and Farnborough. The Crystal Palace and West End Railway runs from a point near to Chelsea New Bridge, through the populous districts of Wandsworth, Balham Hill, Streatham, and Norwood, to the Crystal Palace.

In 1801, the population of the county amounted to 269,043; in 1821, to 398,658; in 1831, to 485,700; in 1851, to 683,092 (325,051 males and 358,041 females). At the latter period the inhabited houses numbered 103,822; the uninhabited houses, 5770; houses building, 1540. The principal boroughs and towns of the county, with their populations in 1851, are—Lambeth, 251,345; Southwark, 172,863; Newington, 64,816; Bermondsey, 48,128; Camberwell, 54,667; Wandsworth, 50,764; Rotherhithe, 19,805; Clapham, 16,290; Croydon, 10,260; Richmond, 9065; Streatham, 6901; Kingston, 6279; Guildford, 6740; Putney and Roehampton, 5280; Reigate, 4927; Mitcham, 4641; Egham, 4482; Farnham, 3515; Dorking, 3490; Epsom, 3390; Chertsey, 2743; Godalming, 2218; Kew, 1009.

The eastern division of Surrey (population, 580,226; electors, 8020) returns 2 members to parliament. The western division (population, 102,856; electors, 3924) has the same number of representatives. Southwark, with 10,606 electors, and Lambeth with 21,737 electors, return 2 members each. Guildford, with 739 electors, has 2 members; and Reigate, with 548 electors, 1 member.

	Males.	Females.
Landed proprietors	442	131
Farmers	1808	118
Farm bailiffs	263	
Outdoor labourers	14,293	133
Indoor labourers	815	263
Gardeners	2546	21
Nurserymen	138	
Labourers employed in agriculture	20,217	725
Male and female servants	2429	8593

History. Before the Roman era, Surrey formed a portion of the dominions of a Celtic tribe, named by Ptolemy the Ῥηγνοι, or Regni, and after the Roman conquest, was merged into the province of Britannica Prima, though, for many years, it retained its native princes, or *sub-reguli*. Eventually it was swallowed up in the territory of the South Saxons, and reduced by Kenulf, king of Wessex, about 760, into that progressive kingdom which Alfred finally brought into constitutional harmony and national completeness. During the Saxon era Kingston was a town of considerable importance, and witnessed the coronation of Edward the Elder (A.D. 900), Athelstan (A.D. 925), Edmund I. (A.D. 940), Edwin (A.D. 955), Edward the Martyr (A.D. 975), and Ethelred II. (A.D. 978). At Merton, in 784, perished Kenulf, the prince of the West Saxons, slain in a domestic feud by Cynehard, brother of Sigibert, king of Kent.

From the period of the Norman conquest, Surrey can claim no separate annals. It was to Merton, however, that Hubert de Burgh retired for sanctuary, when the barons demanded his expulsion from the councils of the king. Runnimede, the meadow where, on the 15th day of June 1215, the sun shone upon an event ever-memorable in English history, the signature of the Great Charter, is within the limits of Egham, a Surrey parish. Wyat's brief and disastrous insurrection in 1554, involved in its calamities the town of Kingston. Queen Elizabeth in her progresses visited Beddington, Nonsuch, Croydon, and Loseley. At Kingston, in 1642, took place the first military movement of the great civil war; a body of royalists unsuccessfully attempting to seize upon its magazine of arms. And there, on the 7th of July 1648, Lord Francis Villiers, the brother of Charles the Second's Duke of Buckingham (Dryden's Zimri), met his death in the skirmish which closed the famous struggle.

Worthies of Surrey. Among the most celebrated of her sons Surrey counts George Abbot, born at a public-house in Guildford in 1592; dying in 1633, archbishop of Canterbury, at his palace in Croydon. A man, says Clarendon, of very morose manners and a very sour aspect; but, undoubtedly, a man of considerable natural powers and unquailing energy. His brother Robert became bishop of Salisbury, and a second brother, Sir Maurice, Lord Mayor of London; a singular prodigality of fortune, which almost justified Fuller's quaint description of the cloth-worker's sons as "a happy ternion of brothers." With Stoke, near Guildford, is associated the memory of a once popular novelist and pleasing poetess, Mrs Charlotte Smith, the author of the *Old Manor House*. At Merrow is the family vault of the Onslows, notable among whom is the Mr Speaker Onslow of history, who, for three-and-thirty years, filled the chair of the House of Commons with unequalled impartiality, dignity, and courtesy. At Beddington, Admiral Sir Benjamin Hallowell, the brother in arms of Nelson, and the eccentric donor of that hero's famous coffin, lived for some years, and died in 1834. Moor Park is connected with the famous names of Sir William Temple, and his amanuensis, "the eccentric, uncouth, disagreeable young Irishman," afterwards more widely known as "the great Dean Swift." At Waverley Abbey was born Poulett Thomson, a useful public servant, and Governor-General of Canada at a time of peculiar difficulty. The old house at Claremont was built by Sir John Vanbrugh; the present mansion was erected by Lord Clive, and in its neighbourhood was born William Huntingdon, the zealot, who loved to describe himself as S. S., or a "Sinner Saved." At the Rookery, near Dorking, was born Malthus, the political economist. Wotton was the birth-place of John Evelyn, and in Wotton Church lies his dust. Sturdy William Cobbett was born at an inn near Farnham, and died at Normandy Farm in the parish of Ash. A more philosophical grammarian, and an equally uncompromising politician, Horne Tooke, wrote his Επεα Πτεροεντα at Purley, and died at Wimbledon. Thomson the poet is buried at Richmond, where, too, for a period resided Collins, the lyrist of *The Passions*. At Bowling Green House, on Putney Hill, died William Pitt, January 23d, 1806. At Putney, Gibbon, the historian of the decline and fall of Rome was born; and Nicholas West, who, after a wild youth, became bishop of Ely, verifying, says Fuller, the adage, that naughty boys sometimes make good men. Cromwell, the minister of Henry VIII., was a native of Putney, and his father's forge is still shown to inquiring strangers.

Antiquities and memorable places. Our limits will but suffer us to glance at the more interesting antiquities of the county. Those which belong to the Roman period are not important. Some coins, an urn or two, and traces of their encampments have been discovered at Albury, Woodcote, Walton-on-the-Hill, and Pendhill. At Cowey Stakes, near Walton, Cæsar led his army across the river, though some antiquarians have thought fit to place the scene of his passage at Kingston. There are some brasses of a very early date and remains of Norman architecture at Stoke d'Abernon; at Great Bookham, Chipstead, and Peperharow, there are Norman doorways, arches, and columns. Specimens of early English are noticeable in the churches of Carshalton, Crowhurst, St Mary's, Guildford, West Horsley, and Merstham; Leatherhead, Reigate, and Shere, present some good examples of Decorated; while in the stately tower of Croydon, and at Bletchingley, Godalming, Leigh, and Putney, the student may study Perpendicular. Of Merton Abbey the ruins are barely perceptible,

and of very little interest; but Newark Priory and Waverley Abbey will well repay the attention of the ecclesiastical antiquarian. The historical student cannot fail to be as deeply interested as the archæologist, in Abbot's hospital at Guildford, Beddington Hall, the ancient archiepiscopal palace at Croydon, Nelson's residence at Merton, Loseley, the seat of the Mores, Farnham and Guildford Castles, and Crowhurst Place. To the man of letters, Wolsey's Tower at Esher, Thomson's grave at Richmond, and his house in Kew Lane, Cowley's house at Chertsey, Douglas Jerrold's cottage at Putney, Ham House, Kew, and the poet Denham's residence at Egham, must always be shrines worthy of a pilgrimage.

Honours. Surrey gives the title of earl to the head of the ducal house of Norfolk, Richmond has its dukedom, and Guildford bestows an earldom upon the family of North. The barony of Abinger and the earldom of Onslow are also derived from this county.

Principal seats. It is almost impossible to enumerate a tithe of the seats belonging to noblemen and gentlemen, which, in Surrey, are worthy of notice. We must not omit, however, Claremont, the residence of the exiled royal family of France; Beddington, until a recent date the seat of the Carews; Albury, the late Henry Drummond, Esq., M.P.; Norbury Park, T. Grissell, Esq.; Nonsuch, W. F. Farmer, Esq.; Gatton Park, Lord Monson; Addington and Lambeth Palaces, the residences of the Archbishops of Canterbury; Peperharow, Lord Middleton; Barn Elms, J. Short, Esq.; Wimbledon, the Duke of Somerset; Eastwick Park, David Barclay, Esq.; Clandon Place, Earl of Onslow; Woburn, Hon. Locke King; Ockham Park, Earl of Lovelace; Esher Place, J. W. Spicer, Esq.; Loseley, J. More Molyneux, Esq.; the Deepdene, H. T. Hope, Esq.; and Denbies, G. Cubitt, Esq.

Aubrey's *Perambulation of Surrey*, edited by Rawlinson; Manning and Bray's *Surrey*; Brayley's *Surrey*; Lysons' *Environs of London*; Lysons' *Magna Britannia*; Camden's *Britannia*; Leland's *Itinerary*; Fuller's *Worthies*; Salmon's *Antiquities of Surrey*; Ducarel's *History of Croydon*; Stevenson's *View of the Agriculture of Surrey*. (W. H. D. A.)

SURVEYING. See Trigonometry.

SURVIVORSHIP. See Annuities and Mortality.

SUSA (Gr. τὰ Σοῦσα), called in the Bible Shushan (Heb. שׁוּשַׁן), an ancient city of the Persian empire, capital of the province of Susiana, and one of the residences of the court. There has been some difficulty in the exact identification of the site of this celebrated city, on account of the brief and sometimes obscure notices of ancient writers, and our imperfect knowledge of the geography of these regions. It stood, according to the testimony both of profane writers and of the prophet Daniel (ch. viii. 2–16), on the river Eulæus or Ulai (אוּלַי); but this river itself cannot be very certainly identified. The Choaspes, which flowed to the west of Susa, is generally believed to be the modern Kerkhah. The Coprates is identified with the river of Diz, and the Pasitigris with the Kuran, into which the former falls; but about the Eulæus modern investigators have differed considerably. Major Rawlinson supposes it to be the upper part of the Kuran, above its confluence with the river of Diz; and he thinks that the Hebrew Shushan was different from Susa, and identical with the modern Susan on the Kuran. Others hold that the Eulæus is the small river Shapur, an affluent of the river of Diz, and that the ruins of Shush, near the former stream, mark the site of Susa or Shusan. A third opinion is, that, while Shush represents the ancient Susa, the Eulæus does not correspond with any of the present rivers, but was a branch of the Choaspes flowing past Susa into the Coprates. (On this question see a number of papers in the *Royal Geographical Society's Journal*, vols. iii., ix., xii., xvi., and xxvii.) It is pretty certain that the ruins of Shush are those of the ancient Susa; for by recent excavations, there have been discovered there the remains of two palaces, one of which has a magnificent colonnade, similar in size and structure to that of Persepolis; and the columns have inscriptions in three languages, stating that the building was begun by Darius Hystaspes, who, according to Pliny, was the founder of Susa. The name of the city is said to have been derived from a Persian word signifying a lily, on account of the abundance of those in the neighbourhood. It was about 120 stadia, or about 15 miles in circumference, and was surrounded with a wall of brick. The climate of Susa was very salubrious, and the Persian monarchs used to make it their residence during the spring months. It was also the seat of the principal treasury of the empire, and vast sums of money were found here by Alexander, and some treasures were still left in subsequent times, even after they had been plundered by him. There is a monument in the neighbourhood, said to be the tomb of Daniel, but manifestly of modern origin.

Susa, a town of the kingdom of Sardinia, capital of a province, in the division and 37 miles W. of Turin, in a valley on the right bank of the Dora Ripaira. It consists of an old and a new town, both somewhat irregularly laid out, although the latter has some handsome streets and squares. Here are a cathedral, town-hall, college, several schools, hospitals, convents, &c. There are also some remains of antiquity, including a Roman triumphal arch, and the ruins of the castle La Brunetta, on a steep height, 11,000 feet above the sea. Pop. 3500.

Susa, a fortified seaport of Northern Africa, Tunis, 40 miles S. of Hammamet, on the S.W. shore of the gulf of that name. It is, next to Tunis, the chief trading place in the country, contains several mosques and bazaars, manufactories of woollen and linen cloth, shoes, &c., and a good harbour, which receives the largest vessels. Pop. 10,500.

SUSPENSION-BRIDGE. See Bridges and Statics.

SUSSEX, a maritime county of England, bounded on the N. by Kent and Surrey, E. by Kent, S. by the English Channel, and W. by Hampshire, is of an oblong form, 76 miles wide, and 27 miles in its extreme length. Its area is 1463 square miles, or 936,320 statute acres. Its divisions are six in number, and are locally called *rapes* or *ropes*, a term which Sir Francis Palgrave thus explains:—"The Normans were a hard people. Whenever they conquered, and did conquer outright, they went to work like plunderers, dividing the country by measurement—by the *rope*, as it was termed; measuring out the land amongst themselves, a process which singularly marks the original violence of their character, for in such allotments they neglected all the natural relations which might previously exist amongst the nations whom they conquered." In each of these rapes (*hreppai*, Icelandic) the Norman lord built, at a convenient point on the sea-coast, a castle or military station; in E. Sussex, in the rapes of Hastings, Lewes, and Pevensey; in W. Sussex, in the rapes of Bramber, Chichester, and Arundel, each, as it were, commanding a "high road to Normandy." These *rapes* are subdivided into 65 hundreds and 313 parishes, all—except the deaneries of Popham and South Malling, and All Saints, Chichester, which are peculiars of the see of Canterbury—in the diocese of Chichester. Boundaries, extent, and divisions.

The population of Sussex, in 1801, amounted to 159,311; in 1811, to 190,083; in 1821, to 233,019; in 1831, to 272,800; in 1851 to 336,844 (165,772 males, 171,072 females). At that period the distribution of the inhabitants was—

	Males.	Females.
Landed proprietors	408	342
Farmers and graziers	3,961	239
Farm bailiffs	454	
Outdoor labourers	25,684	86
Indoor labourers	1,570	704
Labourers employed in agriculture	37,880	1,877
Servants	2,725	12,726

The eastern division of Sussex (pop. 225,387, electors 6401,) returns two members to Parliament. The western division (pop. 111,457, electors 2853,) has the same number of representatives. Brighton, with 4609 electors, returns two members; Hastings, with 1235 electors, returns two; Chichester, with 627 electors, returns two; Lewes, with 697 electors, returns two; Arundel,

with 196 electors, returns one; Horsham, with 387 electors, returns one; Midhurst, with 429 electors, returns one; Rye, with 426 electors, returns one; and Shoreham, with 1843 electors, returns two representatives to Parliament. The election for East Sussex is held at Lewes; for West Sussex at Chichester.

The principal boroughs and towns of Sussex, with their populations in 1851, are—Brighton, 69,673; Hastings, 33,977; Shoreham, 30,553; Rye, 12,612; Lewes, 9533; Chichester, 8662; Horsham, 5947; East Grinstead, 3820; Cuckfield, 3196; Mayfield, 3055; Arundel, 2748; Bognor, 1913; Newhaven, 1358; Pevensey, 412.

A range of chalk-hills, known as the North Downs, in continuation of the chain which traverses Surrey and Kent, crosses to the north-eastern parts of the county from Tunbridge Wells to Hythe. The South Downs, a range of considerable elevation, 53 miles long, and 4 to 6 miles broad, runs through the entire county, in a line nearly parallel to that of the sea-coast, but broken into valleys by the rivers Arun, Adur, Ouse, and Cuckmere. Some of the heights are noticeable for their elevation. Ditchling Beacon is 858 feet above the sea-level; Firle Beacon, 820 feet; and Chanctonbury Ring, with its crown of firs, about 814 feet; Crowbury Beacon, 804 feet. The northern districts of the county were formerly covered with an almost impervious wood, the famous *Andredsleas* of the Celts; and there is still a general luxuriance of leafiness, which much commends the locality to the sketcher and tourist. How wide-spread was the forest growth, is evidenced by the names of hamlets still in existence, such as As-*hurst*, Lamber-*hurst*, Wad-*hurst*, Tice-*hurst*, and Crow-*hurst*. The Weald clay in the northern part is of a very tenacious character. It covers an area of about 425,000 acres. Between it and the chalk-range of the Southern Downs lie long narrow belts of gault and green sand, where the land is chiefly arable and pasture. The South Downs, and the broad stretches of luxuriant verdure which smile between them and the sea-marge, are eminently beautiful, and offer some of the most attractive "bits" of scenery in this portion of England. In the coombes and denes which break their rounded outline nestle clumps of ancient but still vigorous trees—ash, oak, and hazel, the white hawthorn and the bright green box; and on their slopes are clustered quiet villages, sleeping in the shadow of tall elms, with perhaps an old gabled manor-house and the gray tower of a venerable church peeping out of the leafy framework. On these Downs are constantly to be observed those circular belts of dark-green turf called "fairy-rings," popularly supposed to be the traces of fairy footsteps—of the *pharisees*, as the diminutive elves are named by the Sussex shepherds. The star-like gentian and the beautiful orchis are there abundant; the wheatear haunts the sweet thymy grass; and the hill-sides are everywhere dotted with the famous South Down breed of sheep. The south-eastern district, or Forest Ridge, is composed of Hastings sand, and is especially rich in romantic nooks and picturesque corners. Fairlight Down, 600 feet above the sea, commands a prospect of almost unequalled beauty; and the whole country around Hastings and Eastbourne has afforded endless materials to our Hardings, Stanfields, and Copley Fieldings.

Climate. In the northern districts of Sussex the climate is mild and genial, though their clayey soils and luxuriant woods incline it to humidity. On the coast it varies considerably. The air of Hastings is too relaxing for delicate persons, while that of Brighton is usually dry and bracing. At Worthing, the climate is so mild that figs are largely cultivated. Rottingdean rejoices in a fresh and strengthening air, free, however, from excessive keenness.

Rivers and railroads. The principal rivers of Sussex are the Cuckmere, the Ouse, the Adur, and the Arun. The Cuckmere rises in the south-eastern Downs—in several streams, which unite near Hellingly—and flows through a pleasant valley, or depression of the hills, into the English Channel at Cuckmere Harbour. The Ouse is a more important river, whose main channel has its source near Slaugham, on the southern boundary of St Leonard's Forest; passes Lindfield, and, increased by numerous tributaries, skirts Sheffield Park, running southward through a fertile country-side to Lewes; thence over an extensive flat, as Pennant says, which stretches many miles inland, and is "prettily bounded by extensive risings," proceeds to Newhaven, where its junction with the sea forms a convenient harbour. The Adur, rising in St Leonard's forest, in its brief course, passes ancient Bramber, and flows through a deep gully in the chalk-hills—the "Shoreham Gap"—into the sea at New Shoreham. The Arun is formed by other branches, one of which rises in Surrey; another in the neighbourhood of St Leonard's and Tilgate Forests; and a third, the Rother, rising in Hampshire, after washing the towns of Midhurst and Petworth, unites with the main stream at Pulborough, whence the augmented river flows, with many windings, through Arundel, and across a level country into the English Channel, below Littlehampton. The Arun is a navigable river, famous for its excellent mullets. The name is derived by Horsfield from *arundo*, a reed.

The railway communications are important. The London and South Coast line enters the county near the Three Bridges station (where a branch diverges to East Grinstead, and another to Horsham), proceeds southerly to Lewes, and thence to Newhaven. The main line runs on to Brighton. From Lewes the railway is continued to Pevensey and Hastings. There are short branches to Hurstmonceaux and Eastbourne. From Brighton a line proceeds to Portsmouth, in a direction nearly parallel to the sea-coast, touching the important towns of Shoreham, Worthing, Chichester, and Havant. The London and South-Eastern Railway crosses the eastern portions of Sussex to Battle and Hastings, whence it is continued through Winchelsea and Rye into the southern districts of Kent. There is a canal between Arundel and Chichester; and a more important one (see SURREY) connects the Arun navigation with the Wey.

Manufactures and products. There are now no manufactures in Sussex; but its iron-works in bygone days attained a great celebrity, employing a large number of the inhabitants of the Weald, where the strata embodying iron ore are principally found. These iron-works were of great antiquity; certainly known to the Romans, and probably to the Britons. Disused by the Saxons and the early Norman landowners, they rose into repute in the days of the Plantagenets; and in the 16th century the manufacture had assumed such considerable proportions as to excite the indignation of the poet Drayton. "These iron times," he cries, "breed none that mind posterity." Early in the 18th century, when coke took the place of charcoal in the iron manufacture, the trade in Sussex began to decline, and it has now for seventy years been hopelessly extinct.

Sussex, therefore, is a purely agricultural county. The Southdown breed of sheep is widely famous; they have no horns, and their faces and legs are dark-coloured. The wool is fine, and the flesh of excellent flavour. Sussex cows are scarcely less celebrated. They are of a deep-red colour, with small heads, and thin, transparent horns; are not kept for dairy purposes, but for the sake of the meat, always of a superior quality. In the eastern division, wheat and other grain are neglected, and hops are largely grown. The Sussex timber is even now in good repute; and in many parts of the county may yet be noticed elms, oaks, and other forest-trees, of surprising growth.

Watering places. Much of the prosperity of the county is due to the attractiveness of its sea-coast towns, whither, in the genial months of the year, repair by thousands the jaded London

Sussex.

citizens as well as the volatile leaders of the world of fashion. Hastings, Eastbourne, Rottingdean, Brighton, Worthing, and Bognor, owe their prosperity in no inconsiderable degree to the perfection of railway communication, which has

"To those in populous city pent
Glimpses of wild and beauteous nature lent,"

and created thriving towns in neighbourhoods hitherto unvisited and almost desolate. As many as 100,000 persons have been conveyed to Brighton by excursion-trains in one week.

History.

We have scarcely space even for a glance at the principal historical events associated with the "memorable places" of Sussex. "Hallowed ground," indeed, is trodden by the traveller at almost every step. The Regni held the county before the coming of the Romans, and even after the subjugation of England preserved a qualified independence, under their native king, Cogidubnus, whom Tacitus speaks of as always faithful to the Roman alliance. Regnum, the modern Chichester, was the capital, and thence to Augusta (or London) ran the great Stane Street, or Stone Street, a famous military highway. Another important road ran along the coast, and united Anderida (Pevensey), through Chichester, with Portus Magnus (Porchester). Ælla and his sons were the first Saxons who landed on the Sussex coast (A.D. 477). Their place of disembarkation is said to have been Wittering, near Chichester, which they assaulted and captured, spreading afterwards through the vast *Andredsleas* with fire and sword, and finally establishing the South-Sexe, or Sussex kingdom. Mr Kemble points out the probability of their settlements here having been very numerous, and among the earliest in England, from the frequent occurrence in this county of places whose names present the termination *ing*, which always indicates a "mark," or cluster of habitations. The religion of the Cross did not creep into Sussex, however, until long after Augustine had preached it to the men of Kent. It was introduced by Wilfrid, archbishop of York, who, about A.D. 680, was cast by a storm upon the coast—now bare and level, but then all richly wooded—of the peninsula of Selsey. A miracle attended its advent. Bede tells us that for three years no rain had fallen in "the Island of the Sea-Calf," and the drought had produced so great a famine, that very often bands of forty or fifty men would rush to the brink of a neighbouring precipice, and hand-in-hand cast themselves into destruction; but on the very day which witnessed the baptism of the proselytes there fell a soft and plenteous rain, restoring verdure to the earth, and hope to the heart of man.

The sea-board of Sussex suffered terribly from the ravages of the Danish jarls; but it does not appear that they effected any permanent settlements. The county afterwards formed a portion of the demesnes of the great Earl Godwin, and his greater son, King Harold. Within its limits—on a down covered with heath and furze, and surrounded by dangerous morasses—was fought (Oct. 14, 1066), the memorable battle which overthrew the Saxon dynasty, and eventually resulted in that union of Saxon solidity and Norman enterprise now recognised as distinctive of the English character.

Lewes, on the 13th of May 1264, was the scene of a contest scarcely less important in its results—the sanguinary battle of Lewes, between De Montfort earl of Leicester, and the barons' army, and the royal forces under Henry III. and Prince Edward. The slaughter was terrible, but De Montfort was victorious, and thus the final seal to Magna Charta was affixed in blood.

The French fleet, under D'Annebaut, made an attack on Brighton in 1545, and landed a body of troops, who were stoutly resisted by the natives, and compelled to retire. It was at Brighton Charles II. spent the night before his escape from the English shore (Oct. 15, 1651), in a small vessel fitted out by Capt. Nicholas Tattersall. In 1643, the Parliamentarian forces, under Sir William Waller, besieged Chichester for ten days, and, after its surrender, set to work lustily to purify it from "idolatrous images," and remove all "superstitious" decorations. The same leader, later in the year, beleaguered Arundel Castle for seventeen days, and reduced it to a heap of ruins. Off Beachy Head, on the 30th of June 1690, Lord Torrington's Anglo-Dutch fleet of 56 sail was attacked by a French force of 78 ships of war and 22 fire-ships, under Count de Tourville. The combat had no decisive results. And here we must pause, referring the reader for fuller historical details to the authorities indicated at the conclusion of this article.

Worthies.

At Field Place, near Horsham, on the 4th of August 1792, was born Percy Bysshe Shelley, and here that most psychological of poets wrote the greater part of *Queen Mab.* Chichester (Dec. 25, 1719) was the birth-place of William Collins, our great English lyrist; and in a house near Chichester Cathedral he died, in 1759. In the church of Horsted Keynes, sleeps the dust of one of the "wisest and virtuousest" of English prelates, Archbishop Leighton, who resided for ten years at Broadhurst, in its vicinity. Eartham is connected with the names of the poet Halley—to whom it descended from his father—and Huskisson, the statesman, who purchased it of him. John Fletcher, the greater of the dramatic fraternity of Beaumont and Fletcher, was born at Rye in 1579. Archdeacon Hare is interred in Hurstmonceaux churchyard. At Sheffield Place, Gibbon the historian spent his closing years, and in the adjacent church (Fletching) lie his remains. In a cottage named Lacies, near Salvington, was born the erudite Selden (A.D. 1584), and at the Chichester Free School he received his rudimentary education. Lewes is justly proud of Dr Mantell, the eminent geologist. Gilbert White, the naturalist, has associated his memory with the village of Ringmer and the Sussex downs.

Antiquities and objects of interest.

Sussex is rich in antiquities: we can but indicate the more important. Celtic earthworks may be traced at Cisbury, or Cissa's ties and Byrig, near Vindon; the Devil's Dyke, near Poynings; and Mount Caburn, near Lewes. Barrows, or *tumuli*, are scattered over the entire range of the South Downs. Roman relics are numerous, and of peculiar interest, especially the ancient walls of Anderida (Pevensey), and the fine villa at Bignor. To the historical student, there is a mine of wealth in Lewes Castle; in the stately towers of Pevensey; the picturesque keep of Arundel; and the ruins of Battle Abbey. There is a wide field, too, for ecclesiological speculation at Bayham Abbey, St Pancras Priory (Lewes), Michelham, and Wilmington. The most interesting churches are those of Shoreham, Steyning, Broadwater, Climping, Bosham, Winchelsea, and Etchingham. Chichester Cathedral must always be an attractive object to the archæologist as well as to "the man of taste." The lovers of English fiction will remember that Brambletye House suggested to Horace Smith his best romance, and that Ainsworth has transferred the features of Cuckfield Place to the "haunted house" in *Rookwood.* There is an interesting Elizabethan mansion at Parham, and a manor-house of an earlier date at Crowhurst. Brickwall House is curious in itself, and rejoices in some curious relics of Elizabethan days. Winchelsea and Rye are not without noteworthy traces of their past importance.

Honours.

The titles derived from this county are those of the Earls of Winchelsea, Ashburnham, Chichester, and Sheffield, and the Barons Arundel and Selsey.

Chief seats.

We can but name a few of the principal mansions and seats in Sussex:—Goodwood, the Duke of Richmond; Arundel Castle, Duke of Norfolk; Petworth, Colonel Wyndham (rich in art-treasures of the highest order); Sheffield Place, Earl of Sheffield; Eridge Park, Earl of Abergavenny; Maresfield Park, J. V. Shelley, Esq.; Buxted Park, Colonel Vernon Harcourt; Ashburnham Place, Earl of Ashburnham; Heathfield Park, G. E. Towery, Esq.; Buckhurst Park, Lord Delawarr; Stanmer Park, Earl of Chichester; Knepp Castle, Sir C. M. Burrell; Parham, Hon. R. Curzon; and Westdean House, Lord Selsey.

Horsfield's *History of Sussex;* Horsfield's *History of Lewes;* Lower's *Contributions to Literature;* Lower's *Handbook to Lewes;* Pennant's *Tour from London to the Isle of Wight; Collections of the Sussex Archæological Association;* Fuller's *Worthies;* Kemble's *Saxons in England;* Hussey's *Churches of Kent, Surrey, and Sussex;* Lyell's *Principles of Geology;* Dr Mantell, in Brayley's *History of Surrey.* (W. H. D. A.)

Sutherland.

Situation and boundaries.

SUTHERLAND, an extensive county in the north of Scotland, situated between 57. 53. and 58. 36. N. Lat., and between 3. 39. and 5. 15. W. Long.; having the sea on the S.E., W., and N., Caithness on the N.E., and Ross-shire on the S.; is separated from the latter for about 30 miles by the Dornoch Frith, and has communication with the south by Meikle Ferry and Bonar Bridge. The county forms an irregular square, extending from 45 to 50 miles both ways, and contains an area of 1754 square miles, or 1,112,560 imperial acres, divided into thirteen parishes, with a portion of the parish of Reay, forming part of the synod of Sutherland and Caithness. The other recognized divisions of the county are—Sutherland, being the south-eastern part; Assynt; the Reay country; and Strathnaver; and these names still serve to designate the different localities.

Surface.

The coast of Sutherland, in the N. and W. is rocky and precipitous, in the S.E. flat or sloping, except on the confines of Caithness, where the Ord projects into the sea with perpendicular abruptness; and presents a succession of inlets of the sea, and bold promontories, with several islets. The principal lochs or friths are—Lochs Assynt, Laxford, and Inchard, on the W.; Durness Bay, Loch Eriboll, the Kyle of Tongue, and the Bays of Torrisdale and Strathy, in

the N.; and Loch Fleet, branching out from the Dornoch Frith, on the S.E. Of the promontories, the more remarkable are—Rue Stoer, on the S. side of Loch Assynt; Cape Wrath in the N.W. extremity of the county; Far-out-Head, and Whiten Head on the N.E. coast. The interior consists of mountains, rising in Ben More, Assynt, to a height of 3230 feet, elevated plateaus covered with heath, vast fields of peat-bog, some pleasant straths watered by streams in which salmon and trout are found, and numerous lakes embosomed either in bleak, dismal regions of moorland, or begirt by a series of lumpy hills of conglomerate, whose naked and rugged sides have no covering even of heath. Wildness and sterility are the great features of the landscape, the dreary monotony being seldom relieved by tree or shrub; and this uniformity of desolation is only occasionally broken by some glen or strath presenting itself, as an oasis of verdure in the bleak desert. Of a different character, however, is the S.E. coast; for here the shore is flat or sloping for a distance varying from $\frac{4}{5}$ths of a mile to 2 miles, and a fringe or border of average fertility, well laid off into farms, highly cultivated, varied with plantations of considerable extent, and studded with handsome farm-houses, commodious steadings, and comfortable and tidy cottages. At about equal intervals are five fairly built and thriving villages, ornamented with proprietors' seats and a few handsome villas, sheltered from the north by a continous line of hills, or opening into the pleasant and fertile valleys of Strathfleet, Strath-Brora, and the Strath of Kildonan. This district has a fine southern exposure, and both in its appearance and productions can bear comparison with cultivated districts in the Lowlands.

Rivers.

The principal streams are Oikel, with its confluent the Shin, Fleet, Brora, and Helmsdale, all falling into the Dornoch Frith or German Ocean. The Oikel, of which the Dornoch Frith is an expansion, is by the tide navigable for ships of 50 tons as far as Bonar Bridge, a distance of 12 miles, and for boats about 8 miles further. On the N. coast the rivers are Dinart, the Naver, and the Halladale. All take their rise in the heights in the centre of the county, whence they disperse to different seas. Salmon is to be found in all the above-named rivers. Loch Shin, about 20 miles long and 1 mile broad, is the most considerable of the lakes; but, with the exception that its south-eastern extremity is lined by pretty little fields and neat cottages with a few trees at Lairg, it has not much of the picturesque in its appearance. Through this lake flows the river of the same name. It is said that there are about 200 lakes, many of them small, in the county, and that they occupy about 53 square miles, or nearly 34,000 acres. On the N. coast, the sea has formed some remarkable caves in the limestone rock; the most remarkable are that of Smoo, in Durness, 32 yards wide and 20 yards high; and that at Fraisgill, 50 feet high and 20 feet wide at the entrance, but gradually narrowing to its termination, at a distance of more than half a mile.

Minerals.

The oldest formation of rocks in Sutherland is gneiss, which extends over the whole county, and affords a great variety of aspect in the stratification. This formation is traversed by granite veins, which abound in various places in the south-east part of the county, as also in the upper parts of the parishes of Reay and Edderachylis. The gneiss is also traversed by veins of greenstone and porphyry. Those of the greenstone are found in great abundance in the south-east district of Assynt, and in the country around Scourie in Edderachylis. Porphyry veins are of rare occurrence. Mica-slate is developed to a considerable extent in two parts of the country: in that portion of the district of Moin which stretches southwards, and constitutes the whole of the mountains of Ben Hope, Ben Hee, and Meal Rynies; and that part of the county between Loch Fleet and Bonar Bridge. Granite fields prevail in the lower part of the parish of Reay, and in the parishes of Loth and Rogart. Syenite is to be met with in several places. It is most abundant in the mountain of Ben Laoghal, and that considerable tract of country which intervenes between the head of Loch Fleet and Lairg, at the head of Loch Shin. The quartz series of rocks occurs principally, in greater or lesser fields, in the western part of the county, from Loch Eriboll on the north to Loch Vattie on the south. This series is connected with sandstone and limestone. The latter is divided into four great fields connected with one another, and running in the same direction as the quartz. There is also a portion of nearly 6 miles in length at Durness, between Loch Eriboll and Cape Wrath. Redstone and conglomerate are extensively displayed on the east side, and at several points on the north coast, and in the interior. The oolite series of rocks, consisting of white sandstone, sandstone-flag, slate-clay, limestone, and coal, forms the coast between Golspie and the Ord of Caithness, and has a breadth at the River Brora of 3 miles. At Brora, coal occurs at several points, but although the seam is 3 feet 2 inches thick, the coal is so inferior in quality that it has been found to be not worth the working. Calcareous sinter and bog-iron ore are the only chemical alluvial deposits to be found in the county.

Valuation and rental.

This county, which is valued in the cess-books at L.26,193, 9s. 7d. Scots, is almost entirely the property of the Duke of Sutherland. In 1812 the gross rental of lands and houses, as returned under the Property-tax Act, was L.28,458, 8s. 4d., including about L.1700 as the rent of the salmon and other fisheries. In 1859 the rental of the same subjects, including shootings let, amounted to L.52,376, that of land alone being upwards of L.46,000.

Mansions.

The mansions of proprietors in the county are Dunrobin Castle, a palatial structure in the Old English baronial style, greatly enlarged and improved in the years 1845–51, at an expense of upwards of L.100,000; House of Tongue, Lochinvar House, Embo, and Skelbo Cottage,—all belonging to the Duke of Sutherland; Skibo Castle (Dempster's); Ospisdale (Gilchrist's); and Rosehall (Sir J. Matheson's). There are not more than two other proprietors in the county, and these have their mansions in Ross-shire. The farm-houses are, however, of a superior character, and several of them would form suitable mansions for moderate estates.

Means of communication.

Fifty years ago there were almost no roads, except bridle tracks, in the county; but for the last thirty years it has possessed a complete system of excellent roads intersecting the county in every direction, while no such thing as a toll-bar is to be seen upon them. There are also good inns, well kept, in every quarter in which the accommodation of travellers requires them. The roads are partly parliamentary; but by far the greatest extent of the several hundreds of miles of road connecting the different parts of the country was made and is maintained from the county rate. These roads, and other changes effected in the first quarter of the present century, have put this remote county on a level, in point of civilization, with districts more favourably situated for receiving an impulse from the great centres of intelligence and improvement.

Changes and improvements.

Previous to the year 1808, Sutherland was in a state of nature; and owing to the want of means of communication, the inhabitants continued in a state of primitive rudeness and ignorance. They were almost all engaged in tillage; but as their implements were of the rudest description, and as their skill and industry were unequal to the task of overcoming the unproductiveness of the soil and the rigours of climate, they only earned a miserable subsistence: their crops often blighted by mildew, they sometimes had recourse for sustenance to the expedient of bleeding their living cattle, and were frequently saved from absolute starvation by supplies of meal furnished by the landlord. The

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mountain region, the glens, and corries in which the inhabitants were located, presented insuperable obstacles to successful or profitable tillage; and as the very existence of a population so situated must always be precarious, the first Duke of Sutherland, a nobleman of enlightened views, resolute purpose, upright character, and withal possessing great wealth, had the foresight and the courage to effect in Sutherland a change which, whatever its hardships at first, has been attended with beneficial results. He removed the Sutherland man from his possessions in the heights of the county, and offered him an allotment on the coast-side at a nominal rent; or, if such was his choice, he was furnished with the means of emigrating to Canada. That any views of immediate gain influenced the proprietor in removing the tenants can hardly be maintained, when it is borne in mind, that although the Sutherland family have spent on this county many thousands drawn from their English estates, they have never, up to this date (1860), derived one penny of clear revenue from their extensive Highland property, forming nineteen-twentieths of the sixth largest county in Scotland. All has been spent in real or attempted improvements.

Agriculture.

For the last forty years tillage has been carried on in this county on the same plan, with the same appliances, and, taking soil and climate into account, with the same success as in the southern counties of Scotland. At Balnakiel, Keoldale, Eriboll, and Tongue, on the north coast, there are considerable corn farms; while on the south-east coast, in the parishes of Creich, Dornoch, Golspie, Clyne, and Loth, there are about thirty arable farms, paying each from L.150 to L.750 of annual rent, besides a small proportion of farms of from L.20 to L.100 rental; and, in addition to these, hundreds of lots of land, consisting of from one to ten acres. These lots are numerous in the inland parishes of Rogart and Lairg, and also along the west and north coast. As a body, the Sutherland farmers may, in intelligence, professional skill, and capital, stand a comparison with the agriculturists of any part of Scotland. The management of their farms, the adoption of every improvement in modes of tillage and implements of husbandry, the erection of handsome farm-houses with convenient steadings by the proprietor, and the raising of excellent crops of wheat, barley, oats, turnips, and hay—the grain sent south often fetching the highest price in the Edinburgh markets—furnish sufficient proof that the changes in the occupancy already referred to have been decided improvements so far as relates to corn farms. The regions in the interior, from which the aborigines were removed, are occupied with sheep farms, and the grazing of sheep or cattle appears to be the only purpose to which such districts of country can be applied. The sheep farms in the county are in number about thirty-five, carrying each from 1500 to 8000 sheep. The Cheviot is almost the only sheep on these farms, and it has not degenerated in the country of its adoption. From 2s. 6d. to 3s. 6d. per sheep is the general rental. A few years ago these farms were larger than they are now; but as leases fall in, their size is reduced and the number increased, portions of every large sheep farm being allotted to the corn farmers. The Dunrobin breed of cattle, originally from Argyleshire, was long celebrated; but on the larger farms these are giving way to other breeds, such as the short-horn and polled cattle, which come sooner to maturity. On the small holdings occupied by the cottars, now generally the descendants of those formerly dispossessed in making room for sheep farmers, there are substantial, comfortable cottages; and partly from the produce of their lands, which pay a very low or even nominal rent, and partly from earnings drawn from labour elsewhere, the occupants appear to live in more comfort than their forefathers did before the days of removals. But it can scarcely be maintained that their condition is as much in advance of that of the peasantry of the beginning of the century, as the condition of the farmer of 1860 is superior to that of the tacksman of 1800. Further, it may be stated, that to enable the people to live on these allotments, the landlord must forego one-half of the rent which the land would fetch. There are numerous fir plantations near the coast, which, however, take a long time to arrive at maturity. The sharp air of the German Ocean is unfavourable to the growth of timber, and close to the sea trees have a blasted and stunted appearance. Oaks, elms, and ash, in sheltered localities, attain considerable size. In the interior, any tree that is to be seen is dwarf birch. Horticultural productions are similar to those in more southern counties; and even at Tongue, on the north coast, there is a well-stored and productive garden.

Manufactures.

A cotton-mill had been for some time in operation at Spinningdale, but having been burnt down in 1806, the undertaking was abandoned. The only manufactory in the county is a woollen-mill on a small scale at Pittentrail in Rogart. Only one distillery, but no brewery, exists in the county.

Fisheries.

A few boats are engaged in the white fishing on the west and north coast. Lobsters and oysters are also found in considerable quantities. At Embo, Golspie, Port-Gower, Brora, and Helmsdale, about 30 boats altogether are employed in fishing all the year round; the two latter are herring-curing stations, and 200 boats are employed at Helmsdale, and 30 at Brora, during the herring season.

Commerce.

The exports are sheep, wool, cattle, ponies, grain, whisky, salmon, cod, haddock, and herring; meal and flour, however, are both imported, besides groceries, manufactured goods, and coals. The only way of accounting for the import of meal and the export of oats seems to be, that the farmers, who are all possessed of considerable capital, can keep up their grain in order to take advantage of high prices, and also that Caithness meal is generally preferred by the consumers.

Towns and villages.

Dornoch, the county town, is the only royal burgh in Sutherland, and has been stationary at a population of about 500 for the last sixty years. Though small, it is now pretty well built, and contains an excellent jail (often empty), court-room, and other public buildings, all erected within the last twenty years. The parish church is a cathedral on a small scale, which was renovated and restored in 1836. Golspie, with 900 inhabitants, is beautifully situated in the vicinity of Dunrobin Castle, has two banks, half-a-dozen good shops, and is ornamented by a handsome fountain, being a monument to the Duchess-Countess of Sutherland; while on Ben-Bhraggie, overlooking the village, 1000 feet above the sea, stands a monument 70 feet high, surmounted by a colossal statue, 30 feet in height, of the late duke; both it and the fountain having been erected by the tenantry in acknowledgment of their appreciation of the character of these noble persons. The other villages are Bonar, Brora, and Helmsdale, the last the largest place in the county. In Sutherland, as in the rest of the Highlands, the military spirit, that formerly sent forth a regiment from every county, appears to be extinct: the cause is to be found in the dissolution of feudal ties, and in the commercial character of the age, which draws off the surplus young men in quest of money and the comforts of life—things not to be found in camps or campaigns.

Churches and schools.

Before 1843, Sutherland contained no dissenting place of worship, and scarcely a single dissenter; but though at the disruption, the Duke of Sutherland was a firm supporter of the Established Church, at least nine-tenths of the people, headed by their more popular pastors, joined the Free Church, and continue steady adherents to that denomination. In 1851, there were 10 Established churches, with 3696 sittings; and 19 Free

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churches, having 7920 sittings. On 31st March 1851, the attendance at the Established churches was—forenoon, 255; afternoon, 200: at the Free churches—forenoon, 6723; afternoon, 4504. By the census returns of 1851, it appeared that a greater proportion of the population of this county than of any other in Great Britain attends school. This is owing to two circumstances—that there is little or no employment for youths under sixteen years of age, and that every inhabited district of the county has an excessive number of schools. In addition to the parish school, there are in every parish one or two General Assembly schools, as many Free Church schools, and in some a society school. In Dornoch parish, a radius of two miles would sweep over the parish school, three General Assembly schools, four Free Church schools, and a society school. In other parishes, an Assembly school has been planted within a mile of efficiently-taught but half-filled parish schools; while a Free Church school is always at hand to supplement deficiencies in both. Although there is no printing-press in the county, Sutherland matters are sufficiently discussed by neighbouring journalists. Gaelic is losing ground daily, and many young people on the coast cannot speak it.

Antiquities.

In various districts along the coast there are some remains of antiquity. The most interesting are two circular buildings, called Dun-Dornadil, or Dornadilla's Tower, and Castle Coll, both reared of large stones, nicely fitted, but without cement, and of which considerable portions are still entire, after the lapse of probably 1000 years. Castle Coll, which is situated on the east side of the county, on a stream that falls into the Brora, has an exterior circumference of 54 yards, with walls 4½ yards thick at the base, inclining inwards 9 inches in every 3 feet in height; and two small apartments on each side of the doorway, as if intended for guard-rooms. The highest part of the wall is now only 11 feet high, but old people remember it twice that height. Dun-Dornadil is in the parish of Darness, on the northern side of the county. It is a building of the same character with Castle Coll, but still more dilapidated, and is celebrated in the ancient Gaelic ballads as a place of renown at a very early period. At Backies, near Golspie, are the remains of a Pictish tower, with covered passages and chambers, all formed of stone without any cement, and apparently intended to be fire-proof. Others of a similar character, tumuli, and some small forts, may still be traced in various situations along the coast.

Representation.

The county sends one member to Parliament; and the town of Dornoch joins with Cromarty, Dingwall, Tain, Wick, and Kirkwall, in election of a burgh member.

The population, according to the census of 1801, was 23,117; in 1811, it amounted to 23,629; in 1821, to 23,840; in 1831, to 25,518; in 1841, to 24,782; in 1851, to 25.793; and in 1860 it is estimated at 26,500.

SUTLEJ, or SUTLUJ, the most easterly of the five rivers of the Punjab, in India, rises in the lakes of Manasarovara and Rawan Hrad, among the Himalayas, about N. Lat. 30. 8., E. Long. 81. 53. It flows north-west for 188 miles, through a country wild and sublime in the highest degree, as far as Khab, where it receives from the north-west the river of Spiti. The confluence of these rivers is one of the most grand and awful scenes in the world; the muddy stream of the Sutlej dashing tumultuously over its rocky bed, and mingling in a deep gulf with the deep, calm, and blue stream of the other. The rivers are, at the confluence, 8600 feet above the sea; and from this point the united stream flows south-west with a very rapid current and steep declivity. At Rampoor, which is a comparatively short distance off, the bed is only 3360 feet high, and the breadth of the stream is 211 feet. Near Bilaspoor it takes a sweep to the north-west, but soon returns to its former course. It joins the Beas a little above Hurekee; and the united river bears the name of Ghara until its junction with the Chenaub, when it takes that of Punjnud, which it bears till it joins the Indus. The Sutlej is believed to be the Zaradrus or Hesudrus of the ancients, and the Hypanis of Strabo.

Sutton Coldfield || Swaffham.

SUTTON COLDFIELD, a market-town of England, Warwickshire, on the slope of a hill, 7 miles N.N.E. of Birmingham. It is for the most part regularly laid out and well built; and it contains a handsome parish church, partly built by Bishop Vesey, in the sixteenth century, and containing some ancient monuments; a Roman Catholic chapel, a grammar-school, and several others; a public library, and a neat brick town-hall. South-west of the town lies the Coldfield, a bleak tract of 13,000 acres, stretching into Staffordshire; and to the north-west and west is Sutton park, a pasture-ground of about 3500 acres, given to the poor of Sutton by Bishop Vesey. There are no manufactories in the town; but many of the people are employed in the making of hardware in the vicinity, and within the limits of the parish there is a celebrated factory of music-wire. Pop. 4574.

SVEABORG, or SWEABORG, a fortified town of the Russian empire, Finland, on seven small islands in the Gulf of Finland, immediately S.E. of Helsingfors, the harbour of which it protects. It has docks and dockyards, and is a station of the Russian fleet, and the chief fortified place in Finland. Pop. 3500. For an account of the bombardment of Sveaborg by the British, June 9, 1855, see RUSSIA.

SWABIA (Germ. *Schwaben*), an ancient division of Germany, deriving its name from the Suevi. It is the same country that was originally called Allemannia, and occupied the right bank of the Rhine, where that river forms an acute angle at Basle; bounded on the N. by the Palatinate of the Rhine and Franconia, E. by Bavaria, S. by Switzerland, and W. by Alsace; including the mountains of the Black Forest, and the sources and upper courses of the Neckar and Danube. It thus corresponded with the modern Würtemberg, the southern part of Baden, and the province of Swabia and Neuburg, in Bavaria. It received the name of Swabia when the Allemanni were conquered by Chlodwig in 496, and brought into subjection to the Franks; and it was at first governed by dukes appointed by the Frankish kings. In 1080, Henry IV. made the dukedom hereditary in the family of Frederick of Hohenstaufen. The country was at this time in a very flourishing condition, and the reigning house soon became one of the most powerful in Germany: in the great civil war it stood at the head of the Ghibelline party, and included among its members several emperors,—Conrad III., Frederick I., Barbarossa, Henry VI., Frederick II., and Conrad IV. With the unfortunate Conradin, the son of the last of these monarchs, who was executed in 1268, the line of Hohenstaufen became extinct; and upon this the various princes, prelates, and cities of Swabia, that had been formerly vassals of the dukes, made themselves independent. Since then Swabia has not formed a separate state, but it was one of the ten circles of the German empire till 1806.

SWAFFHAM, a market-town of England, in the county of Norfolk, on the top of a hill, 27 miles W. by N. of Norwich, and 93 N.N.E. of London. It is generally well built, and has in the centre a large market-place, containing a handsome cross. The chief buildings are the parish church, a large cruciform structure of the fifteenth century, with a pinnacled tower, and some ancient monuments; a town-hall, jail, theatre, and assembly-rooms. There are also places of worship for Wesleyan Methodists, Baptists, and others; several schools, and a savings bank. Markets and fairs are held here, and there is some trade in butter. Pop. 3858.

Swammerdam || Swansea.

SWAMMERDAM, JOHN, a celebrated natural philosopher, was the son of John James Swammerdam, an apothecary and naturalist of Amsterdam, and was born in 1637. His father intended him for the church, and with this view had him instructed in Latin and Greek; but thinking himself unequal to so serious a vocation, he prevailed with his father to consent to his applying himself to physic. When grown up, he seriously attended to his anatomical and medical studies; yet spent part of the day and the night in discovering, catching, and examining the flying insects not only in the province of Holland, but in those of Guelderland and Utrecht. Thus initiated in natural history, he went to the university of Leyden in 1651; and in 1653 was admitted a candidate of physic in that university. His attention being now engaged by anatomy, he began to consider how the parts of the body, prepared by dissection, could be preserved, and kept in constant order for anatomical demonstration; and here he succeeded as he had done before in his contrivances for dissecting and preserving the minutest insects. He afterwards made a journey into France, where he spent some time at Saumur, and where he became acquainted with several learned men. In 1667 he returned to Leyden, and took the degree of M.D. The Grand Duke of Tuscany offered him 12,000 florins for his collection, on condition of his removing them himself into Tuscany, and coming to live at the court of Florence; but Swammerdam, who hated a court life, declined his highness's proposal. In 1663 he had published a *General History of Insects.* Respecting this work, his biographer, Boerhaave, subsequently wrote that "all the ages from the commencement of natural history have produced nothing to equal, nothing to compare with it." About this time his father began to take offence at his inconsiderately neglecting the practice of physic, which might have supported him in affluence, and would neither supply him with money nor clothes. This reduced him to some difficulties. In 1675 he published his *History of the Ephemeras;* and his father dying the same year, left him a fortune sufficient for his support; but he did not long survive him, for he died in 1682. Gaubius gave a translation of all his works from the original Dutch into Latin, from which they were translated into English, and published in folio, in 1758.

SWANAGE, or SWANWICK, a market-town of England, Dorsetshire, on a bay of the same name, N.E. of St Alban's Head, 22 miles E.S.E. of Dorchester. It consists of one main street, and has an old church, with a tower 80 feet high, Independent and Methodist chapels, a library, and baths. Many of the people are employed in the neighbouring quarries of Purbeck stone; others in plaiting straw and making buttons. Swanage is visited for the sake of sea-bathing; the climate is mild, and the bay is very beautiful. Pop. 2139.

SWANEVELT, HERMANN VAN, usually called "the Hermit of Italy," was a Dutch painter of distinction, and was born at Woerden about 1620. He is said to have been originally the pupil of Gerard Dow, and subsequently of Claude Lorraine, but there is no evidence of this beyond the most slender tradition. This artist went early to Italy, and spent his life in painting the delightful landscapes of that country. He was distinguished by the warmth and tenderness of his tints, and by the fine gradation of his aërial perspective. Many of his landscapes are exquisitely embellished with ruins, cattle, and figures, admirably grouped. His pictures are now exceedingly scarce. His death is said to have occurred in 1680, but many writers place it ten years later.

SWANSEA, a seaport on the south coast of Wales, is one of the chief towns of Glamorganshire, and ranks as the metropolis of the Principality. It is situated between high hills, at the entrance of a valley through which runs the River Tawy (whence the Welsh name of the town, "Abertawe," is derived), and at the head of a fine bay. Formerly Swansea was much frequented as a watering place, but its rapidly growing commercial and manufacturing interests have given a new character to the population, and even changed the face of the country. The natural features of the neighbourhood are attractive, but the smoke from the copper-works destroys vegetation, poisons cattle, and makes the hill-sides look barren and desolate. The smoke, however, does not find its way outside the town to the westward, and the town is fast increasing in that direction. Its proximity to the Welsh coal-field, combined with the facilities it affords as a seaport, have led Swansea to become the great seat of the copper-ore trade. Nine-tenths of the whole quantity of copper ore smelted in the United Kingdom is smelted at Swansea; the foreign ore being brought here from Cuba, South America, Australia, and elsewhere. The first copper-works were established in Swansea in 1719, and the first cargo of foreign copper ore was imported into the town in 1827. There are also silver, tin, and iron-works here, which are supplied with ore from abroad. The value of the silver and copper ore imported into Swansea is very large: a single cargo is often worth from L.60,000 to L.70,000, and a single smelting firm has imported ore to the value of a quarter of a million in three months. The principal exports are coal and patent fuel, the latter of which is largely manufactured in the town.

Swansea.

The progress of Swansea as a port is of recent date. In 1768 the total number of vessels visiting the place was 694, with a total amount of tonnage of 30,631. In 1800, nine years after the passing of an act for the improvement of the harbour, there were 2590 vessels, with a tonnage of 154,264. In 1850, two years before the opening of the first floating dock, the number of vessels was 3616; tonnage, 262,207. In 1859 the number of vessels was 4772; tonnage, 508,814. In the last-named year extensive new docks were opened, and supplied, together with the old docks, with elaborate hydraulic machinery by which the gates are moved, the bridges swung, and vessels are loaded and discharged. A branch line of railway to the new docks was opened at the same time.

Swansea became a corporate town upon the passing of the Municipal Reform Act, in 1835, and is now divided into two wards, and governed by a mayor, six aldermen, and eighteen common councillors. The town council also forms a Local Board of Health, under the Health of Towns Act. Swansea, in conjunction with the neighbouring towns of Neath, Loughor, Aberavon, and Kenfig, returns one member to Parliament.

The remains of Swansea Castle stand on an eminence near the centre of the town. This castle was built by Henry Beaumont, Earl of Warwick, in 1100. The Earl obtained a grant of the lands of Gower (a peninsula running out into the Bristol Channel to the west of Swansea), from William Rufus, and having dispossessed the Welsh prince Caradoc of those lands, built Swansea Castle and several other castles for the defence of his domain. Within the last century the castle has comprised at the same time a union, market-house, blacksmith's shop, Catholic chapel, and gaol. It was used as a debtors' prison by the Duke of Beaufort, the lord of the seigniory of Gower, up to 1859; when, through the intervention of Government, this and the only other two or three prisons of the same kind in the kingdom were abolished. A fine post-office, having the appearance of a church at a distance, was built adjacent to the old castle, and opened in 1857. There are three churches in the town—St Mary's (the parish church), Trinity, and St John's (a Welsh church); and numerous chapels used by the Welsh and English Dissenters of various denominations. The Wesleyan chapel is a handsome

Swartz || Sweden.

structure in the Italian style, and forms one of the chief ornaments of the town. Among the other public buildings worthy of note are the town-hall, the Royal Institution of South Wales (a literary and scientific institution containing a valuable library and museum), the endowed grammar-school, the harbour offices, and the Glamorganshire Bank. Two county newspapers are published at Swansea—the *Swansea and Glamorgan Herald*, and the *Cambrian*.

The terminus of the Swansea Valley Railway, opened in 1860, is at Swansea, and by means of the South Wales line the town is placed in direct communication with Gloucester on the one side, and Milford on the other. Constant steam communication by sea is kept up with Bristol and Liverpool. Swansea is 216 miles from London, and 84 from Bristol; and the borough has a population (in 1860) of about 50,000.

SWARTZ, Olof, a celebrated Swedish botanist, was born at Norrköping in East Gothland in 1760. He commenced his studies in Upsal, and began early to make excursions through various districts of Sweden in quest of botanical specimens. He made a voyage to America in 1783, and returned to England in 1788, on his way home. After staying about a year, diligently examining whatever was of note in regard to his favourite study in Britain, he returned to Sweden in 1789, and was made professor of natural history in the medical school of Stockholm. He published his first work on mosses at Erlangen in 1799. We can only signalize his works, which were as follows:—*Nova Genera et Species Plantarum*, 1788; *Observationes Botanicæ*, 1791; *Icones Plantarum Incognitarum*, 1794–1800; *Flora Indiæ Occidentalis*, 1806; *Synopsis Filicum*, 1806; *Summa Vegetabilium Scandinaviæ Systematicè co-ordinatorum*, 1814. Besides writing from the 5th to the 8th volume of the *Svensk Botanik*, a national work on Swedish botany, he also contributed numerous papers to the *Philosophical Transactions*, and to the *Transactions of the Linnæan Society* of London. He added some 50 genera and 850 species to the list of flowering plants, and a great number to the class of cryptogamia. He died in 1818.

Sweden.

SWEDEN.

The early history of Sweden, like that of most other countries, is involved in fable. Some historians pretend to give regular lists of the kings who reigned over this country from very early times, but these differ so much from each other, that no degree of credit is to be given to any of them. It is generally agreed that Christianity was first established here in the beginning of the eleventh century, by Olaf, surnamed Skotkonung; but different lists of kings are given down to the twelfth century. This may be partly accounted for from there being sometimes two kings reigning in the country at the same time, one over the Goths, the other over the Swedes, and sometimes either of these races would have two kings ruling over them.

On the death of Inge II. in 1129, the Swedes conferred the royal dignity on a private individual, named Swerker I.; and to conciliate the Goths, who supported the claims of Eric, descended from a female branch of the royal family, it was agreed that Eric should succeed Swerker, and that afterwards the representatives of each of the two families should reign alternately. Accordingly, on the death of Swerker in 1155, Eric ascended the throne, and signalised his reign by the subjection of the Fins and the establishment of Christianity among them, and by the compilation of a code of laws. The arrangement come to with respect to the succession led, as might have been expected, to endless disputes, but the order was observed with several succeeding sovereigns. About the year 1319, Magnus Smeck, then an infant, ascended the throne, and subsequently, in right of his mother, succeeded to the crown of Norway. In 1343 he was deposed by the diet, and his son Eric raised to the throne, but on the death of the latter, in 1359, he was restored. He established his son Haquin in Norway, and induced him to marry Margaret, daughter of Waldemar IV., king of Denmark; and having strengthened himself by his connection with these states he attempted to obtain absolute power in Sweden by abolishing the senate. The Swedes, however, immediately rose in defence of their liberties, expelled Magnus, and elected Albert, second son of the Duke of Mecklenburg, in his room. Albert soon after entered into a league, offensive and defensive, with the Earl of Holstein, the Jutland nobility, the Dukes of Sleswick, Mecklenburg, and the Hanse Towns, against the Kings of Denmark and Norway. At that time he proved very successful against Waldemar king of Denmark, driving him entirely out of his dominions; but he himself was defeated by the King of Norway, who laid siege to his capital. A new treaty was soon afterwards concluded, by which Albert was allowed to enjoy the crown of Sweden in peace. Having, however, formed a design of rendering himself absolute, he so displeased his subjects that Margaret of Norway was proclaimed queen of Sweden by the malcontents. A war immediately ensued, in which Albert was defeated and taken prisoner; but as the princes of Mecklenburg, the earls of Holstein, and the Hanse Towns, entered into a league in his favour, the war raged with more fury than ever. At length the contending parties were reconciled. Albert was set at liberty, on condition that he should in three years resign to Margaret all pretensions to the city of Stockholm; and the Hanse Towns engaged to pay the sum of 60,000 marks of silver if Albert should break that treaty. Eric, the son of Albert, died not long afterwards; and having no other child, he did not think it worth his while to contend for the kingdom of Sweden: he therefore acquiesced in the pretensions of Margaret, and passed the remainder of his days at Mecklenburg.

War with Denmark and Norway.

Is defeated and taken prisoner by Margaret of Norway.

Set at liberty, A.D. 1394.

Margaret died in 1415, and was succeeded by Eric of Pomerania. This prince's reign was cruel and oppressive. His misdeeds produced a revolt; and Charles Canutson, grand mareschal of Sweden and governor of Finland, having joined the malcontents, was declared commander-in-chief of their army. Eric was now formally deposed, and Canutson was chosen regent; but beginning to oppress the people, and aspiring openly to the crown, the Swedes and Danes revolted. This event was followed by a revolution; and Christopher duke of Bavaria, nephew to Eric, was chosen king of Denmark, Sweden, and Norway, in 1442.

Margaret is succeeded by Eric, a cruel tyrant, A.D. 1415.

On the accession of this prince, complaints against Canutson were presented from all quarters; but through the interest of his friends he escaped punishment; and in 1448, Christopher having died, after a tyrannical reign of about five years, he was raised to the throne to which he had so long aspired. The kingdoms of Denmark and Norway however refused allegiance to him, and a war immediately ensued. In 1454 peace was concluded, and Denmark for the present freed from the Swedish yoke. Nor did Canutson long enjoy the crown of Sweden. Having quarrelled with the magistrates and the Archbishop of Upsala, the latter formed so strong a party that the king could not resist him. Canutson died in 1470, after a long and turbulent reign.

Charles Canutson, A.D. 1448.

The affairs of Sweden continued to be involved in the utmost confusion till the year 1520, when a great revolution was effected by Gustavus Ericson, a nobleman of the first rank, who restored the kingdom to its liberty, and laid

A.D. 1520.

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Christiern king of Denmark invades Sweden, but is defeated and driven out.

the foundation of its future grandeur. In 1518, Christiern king of Denmark had invaded Sweden, with a design to subdue the whole country; but being defeated with great loss by young Steen Sture, at that time regent, he set sail for Denmark. Meeting with contrary winds, he made several descents on the Swedish coast, which he ravaged with all the fury of an incensed barbarian. The inhabitants bravely defended themselves, and Christiern was reduced to the utmost distress. He then thought of a stratagem which had almost proved fatal to the regent; for having invited him to a conference, at which he designed either to assassinate or take him prisoner, Sture was about to comply, when the senate, who suspected the plot, enterposed to prevent him. Christiern then offered to proceed in person to Stockholm in order to confer with Sture, on condition that six hostages should be sent to his place. They were accordingly sent; but the wind happening then to prove favourable, he set sail for Denmark with the hostages, of whom Gustavus Ericson was one. Next year he returned, and having drawn Sture into an ambush, the regent received a wound, of which he died some time after. The kingdom being thus left without a head, matters soon came to the most desperate crisis. The army disbanded itself; and the senate, instead of taking proper measures to oppose the enemy, spent their time in idle debates. Christiern in the mean time advanced into the heart of the kingdom, destroying every thing with fire and sword; but on his arrival at Stragnez, he granted a suspension of arms, on condition that they would elect him king. To this condition they submitted, and Christiern proved one of the most bloody tyrants that ever sat on the throne of any kingdom. Immediately after his coronation, he gave grand entertainments for three days; during which time he projected the diabolical design of extirpating at once all the Swedish nobility, and thus for ever preventing the people from revolting, by depriving them of their proper leaders. As the tyrant had signed articles by which he promised indemnity to all who had borne arms against him, it became necessary to invent some cause of offence against those whom he intended to destroy. To accomplish his purpose, Gustavus Trolle, formerly archbishop of Upsala, but who had been degraded from that dignity, in an oration before his majesty lamented the demolition of Stecka, his place of residence, and the losses sustained by the see of Upsala, amounting to a very large sum of money. He then proceeded in a bitter accusation against the widow and the son-in-law of Sture, the late regent, comprehending in the same accusation about fifteen of the principal nobility, the whole senate, and the burghers of Stockholm. In consequence of this, about eighty of the principal nobility and people of the first rank in Sweden, among whom was the father of Gustavus Vasa, were hanged as traitors. Innumerable other cruelties were committed, part of which are owned by the Danish historians, and the whole are minutely related by those of Sweden. At last he departed for Denmark, ordering gibbets to be erected, and causing the peasants to be hanged on them for the slightest offences.

He treacherously carries off six hostages, of whom Gustavus Ericson is one, A.D. 1519.

Is chosen king, and proves a most bloody tyrant.

Massacres the nobility.

Adventures of Gustavus Vasa or Ericson.

This monstrous cruelty, instead of securing him on the throne, exasperated the whole nation against him. It has already been mentioned, that Gustavus Ericson, or, as he is commonly called, *Gustavus Vasa*, was among the number of the hostages whom Christiern had perfidiously carried to Denmark in 1519. At length he escaped from confinement and fled to Lübeck, which he in vain endeavoured to gain over to his aid, and afterwards he took refuge in the mountains of Dalecarlia. A price being set upon his head, and death threatened to every one who afforded him the least assistance, he was frequently reduced to the deepest distress. He wrought for some time as a labourer in the mines of Fahlun; and on more than one occasion he narrowly escaped detection. At length he seized a favourable opportunity to reveal himself at an annual feast of the peasantry, who were soon excited to enthusiasm in his cause, and instantly resolved to throw off the Danish yoke. Gustavus did not allow their ardour to cool, but instantly led them against the governor's castle, which he took by assault, and put the garrison to the sword. This inconsiderable enterprise was attended with the most happy consequences. Great numbers of the peasants flocked to his standard; some of the gentry openly espoused his cause, and others supplied him with money. Christiern was soon informed of what had passed; but despising such an inconsiderable enemy, he sent only a slender detachment to assist his adherents in Dalecarlia. Gustavus advanced with 5000 men, and defeated a body of Danes; but he was strenuously opposed by the Archbishop of Upsala, who raised numerous forces for Christiern. The fortune of Gustavus, however, still prevailed, but the archbishop was defeated with great loss. Gustavus then laid siege to Stockholm; but his force being unequal to such an undertaking, he was forced to abandon it with loss.

The Danes defeated.

This check did not prove in any considerable degree detrimental to the affairs of Gustavus; the peasants from all parts of the kingdom flocked to his camp, and he was joined by a reinforcement from Lübeck. Christiern, unable to suppress the revolt, wreaked his vengeance on the mother and sisters of Gustavus, whom he put to death. His barbarities served only to make his enemies more resolute. Gustavus having assembled the states at Wadstena, he was unanimously chosen regent, the Diet taking an oath of fidelity to him, and promising to assist him to the utmost. Having thus obtained the sanction of legal authority, he pursued his advantages against the Danes. A body of troops appointed to throw succours into Stockholm was cut in pieces; and the regent sending some forces into Finland, struck the Danes there with such terror, that the Archbishop of Upsala, together with the Danish governors, fled to Denmark. Christiern then sent express orders to all his governors and officers in Finland and Sweden, to massacre the Swedish gentry without distinction. The Swedes made reprisals by massacring all the Danes that they could find, so that the country was filled with slaughter.

Horrid cruelty of King Christiern.

Success of Gustavus.

In the mean time Gustavus had laid siege to the towns of Calmar, Abo, and Stockholm; but Norby found means to oblige him to retire with loss. Gustavus, in revenge, laid siege to the capital a third time, and applied to the regency of Lübeck for a squadron of ships and other succours for carrying on the siege. This request was granted on condition that Gustavus should oblige himself, in the name of the states, to pay 60,000 marks of silver as the expense of the armament; that, until the kingdom should be in a condition to pay that sum, the Lübeck merchants trading to Sweden should be exempted from all duties on imports or exports; that all other nations should be prohibited from trading with Sweden, and that such traffic should be deemed illicit; that Gustavus should neither conclude a peace, nor even agree to a truce, with Denmark, without the concurrence of the regency of Lübeck; and that if the republic should be attacked by Christiern, he should enter Denmark at the head of 20,000 men. On these hard terms Gustavus obtained assistance from the regency of Lübeck; nor did his dear-bought allies prove very faithful. They did not indeed transfer their services to his enemy; but in a sea-fight, where the Danes were entirely in their power, they suffered them to escape, when their whole force might have been entirely destroyed. This treachery had nearly ruined the affairs of Gustavus; for Norby was now making preparations effectually to relieve Stockholm, and would probably have succeeded in the attempt, if at this critical period news had not arrived that the Danes had revolted, and driven Christiern from the throne; and that the king had retired into Germany, in hopes of being restored by the arms of

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his brother-in-law the emperor. On hearing this intelligence, Norby retired with his whole fleet to the island of Gothland, leaving but a slender garrison in Calmar. Gustavus did not fail to improve this opportunity to his own advantage, and quickly made himself master of the town. In the mean time Stockholm continued closely invested, but he thought proper to protract the siege till he should be elected king. Having for this purpose called a general diet, he first filled up the vacancy in the senate occasioned by the massacres of Christiern. He had the address to procure the nomination of such as were in his interest. The assembly was no sooner met, than one of his partisans made a speech, containing the highest encomiums on Gustavus, setting forth in the strongest terms the many eminent services which he had rendered to his country, and concluding that the states would show themselves equally ungrateful and blind to their own interest if they did not immediately elect him king. This proposal was acceded to by such tumultuous acclamations that it was impossible to collect the votes; so that Gustavus himself acknowledged, that their affection exceeded his merit, and was more agreeable to him than the effects of their gratitude. He was urged to have the ceremony of his coronation immediately performed; but this he delayed, in consequence of some designs which he had formed to reduce the exorbitant power of the clergy. He had himself embraced the doctrines of the reformed religion, and did all in his power to establish the reformation in his new kingdom. His design could not fail to raise against him the enmity of the clergy, and of all the more superstitious part of his subjects. The first years of his reign were accordingly embittered by internal disturbances and revolts, which were aided and fomented by the deposed Christiern, who was at one time very near regaining possession of the Swedish dominions.

He is chosen king of Sweden. A. D. 1523.

Unsuccessful attempt of Christiern.

Christiern having established a powerful interest in Norway, once more made an attempt to recover his kingdoms, and was joined by the Dalecarlians; but being defeated by the Swedish forces, he was compelled to return to Norway, where, being obliged to capitulate with the Danish generals, he was detained in captivity during the remainder of his life.

Unsuccessful negociation for a marriage with Queen Elizabeth. A. D. 1542.

In 1542, Gustavus having happily extricated himself out of all his troubles, prevailed on the states to make the crown hereditary in his family; after which he applied himself to the encouragement of learning and commerce. A treaty was set on foot for a marriage between his eldest son Eric and the princess Elizabeth of England; but this negociation failed of success.

Gustavus dies, and is succeeded by Eric. A. D. 1560.

Gustavus Vasa died in 1560, and was succeeded by his son Eric XIV. The new king was possessed of all the exterior ornaments which gave an air of dignity to the person, but he had neither the prudence nor the penetration, of his father. He created the first nobility that were ever known in Sweden; but this he had no sooner done than he quarrelled with them, by passing some act which they thought derogatory to their honour and dignity. The whole course of his reign was disturbed by wars with Denmark and disputes with his own subjects. In the former he was unfortunate, and towards the latter he behaved with the greatest cruelty. At last, he is said to have become mad. He afterwards recovered his senses, but was soon dethroned by his brothers; one of whom, named John, succeeded him in the kingdom.

Eric deposed, and succeeded by his brother John.

This revolution took place in the year 1568, but with no great advantage to Sweden. Disputes about religion between the king and his brothers, and wars with Russia, threw matters into the utmost confusion. Prince Sigismund, the king's son, was chosen king of Poland, which proved the source of much trouble to the kingdom. In 1590 King John died, and as Sigismund was at a distance, public affairs fell into the utmost confusion; the treasury was plundered, and the royal wardrobe spoiled, even before Duke Charles could come to Stockholm to undertake the administration till King Sigismund should return. This however was far from being the greatest disaster which befell the nation at this time. It was known that the king had embraced the popish religion, and it was with good reason suspected that he would attempt to restore it upon his arrival in Sweden. Sigismund was also obliged, on leaving Poland, to promise that he would remain no longer in Sweden than was necessary to regulate his affairs. These circumstances served to alienate the minds of the Swedes from their sovereign, even before they saw him; and the universal dissatisfaction was increased by seeing him attended on his arrival in Sweden in 1593 by the pope's nuncio, to whom he made a present of 30,000 ducats to defray the expenses of his journey to Sweden.

Prince Sigismund chosen king of Poland. A. D. 1568.

Succeeds to the crown of Sweden. A. D. 1590.

A party formed against him.

What the people had foreseen was too well verified. The king refused to confirm the protestants in their religious privileges, and showed such partiality on all occasions to the papists, that a party was formed against him, at the head of which was Duke Charles, his uncle. Remonstrances, accompanied with threats, took place on both sides. Sigismund was apparently reconciled to his uncle, and promised to comply with the inclinations of the people, though without any inclination to perform what he had promised. The agreement indeed was scarcely made, before Sigismund conceived the horrid design of murdering his uncle at the Italian comedy acted the night after his coronation. The duke, however, having notice of the plot found means to defeat it. This enraged the king so much, that he had resolved to accomplish his designs by force; and he therefore commanded a Polish army to march towards the frontiers of Sweden, where they committed all the ravages that could be expected from an enraged and cruel enemy. Complaints were made by the protestant clergy to the senate; but no other answer was returned than that, till the king's departure, they should abstain from those bitter invectives and reproaches, which had provoked the Catholics, and that during his absence they would be at more liberty.

Forms a design of murdering his uncle.

In 1595 Sigismund set sail for Dantzig, leaving the administration in the hands of Duke Charles. The consequence of this was, that the dissensions which had already taken place being continually increased by the obstinacy of the king, Charles assumed the sovereign power; and in 1604 Sigismund was formally deposed, and his uncle Charles IX. raised to the throne. He proved a wise and brave prince, restoring the tranquillity of the kingdom, and carrying on a war with vigour against Poland and Denmark. He died in 1611, leaving the kingdom to his son, the celebrated Gustavus Adolphus.

Sigismund deposed, and is succeeded by Charles IX. A. D. 1604.

State of Sweden on the accession of Gustavus Adolphus. A. D. 1611.

Though Charles IX. by his wise and vigorous conduct had in some measure retrieved the affairs of Sweden, they were still in a very bad condition. The finances of the kingdom were entirely drained by a series of wars and revolutions; powerful armies were preparing in Denmark, Poland, and Russia, while not only the Swedish troops were inferior in number to their enemies, but the government was destitute of resources for their payment. Though the Swedish laws required that the prince should have attained his eighteenth year before he was of age, yet such striking marks of the great qualities of Gustavus appeared, that he was allowed by the states to assume the administration before this early period. His first act was to resume all the crown-grants, in order that he might be enabled to carry on the wars in which he was engaged, and to fill all places, both civil and military, with persons of merit. At the head of domestic and foreign affairs was placed the chancellor Oxenstiern, a person every way equal to the important trust, and the choosing of whom impressed Europe with the highest opinion of the young monarch's penetration.

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Soon after his accession, Gustavus received an embassy from James I. of Britain, exhorting him to make peace with his neighbours. This was seconded by another from Holland. But as the king perceived that the Danish monarch intended to take every opportunity of crushing him, he resolved to act with such vigour as might convince him that he was not easily to be overcome. Accordingly, he invaded Denmark with three different armies at once; and though the enemy's superiority at sea gave them great advantages, and the number of the king's enemies distracted his attention, he carried on the war with such spirit, that, in 1613, a peace was concluded on terms favourable to himself. This war being finished, Gustavus applied himself to civil polity, and made some reformation in the laws of Sweden. In 1615, hostilities were commenced against Russia, on account of the refusal of that court to repay some money which had been formerly lent. The king entered Ingria, took Kexholm by storm, and was laying siege to Plescov, when, by the mediation of James I., peace was concluded, on condition of the Russians repaying the money, and yielding to Sweden some part of their territory. In this and the former war, notwithstanding the shortness of their duration, Gustavus learned the rudiments of the military art, for which he soon became so famous. He is said to have taken every opportunity of improvement with a quickness of understanding seemingly more than human. In one campaign, he not only learned, but improved, all the military maxims of La Gardie, a celebrated general; brought the Swedish army to a more steady and regular discipline; and formed an invincible body of Finlanders, who had afterwards a very considerable share in the victories of Sweden.

He invades Denmark, and obliges the king to conclude a peace.

Russia invaded with success.

Extraordinary military genius of the king.

Peace was no sooner concluded with Russia, than Gustavus was crowned with great solemnity at Upsala. Soon afterwards he ordered his general La Gardie to acquaint the Polish commander Codekowitz, that as the truce between the two kingdoms, which had been concluded for two years, was now expired, he desired to be certainly informed whether he was to expect peace or war from his master. In the mean time, having borrowed money of the Dutch for the redemption of a town from Denmark, he had an interview on the frontiers with Christiern, the king of that country. At this interview, the two monarchs conceived the utmost esteem and friendship for each other; and Gustavus obtained a promise, that Christiern would not assist Sigismund in any design he might form against Sweden. In the mean time, receiving no satisfactory answer from Poland, Gustavus began to prepare for war. Sigismund entered into a negociation, and made some pretended concessions, with a view to seize Gustavus by treachery; but the latter having some intimation of his design, the whole negociation was changed into reproaches and threats on the part of Gustavus.

Prepares for war with Poland.

Immediately after this, Gustavus made a tour in disguise through Germany, and married Eleonora the daughter of the elector of Brandenburg. He then resolved to enter heartily into a war with Poland; and with this view set sail for Riga with a great fleet, which carried 20,000 men. The place was well fortified, and defended by a body of veterans, enthusiastically attached to Sigismund; but after a vigorous siege, the garrison, being reduced to extremity, were obliged to capitulate, and were treated with great clemency.

Marries a daughter of the elector of Brandenburg.

Riga besieged and taken.

After the reduction of Riga, the Swedish monarch entered Courland, where he reduced Mittau; but ceded it again on the conclusion of a truce for one year. Sigismund, however, no sooner had time to recover himself, than he began to form new enterprises against the Swedes in Prussia; but Gustavus setting sail with his whole fleet for Dantzig, where the king of Poland then resided, so defeated his measures, that he was obliged to prolong the truce for another year. Sigismund was not yet apprised of his danger, and refused to listen to any terms of accommodation: Gustavus entering Livonia, defeated the Polish general, and took Dorpat, Hockenhausen, and several other places of less importance; after which, entering Lithuania, he took the city of Birsen. Notwithstanding this success, Gustavus proposed peace on the same equitable terms as before; but Sigismund was still infatuated with the hopes that, by means of the emperor of Germany, he should be able to conquer Sweden. Gustavus finding him inflexible, resolved to push his good fortune. His generals, Horn and Thurn, defeated the Poles in Semigallia. Gustavus himself, with 150 ships, set sail for Prussia, where he landed at Pillau. This place was immediately surrendered to him, as were several other towns. Sigismund, alarmed at the great progress of Gustavus, sent a body of forces to oppose him, and to prevent Dantzig from falling into his hands. But this measure did not produce any powerful effect; and in May 1627, Gustavus arrived with fresh forces before Dantzig, which he would probably have carried, had he not been severely wounded by a cannon-shot. The states of Holland sent ambassadors to mediate a peace between the two crowns; but Sigismund, depending on the assistance of the emperor of Germany and king of Spain, determined to hearken to no terms, and resolved to make a winter campaign. The king of Sweden was however so well intrenched, and all his forts were so strongly garrisoned, that the utmost efforts of the Poles were to no purpose. The city of Dantzig, in the mean time, made such a desperate resistance as greatly irritated him. In a sea engagement the Swedish fleet defeated that of the enemy; after which Gustavus, having blocked up the harbour with his fleet, pushed his advances on the land side with incredible vigour. He made a surprising march over a morass fifteen miles broad, assisted by bridges of a peculiar construction, over which he carried a species of light cannon invented by himself. By this unexpected manœuvre he obtained the command of the city in such a manner, that the garrison were on the point of surrendering, when, by a sudden swell of the Vistula, the Swedish works were destroyed, and the king was obliged to raise the siege. In other respects, however, the affairs of Gustavus proceeded with their usual good fortune. His general Wrangel defeated the Poles before Brodnitz. At Stum the king gained another and more considerable victory in person. The emperor had sent 5000 foot and 2000 horse under Arnheim, who joined the main army commanded by the Polish general Coniecspolski, in order to attack the Swedish army encamped at Quidzin. The enemy were so much superior in number, that the friends of Gustavus warmly dissuaded him from attacking them. But the resolution of the king was not to be shaken, and the engagement commenced. The Swedish cavalry charged with such impetuosity, contrary to their sovereign's express order, that they were almost surrounded by the enemy; but, coming up to their assistance, he pushed the enemy's infantry with so much vigour, that they gave way, and retreated to a bridge that had been thrown over the Werder. But here they were disappointed, for the Swedes had already taken possession of the bridge. A new action ensued, more bloody than the former, in which the king was exposed to great danger, and thrice narrowly escaped being taken prisoner; but at last the Poles were totally defeated, and with immense loss. The slaughter of the German auxiliaries was so great, that Arnheim scarcely carried off one half of the troops which he brought into the field. This defeat did not hinder the Polish general from attempting the siege of Stum; but here he was as unsuccessful as in his previous enterprises. Arnheim was recalled, and was succeeded by Henry of Saxe-Lauenburg and Philip Count Mansfeldt. The change of general officers, however, produced no good consequences to the Poles; a famine and plague raged in their camp, so that they were at last obliged to consent to a truce for six years, to expire in the month of June 1635.

History.

The Poles defeated.

The Poles defeated a third time. A. D. 1627.

The Poles defeated by sea, and Dantzig invested.

The king obliged by an inundation of the Vistula to raise the siege.

The Poles and Germans defeated with great slaughter in two engagements.

They are again defeated, and obliged to consent to a truce of six years.

History.

Gustavus kept the port and citadel of Memel, the harbour of Pillau, the towns of Elbing, Brunsberg, and all that he had conquered in Livonia.

Gustavus resolves on a war with the emperor.

Gustavus having thus brought the war with Poland to an honourable conclusion, began to think of resenting the conduct of the emperor in assisting his enemies and oppressing the protestant states. Before embarking in such an important undertaking, it was necessary that he should consult the diet. Here the propriety of engaging in a war with Germany was warmly debated; but, after much altercation, the king, in a very noble speech, determined the matter, having declared in such strong terms the virtuous motives by which he was actuated, that the whole assembly wept, and every thing was granted which he could require.

It was not difficult for him to begin his expedition. His troops amounted to 60,000 men, hardened by a succession of severe campaigns in Russia, Finland, Livonia, and Prussia. His fleet exceeded seventy sail, carrying from twenty to forty guns, and manned with 6000 seamen. Embarking his troops, he landed at Usedom on the 24th of June 1630, the Imperialists having evacuated all the fortresses which they there possessed; and the isle of Rugen had been before reduced by General Lesley, in order to secure a retreat if fortune should prove unfavourable. Passing the strait, Gustavus stormed Wolgast, and another strong fortress in the neighbourhood, leaving a garrison for the defence of these conquests. He then proceeded to Stettin, which consented to receive a Swedish garrison, and the king persuaded the duke of Pomerania to enter into an alliance with him. In consequence of this the Swedish troops were received into several towns of Pomerania; and the most bitter enmity took place between the Imperialists and Pomeranians.

Reduces Wolgast, Stettin, &c. A. D. 1630.

These successes of Gustavus struck the empire with consternation; for, being already overwhelmed with civil dissensions, they were in no condition to resist so impetuous an enemy. At last Count Tilly was invested with the dignity of field-marshal. In the mean time, the king, being reinforced by a considerable body of troops in Finland and Livonia under the conduct of Gustavus Horn, defeated the Imperialists before Griffenhagen, and soon afterwards took the place by assault. By this and some other conquests, he opened a passage into Lusatia and Silesia; but in the mean time Tilly cut off 2000 Swedes at New Brandenburg. This advantage, however, was soon overbalanced by the conquest of Frankfurt on the Oder, which Gustavus took by assault, making the whole garrison prisoners. Thus he commanded the rivers Elbe and Oder on both sides, and had a fair passage, not only to the countries already mentioned, but also to Saxony and the hereditary dominions of the house of Austria. He soon afterwards laid siege to Landsberg, which he took by assault.

Count Tilly the emperor's general.

Cuts off 2000 Swedes.

Frankfurt and Landsberg taken by Gustavus.

About this time the protestant princes held a diet at Leipzig, to which Gustavus sent deputies, and conducted his negociations with such address as tended greatly to promote his interests. Immediately after this he reduced Greifswald, and with it all Pomerania. Having then marched to Gustrow, he restored the dukes of Mecklenburg to their dominions.

He reduces Pomerania, and restores the dukes of Mecklenburg.

All this time Tilly was employed in the siege of Magdeburg; but being alarmed at the repeated successes of the Swedes, he now left Pappenheim with part of the army before that city, while he marched with the rest into Thuringia, to attack the landgrave of Hesse-Cassel and the elector of Saxony. After a most obstinate defence, Magdeburg fell into the hands of Pappenheim, who committed all imaginable cruelties. The king formed a plan of recovering the city; but was obliged to abandon it, by Pappenheim's throwing himself into the place with his whole army, and by the progress which Tilly was making in Thuringia. Relinquishing this enterprise, he ordered an attack on Havelsburg; which was conducted with such resolution, that the place was forced in a few hours, and all the garrison made prisoners. Werben was next obliged to submit after an obstinate conflict, in which many fell on both sides. These successes obliged Tilly to attempt in person to check the progress of the Swedes. He detached the vanguard of his army, composed of the flower of the Imperial cavalry, within a few miles of the Swedish camp. An action ensued, in which Bernstein the Imperial general was defeated and killed, with 1500 of his men. Gustavus, after this advantage, placed himself in a situation so much superior to that of his enemies, that Tilly was fired with indignation, and marched up to the Swedish lines to give him battle. The king kept within his works, and Tilly attacked his camp, though almost impregnably fortified, and maintained a most terrible fire from a battery of thirty-two pieces of cannon; which, however, produced no other effect than obliging the Swedish monarch to draw up his army behind the walls of Werben. Tilly had placed his chief hopes in being able to spike the enemy's cannon, or set fire to their camp; after which he proposed making his grand attack. With this view he bribed some prisoners; but they betrayed him, and communicated his design to Gustavus. The king ordered fires to be lighted in different parts of his camp, and his soldiers to imitate the noise of a tumultuous disorderly rabble. This had the desired effect. The count led his army to the breach made by the cannon, where he was received with such a volley of grape-shot as cut off the first line, and put the whole body in disorder, so that they could never be brought back to the charge. In this confusion the Imperial army was attacked, and after an obstinate conflict obliged to quit the field.

Magdeburg taken by the Imperialists, and the inhabitants cruelly used.

History.

Havelsburg and Werben reduced, and the cavalry of the Imperialists defeated by the Swedes.

Count Tilly defeated by Gustavus.

Soon after this action the queen arrived at the camp with a reinforcement of 8000 men; at the same time a treaty was concluded with Charles I. of England, by which that monarch allowed the marquis of Hamilton to raise 6000 men for the service of Gustavus. These auxiliaries were to be conducted to the main army by a body of 4000 Swedes; and were in every thing to obey the king while he was personally present, but in his absence were to be subject to the orders of the marquis. With these troops the king had resolved to make a diversion in Bremen; but the marquis finding it impossible to effect a junction with the Swedish army, resolved, without debarking his troops, to steer his course for the Oder, and land at Usedom. Gustavus was very much displeased at finding his project thus disconcerted; but making the best of the present circumstances, he commanded the British troops to act on the Oder instead of the Weser. The number of this little army was magnified exceedingly by report, insomuch that Tilly had some thoughts of marching against them with his whole force; but on the departure of the marquis for Silesia, he reinforced the army in that country with a large detachment, which was thought to contribute not a little to the defeat which he soon after received.

A body of British soldiers comes to the assistance of the Swedes.

Since the late action Gustavus had kept within his intrenchments, where his army was well supplied with provisions and stores. Tilly made several attempts to surprise or draw him to an engagement; but finding all his endeavours fruitless, he marched into Saxony, and laid siege to Leipzig. This precipitate measure proved highly advantageous to the Swedish monarch. A treaty offensive and defensive was immediately concluded with Gustavus; and the elector willingly promised every thing that was required of him. Tilly, in the mean time, carried fire and sword into the electorate. At the head of an army of 44,000 veterans, he summoned the city of Leipzig to surrender; denouncing, in case of a refusal, the same vengeance against it as had been executed on Magdeburg. The governor was so much intimidated, that he instantly submitted; and he also surrendered the castle of Passenberg, which was in a

Saxony ravaged by Count Tilly, who takes Leipzig.

History.

condition to have resisted till the arrival of the Swedish army. The elector, enraged at the loss of these valuable places, ordered his army to join the Swedes with all expedition, and pressed the king so warmly to engage, that at last he yielded to his desire. On the 7th of September 1631, Gustavus led out his army in the finest order, the Swedes forming one column on the right, and the Saxons another on the left; each amounting to 15,000 men. Tilly drew up his men in one vast column, probably with a view of surrounding the flanks of the king's army. The king led his troops against that wing of the Imperialists commanded by Pappenheim, whom he drove back to a considerable distance. General Bannier in the mean time cut in pieces the troops of Holstein, and mortally wounded the duke, who commanded them. Pappenheim conducted his troops seven times to the charge, but was as often repulsed by the Swedes. Tilly all this while was engaged with the Saxons; but having at last driven them off the field, the whole strength of the Imperial army was turned against the Swedish left wing. The Swedes sustained the attack with the greatest firmness, until the king detached the centre to assist them. The Imperialists then were no longer able to maintain their ground; but gave way everywhere except in the centre, which was composed of eighteen regiments of veterans accustomed to victory, and deemed invincible. They made incredible efforts to maintain their reputation; and, though swept off in great numbers by the Swedish artillery, never shrunk or fell into confusion. Four regiments, after their officers had been killed, formed themselves, and withdrew to the skirt of a wood. Tilly retired at the head of 600 men, and escaped by the coming on of the night. Seven thousand Imperialists lay dead on the field of battle; 4000 were taken prisoners; a fine train of artillery was lost, with upwards of 100 standards, ensigns, and other military trophies.

Battle of Leipzig. A. D. 1631.

The Imperialists defeated with great slaughter.

Gustavus now determined to penetrate into Franconia, where he reduced several places, especially the fortress of Würzburg. Tilly having collected his scattered troops, which formed an army still superior in number to that of Gustavus, marched to the relief of this place, but came too late. He then directed his march towards Rottenberg, where four regiments were cut in pieces by a Swedish detachment. After this, the king reduced Hanau, Frankfurt on the Maine, and Mentz, having destroyed a body of Spaniards who had attempted to obstruct his passage.

The Swedes take a number of towns, and cut off four regiments of the enemy.

The court of Vienna was now thrown into the utmost confusion, and sent everywhere begging assistance, and soliciting the Catholic princes to arm in defence of their religion. The emperor was most embarrassed in finding a general capable of opposing Gustavus in the field; for the late misfortunes of Count Tilly had entirely sunk his reputation. Wallenstein, an old experienced officer, was selected; but as he had formerly been disgraced, it was apprehended that he would not accept of the command of which he had once been deprived. This objection however was surmounted; and Wallenstein not only accepted of the command, but, at his own expense, augmented the army to 40,000 men.

Wallenstein chosen general by the emperor.

During the whole winter the Swedish army kept the field, and before the approach of summer had reduced a great number of places, while the landgrave William made great progress in Westphalia. Gustavus Horn was repulsed before Bamberg, but soon had his revenge, by entirely destroying two regiments of Imperialists. To prevent the troops from being affected by the loss before Bamberg, the king resolved to give battle to Tilly, who was marching into Bavaria to prevent the Swedes from gaining a footing in that electorate. He pursued the Imperial general through a vast tract of country, defeated his rearguard, and having reduced a variety of towns and fortresses on the Danube, penetrated as far as Ulm. Advancing to the river Leck, the count posted himself in a wood on the opposite side, to dispute his passage. Gustavus endeavoured to dislodge him by a regular fire from seventy pieces of cannon. The slaughter was dreadful; and Tilly himself, being wounded by a cannon-ball in the knee, died a few days before he was to have been superseded by Wallenstein. The following night the Imperial army evacuated the post. Gustavus immediately crossed the river, and seized the towns of Rain and Neuburg, which the enemy had abandoned, and Augsburg next submitted. From Augsburg the Swedes advanced towards Ratisbon, but were disappointed in their design of obtaining possession of that city, as the Bavarians had thrown a numerous garrison into the place. In the mean time, ambassadors arrived from Denmark, offering the mediation of that crown for obtaining a lasting peace between the contending parties. This negociation however failed of success, as the ambassadors had not been instructed to offer terms favourable to the protestants. Gustavus, now resolving to retort on themselves the cruelties which the Bavarians had inflicted on the protestants, laid the towns of Morzburg, Friesengen, and Landshut, in ashes. The inhabitants of Munich saved themselves by submission. Gustavus also defeated the forces of the elector, who had been joined by a considerable body of militia.

A great number of towns taken by the Swedes.

Count Tilly defeated and killed.

Three towns laid in ashes by the Swedes.

While the king was thus employed, Wallenstein had assembled a very numerous army. He was strongly solicited by the elector of Bavaria to come to his assistance; but, in revenge of the elector's having formerly obtained the command for Tilly in preference to himself, he drew off towards Bohemia to encounter the Saxons. Arnheim, who commanded the Saxon forces in that place, was an enemy to Gustavus, who had formerly rallied him for his cowardice. He therefore permitted Wallenstein to gain an easy victory, in hopes that his master, the elector of Saxony, a prince entirely devoted to his pleasures, might be induced to relinquish the friendship of such a restless and warlike ally as Gustavus; and indeed he used all the eloquence of which he was master to detach him from the Swedish cause. Several advantages were in the mean time gained by the Imperialists. Pappenheim defeated the archbishop of Bremen's cavalry at Werden; and three Swedish regiments were cut off near Kadingen. Pappenheim was however forced to retire, and to withdraw his forces from Stade, of which the Swedes took possession. Wallenstein and the elector of Bavaria, who had now joined their forces, threatened Gustavus with greatly superior numbers. The king, being reinforced with 15,000 men, no longer declined the engagement; but Wallenstein was too wise to trust the fate of the empire to a single battle against such an enemy as the king of Sweden. Gustavus attacked his camp, but was repulsed with the loss of 2000 men. Several other misfortunes happened to the Swedes; and at last, after various manœuvres, Wallenstein directed his course towards Misnia, in order to oblige the elector of Saxony to declare against the Swedes, and to draw them out of Bavaria. Gustavus, notwithstanding the inconstancy of Augustus, immediately set out to assist him. With incredible diligence he marched to Misnia, where the Imperialists were assembling their whole strength. Hearing that the enemy were encamped at Weissenfels, and that Pappenheim had been detached with a strong corps, Gustavus resolved to engage them before they could effect a junction. With this view he marched to Lützen, where he attacked Wallenstein with incredible fury. The Swedish infantry broke the Imperialists in spite of their utmost efforts, and took all their artillery. The cavalry not being able to pass the river so expeditiously as the king thought necessary, he led the way, attended only by a single regiment and the duke of Saxe-Lauenburg. Here, after charging impetuously, he was killed. The news of his death was in an instant spread

The Saxon troops defeated by Wallenstein.

Gustavus attacks his camp, and is repulsed with loss.

Battle of Lützen.

Gustavus killed.

over both armies. The courage of the Imperialists revived, and they now made themselves sure of victory. But the Swedes, eager to revenge the death of their beloved monarch, charged with such fury that nothing could resist them. The Imperialists were defeated a second time, just as Pappenheim, with his fresh corps, came up to their assistance. On this the battle was renewed, but the Swedes were still irresistible. Pappenheim was mortally wounded, and his army finally routed, with the loss of 9000 killed in the field and in the pursuit.

The Imperialists totally defeated.

Christina, an infant, proclaimed queen of Sweden.

This victory proved more unfortunate to Sweden than the greatest defeat. The crown devolved on Christina, the daughter of Gustavus, an infant of six years old; the nation was engaged in an expensive foreign war, without any person equal to the arduous task of commanding the armies, or regulating domestic affairs, as Gustavus had done. Christina was immediately proclaimed queen. The regency devolved on the grand bailiff, the marshal, the high admiral, the chancellor, and the treasurer of the crown. Oxenstiern was invested with the chief management of affairs, and conducted himself with the greatest prudence. The reign and character of Christina have been detailed under the article Christina, to which we may refer our readers.

Charles Gustavus appointed heir to the crown of Sweden.

From the treaty of Westphalia, Sweden enjoyed some years of repose. Charles Gustavus, Count Palatine, having gained the favour of Christina, was appointed generalissimo of the forces, and heir-apparent to the crown. A marriage was proposed between them; but the queen would never listen to this or any other proposal of the kind. In 1650, the ceremony of the queen's coronation was performed; but in four years after, she resigned the crown in favour of Charles.

A. D. 1654.

State of Sweden on the accession of Charles X.

The new king found himself involved in considerable difficulties on his accession to the throne. The treasury was quite exhausted; great part of the revenue was appointed for the support of Christina's household; the people were oppressed with taxes; and the nation having been disarmed for several years, began to lose its reputation among foreigners. To remedy these evils, Charles proposed to resume all the crown-lands which had been alienated by grants to favourites during the late reign; to repeal a duty which had been imposed on salt; to put the kingdom in a posture of defence; and to enter on a war with some neighbouring state. Under a pretence that Casimir king of Poland had questioned his title to the throne, he prepared to invade that kingdom. Several embassies were sent from Poland to Stockholm; but some point of ceremony always disappointed them of an audience of the king, so that they were obliged to return without executing their commission. As soon as matters were in readiness, General Wittemberg made an irruption into Poland from the side of Pomerania. The Poles opposed him with an army of 15,000 men; but instead of fighting, they began to negociate, and in a short time entirely dispersed. Charles himself soon followed with a powerful army, and pursued his march without obstruction, all the cities throwing open their gates to him as he approached. As he advanced to Cracow, Casimir resolved to make one effort to save his capital. His army amounted only to 10,000 men; and these were unfortunately such as had never stood fire. After a feeble resistance, they fled with precipitation, having lost 1000 men killed and taken prisoners. A few days after this Charles defeated the Poles a second time, about eight leagues from Cracow; on which Casimir fled with his family to Oppeln in Silesia. The capital was then invested, and, though defended with the utmost valour, was in a short time obliged to capitulate. Thus in less than three months Charles apparently became master of Poland; but it was soon evident that the Poles had no intention of abandoning their former sovereign.

War with Poland resolved on.

The Poles defeated, and the kingdom reduced.

In 1656, a war took place with the elector of Brandenburg. While Charles was employed in the conquest of Poland, that prince had invaded Royal and Ducal Prussia, and reduced the most considerable towns with little opposition. The king of Sweden took umbrage at his progress; and having marched against him, defeated his forces in several slight encounters, and obliged him to acknowledge himself a vassal of Sweden. These rapid conquests alarmed all Europe; and the different powers sought for means of driving the Swedes out of Poland, which they had so unexpectedly and unjustly seized. The Poles were no sooner assured that they should obtain assistance, than they everywhere revolted and massacred the Swedes. Casimir returned from Silesia; and those very troops and generals who had before submitted to Charles without opposition, now ranged themselves under the banners of his antagonist. Charles immediately marched from Prussia to chastise the insolence of the Poles, and totally defeated a body of 12,000 men. This event did not hinder all the Poles incorporated with his troops to desert. Their defection considerably reduced his army; and the campaign being performed in the depth of winter, he was at last obliged to retreat to Prussia. In his march he was harassed by the Poles; and a body of 4000 Swedes was surprised and defeated by them at Warka. This loss however was soon after recompensed by a complete victory gained by Adolphus the king's brother, and General Wrangel. In the mean time the king was taking measures for laying siege to Dantzig; but was prevented by the Dutch, who threatened to oppose him, unless a proper regard was paid to their interest. Charles accordingly granted them advantageous terms; and afterwards gained over the elector of Brandenburg, by ceding to him the sovereignty of Prussia, that he might be at liberty to turn his whole strength against Poland.

War with the elector of Brandenburg.

A. D. 1656.

The Poles revolt.

Charles gains a victory, but is obliged to retire.

Concludes a treaty with the Dutch and the elector of Brandenburg.

By the treaty just concluded with the elector, the latter was to assist Charles in his war with Poland; but the elector was so tardy in his measures, that the Poles, having obtained assistance from the Tartars, had reduced the city of Warsaw. The two princes now marched in concert against their enemies, who were encamped in a strong situation in the neighbourhood of the city above mentioned, their camp being fronted by the Vistula. The Poles were driven from their intrenchments with prodigious slaughter. The Poles and Tartars then laboured to break the alliance; and with which view, having entered Ducal Prussia, they defeated the electoral army, and took many prisoners. The Swedes soon obtained their revenge. General Steinboek attacked the same Polish army at Philippowa, and overthrew it with such slaughter as obliged the Poles for that season to quit the field. A more formidable enemy than the Poles now began to make their appearance. The Russians invaded the provinces of Carelia, Ingermania, and Livonia; while the elector of Brandenburg began to waver in his fidelity. To preserve this only ally at such a critical juncture, Charles was obliged to grant him more advantageous terms than those already mentioned; and the Russians were repulsed in the provinces of Carelia and Ingermania. But in Livonia they had better success. For seven months, however, they battered the walls of Riga, without venturing to pass the ditch or storm the practicable breaches.

The Poles and Tartars defeated with great slaughter.

The Russians invade the Swedish dominions.

Charles, notwithstanding the number of his enemies, was now become so formidable by the valour and discipline of his troops, that entire armies often fled on his approach. At last, in 1657, the Poles, finding they could not resist him in the field, contented themselves with harassing the Swedes on their march, and cutting off the foragers and convoys. This proved much more destructive to the Swedes than their former method; so that Charles was obliged to enter into an alliance with Ragotski, prince of Transylvania, by assigning him certain provinces in his neighbourhood, in order to furnish himself with irregular troops, who might fight the Poles in their own way. He did not thus obtain any real advantage; for the confederates, after wasting a whole

A. D. 1657.

Charles enters into an alliance with Ragotski, prince of Transylvania.

History.

campaign in Lithuania, were obliged to retire without accomplishing more than the reduction of a single fortress. Charles then returned with the Swedish army to Prussia.

Leopold king of Hungary declares against Sweden.

Leopold, the young king of Hungary, having long beheld the Swedes with a jealous eye, now resolved to declare for Poland. The more effectually to curb the ambition of the Swedish monarch, he solicited the king of Denmark to come to a rupture with him. This application was attended with immediate success, and the Danes invaded Bremen.

Ragotski's army destroyed by the Poles and Tartars.

Charles hastened to oppose this new enemy, and he thus gave great offence to Ragotski, who, by neglecting to take the proper measures for his own defence in the absence of the Swedes, suffered his army to be destroyed by the Poles and Tartars. At the same time the Turks invaded Transylvania, under pretence that Ragotski, being a vassal of the grand signior, had no right to invade Poland without his permission. Ragotski, opposing them in the field, was defeated and killed, leaving Charles destitute of the only ally on whom he could depend.

He is defeated and killed by the Turks.

The king, however, not dismayed by this misfortune, traversed Pomerania and the duchy of Mecklenburg; after which he attacked Holstein, while General Wrangel with another corps entered the duchy of Bremen. The general executed his measures with the utmost vigour. In fifteen days he retook all the towns which the enemy had reduced; defeated and drove the Danish army out of the country, killing 3000 of their best soldiers. In Holstein the king reduced several fortresses, laid Itzehoe in ashes, defeated a body of Danes, and laid siege to Frederic Udda, into which the Danes had thrown a strong garrison. Leaving to Wrangel the conduct of this siege, he himself retired to Wismar in order to observe the situation of affairs in Poland; and no sooner was he departed than Wrangel attacked the place with such fury, that he became master of it in two hours. In the province of Halland the Swedes were defeated, but the enemy derived no advantage from their victory. At sea the fleets met, and maintained an engagement for two days, without any considerable advantage on either side. In Poland affairs were not better conducted. The house of Austria had now declared for Casimir; and a German army having entered Poland, reduced Cracow, though not without sustaining great loss.

Bravery and success of General Wrangel.

The house of Austria declares against Sweden.

The king of Sweden was now surrounded by enemies. The elector of Brandenburg had declared against him; and he had besides to engage the armies of Austria, Poland, Russia, and Denmark. In this dangerous situation he resolved to attack Denmark, so as to oblige that state to come to a speedy accommodation. His designs were forwarded by a very early frost, which enabled him to transport his troops without shipping. Having marched over the ice to the island of Funen, he cut in pieces a body of 4000 Danish soldiers and 500 peasants. The whole island was reduced in a few days; after which he passed to Langland, then to Laaland, after that to Falster, and lastly to Zealand. The Danes were terrified at this unexpected invasion, and were resigning themselves to despair, when Charles offered to conclude a peace on equitable terms. The king of Denmark gladly consented, intending to renew the war as soon as he thought it could be done with safety.

Charles invades Denmark with great success.

Peace concluded. A. D. 1658.

Charles was no sooner retired, than the king of Denmark began to act secretly against him; on which, resolving to anticipate him in his designs, he appeared unexpectedly with a fleet before Copenhagen. The Swedish monarch laid siege to the capital, but with so little prudence that he made no progress, and was at length compelled to turn the siege into a blockade, which continued to the end of the war. Charles X. died of an epidemic fever, and was succeeded by his son Charles XI.

The war renewed, and Copenhagen besieged.

Charles XI. A. D. 1660.

The new king, Charles XI. was a minor at the time of his father's death; and as the kingdom was involved in a dangerous war with so many enemies, the regency determined to conclude a peace, if it could be obtained on reasonable terms. A treaty was accordingly concluded at Olivia, by which Casimir renounced his pretensions to the crown of Poland, and that state gave up all pretensions to Livonia. Bornholm and Drontheim were ceded to Denmark, and an equivalent in Schonen remained with Sweden. During the minority of the king, nothing remarkable occurs in the history of Sweden. In 1672 he entered into alliance with Louis XIV. which two years after involved him in a war with the elector of Brandenburg. At first the Swedes carried all before them. Almost all the towns in Brandenburg were reduced, when the elector arrived with an army to the relief of his distressed subjects. He retook several towns, defeated the Swedes in a general engagement, and soon after forced them to abandon all their conquests. In conjunction with the Danes, he then invaded the Swedish dominions: many places of importance were reduced; and, in 1676, Sweden received a most destructive blow by the defeat of her fleet in an engagement with the combined fleets of Denmark and Holland. The king soon afterwards took the government into his own hands, and in some degree restored the fortune of Sweden; but although he was more successful where he commanded in person, the same losses and disgrace attended the Swedish arms in every other quarter. In 1678, the Swedish fleet was defeated in two engagements. At Landscrona a most obstinate battle was fought, from ten in the morning till six at night, when both parties were obliged, by fatigue, to retire to their respective camps. At Oldeval, in Norway, the Swedes were defeated; and the Danes laid desolate the islands of Oeland, Smaaland, Unno, and Kuno; while the electoral troops and Imperialists reduced Count Königsmark to the utmost distress in the neighbourhood of Stralsund. In this deplorable situation of affairs Königsmark found an opportunity of attacking his enemies to such advantage, that he obtained a complete victory; after which he ravaged the duchy of Mecklenburg. Notwithstanding this success, he could not prevent the elector from reducing Stralsund. He was afterwards obliged to evacuate Pomerania; and, to complete his distress, the fleet which transported the Swedish army from Pomerania was wrecked on the coast of Bornholm.

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Treaty of Olivia.

War with Brandenburg.

The Swedes defeated by land and sea.

A. D. 1676.

At this unprosperous crisis a peace was concluded at St Germains between France and her enemies, by which the Swedes and Danes were left to decide their quarrel between themselves. Denmark was by no means a match for Sweden, even in the distressed situation to which she was reduced; and a treaty was therefore concluded, on terms much more favourable to Sweden than could have been expected. The peace was confirmed by a marriage between Charles, and Ulrica Eleonora, daughter to the king of Denmark. From this time the Swedish monarch applied himself to the reformation of the state; and by artfully managing the disputes between the nobility and the peasants, he obtained a decree empowering him to alter the constitution as he pleased. The proceedings of the king after this decree were such as to exasperate the nobility, and produce violent commotions.

Peace concluded.

Charles becomes absolute.

On the 15th of April 1697, died Charles XI. leaving his crown to his son, the celebrated Charles XII. at that time a minor. On his accession, he found himself under the tuition of his grandmother Eleonora, who had governed the kingdom during the minority of the late king. Though Charles was at that time only fifteen years of age, he showed a desire of taking the government into his own hands. His counsellors, Count Piper and Axel Sparre, signified his desire to the queen-regent. By her they were referred to the states, and there all were unanimous; so that the queen, finding that opposition would be vain, resigned her power with a good grace; and Charles was invested with absolute authority in three days after he had expressed his desire of

Charles XI. dies, and is succeeded by his son Charles XII.

reigning alone. He was scarcely seated on the throne when a powerful combination was formed against him.

A powerful combination formed against him.

Augustus king of Poland formed designs on Livonia; the king of Denmark revived his disputes with the duke of Holstein, as a prelude to a war with Sweden; and Peter the Great of Russia began to form designs on Ingria, formerly a province of Russia.

Holstein ravaged by the Danes. A. D. 1699.

In 1699 the king of Denmark marched an army into Holstein. Charles sent a considerable body of troops to the duke's assistance; but before their arrival the Danes had ravaged the country, taken the castle of Gottorp, and laid close siege to Tonningen. Here the king of Denmark commanded in person, and was assisted by the troops of Saxony, Brandenburg, Wolfenbuttel, and Hesse-Cassel. Britain and Holland, as guarantees of the last treaty with Denmark, in concert with Sweden, joined Charles against this confederacy, and sent fleets to the Baltic. They proposed a termination of the war on equitable terms; but these were haughtily refused by the Danish monarch, who despised the youth and inexperience of Charles, and relied too much on the alliance which he had formed with Saxony, Brandenburg, Poland, and Russia.

They are repulsed at Tonningen.

Tonningen, however, resisted all his efforts; and when he ordered the place to be stormed, he had the mortification to see his troops driven headlong from the walls by a handful of Swedes.

Charles defeats the fleet of the allies. A. D. 1700.

In the year 1700, Charles, having intrusted the affairs of the nation with a council chosen out of the senate, set out on the 8th May from his capital, to which he never afterwards returned. He embarked at Carlscrona, and defeated the fleet of the allies. Having made a descent on the island of Zealand, he defeated a body of cavalry that opposed his march, and then proceeded to invest Copenhagen by sea and land. The king of Denmark saw the necessity of either having his capital destroyed, or of doing justice to the duke of Holstein.

Obliges the Danes to make peace.

He chose the latter; and a treaty was concluded on much the same terms as formerly. Charles, being thus at liberty to turn his arms against the other princes who had conspired his destruction, resolved to lead his army against Augustus king of Poland.

Marches against the Russians.

On the road, however, he received intelligence that the czar of Russia was on his march to oppose him, and had laid siege to Narva with an army of 100,000 men. The contest that ensued between Charles and Peter, with the celebrated battles of Narva and Pultava, have been already related under Russia, so that we shall here confine ourselves chiefly to those events in which Peter the Great was not immediately concerned. Peter was the chief support of Augustus, and he took the most active measures to oppose the progress of the Swedish monarch. His want of success, and the subsequent contests between him and Charles, till the decisive battles of Pultava, are related in the same article.

Charles marches against the Saxons, A. D. 1701,

In 1701, as early as the season permitted, Charles, having received a reinforcement from Sweden, took the field, and appeared suddenly on the banks of the Duna, along which the Saxon army was posted to receive him. The king of Poland being at that time sick, the army was commanded by Ferdinand duke of Courland, Marshal Stenau, and General Paykel, all officers of valour and experience. They had fortified some islands in the mouth of the river, and taken every other precaution against an attack; the soldiers were hardy, well disciplined, and nearly equal to the Swedes in number;

and entirely defeats them.

yet Charles, having passed the river in boats with high sides, to screen the men from the fire of the enemy, attacked them with such fury, that they were entirely defeated, and with great loss. This victory was followed by the surrender of all the towns and fortresses in the duchy of Courland. Charles then passed into Lithuania, where every town opened its gates to him. At Birsen, an army of 20,000 Russians retired with the utmost precipitation on the news of his approach.

Forms a scheme for dethroning Augustus.

Here Charles, perceiving that the kingdom of Poland was greatly disaffected to Augustus, began to project the scheme of dethroning him by means of his own subjects. This scheme he executed with more policy than he ever showed on any other occasion.

Augustus, in the mean time, finding his scheme of peace frustrated, had recourse to the senate; but met with such a rough answer from them, that he determined to apply to Charles. To him therefore he sent his chamberlain; but a passport being forgotten, the ambassador was arrested.

Warsaw taken.

Charles continued his march to Warsaw, which surrendered on the first summons; but the citadel held out for some days. Augustus, finding at last that no dependence was to be placed on the Poles, determined to trust his fortune wholly to the Saxon army and the nobility of the palatinate of Cracow, who offered to support him to the utmost of their power. The Saxon army had now advanced to the frontiers, and Augustus immediately put himself at its head. Being joined by the nobility of Cracow, he found that his forces amounted to 30,000 men, all brave and well disciplined. With these he marched in quest of his enemy; nor did the Swedish monarch decline the combat, though he had with him only 12,000 men.

The Saxons entirely defeated.

Though the Saxons were strongly posted, having their front covered by a morass, besides being fortified with pallisadoes and chevaux de frise, they were attacked with irresistible impetuosity, and entirely defeated.

Cracow taken.

This victory was followed by the loss of Cracow. Charles then set out in pursuit of the flying army, with a design of preventing them from re-assembling; but his horse falling under him, he had the misfortune to break his thigh, by which he was confined six weeks, and thus Augustus obtained some respite. He improved this interval. Having convoked a diet, first at Marienburg, and then at Lublin, he obtained the following resolutions; that an army of 50,000 men should be raised by the republic for the service of the prince; that six weeks should be allowed the Swedes to determine whether they were for war or peace; and that the same time should be granted to the turbulent and discontented nobles of Poland to make their concessions.

Remains of the Saxon army entirely defeated. A. D. 1704.

To counteract the effects of these resolutions, Charles assembled another diet at Warsaw; and while the two assemblies disputed concerning their rights and privileges, he recovered from his wound, received a strong reinforcement from Pomerania, and utterly defeated and dispersed the remains of the Saxon army.

Augustus deposed, and Stanislas raised to the throne.

The ill fortune of Augustus continued still to prevail. In 1704 he was formally deposed by the diet, and the crown was conferred by Charles on Stanislas Lecsinsky, palatine of Posnania. Augustus however did not yet tamely relinquish his kingdom.

Warsaw retaken by Augustus.

His adherents daily skirmished with the Swedes; and Augustus himself, being reinforced by 9000 Russians, retook Warsaw, and had nearly surprised the new king, who lived in perfect security in the city while Charles fought his battles. Count Horn, with 1500 Swedes, vigorously defended the citadel; but at last, finding it no longer tenable, he was obliged to surrender at discretion. The reduction of Warsaw was among the last advantages gained by Augustus in the course of this war. His troops were now composed of Saxon recruits and undisciplined Poles, who had no attachment to his person, and were ready on all occasions to forsake him. Charles and Stanislas advanced with the victorious army; the Saxons fled before them, and the towns several miles round tendered their submission.

Excellent conduct of his general Schullemberg.

The Poles and Saxons were under the command of Schullemberg, a most sagacious and experienced general, who used every expedient to check the progress of the Swedes. With all his conduct and caution he found himself outwitted, and Charles in the neighbourhood of his camp, ready to fall on him, while he thought him at fifty leagues distance.

His engagement with the Swedes.

The Swedish monarch attacked him with a superior army, but entirely composed of horse. Schullemberg had posted his men in such a manner as rendered it impossible to surround them. His first rank, being armed with pikes and muskets, presented a rampart of bayonets; the

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second line, stooping over the first, who kneeled, fired over their heads; while the third rank, who stood upon their feet, kept up an incessant fire, by which the Swedish horse were exceedingly galled and put in disorder. Charles lost the opportunity of cutting off the whole Saxon army, by omitting to order his men to dismount. This was almost the first time that infantry had been regularly opposed to cavalry, and the superiority of the former was evident. After the engagement had continued about three hours, the Saxons retreated in good order; which no enemy had ever done before in any engagement with Charles. The Swedes pursued their enemies towards the Oder, and forced them to retreat through thick woods, almost impervious even to infantry. The Swedish horse, however, pushed their way, and at last enclosed Schullemberg between a wood and the river, where Charles had no doubt of obliging him to surrender at discretion, or die sword in hand, as having neither boats nor bridges; but the genius of Schullemberg supplied every defect. In the night he ordered planks and floats of trees to be fastened together, on which he carried over his troops, while the Swedes were employed in dislodging 300 men, whom he had placed in a wind-mill for the purpose of defending his flank, and diverting the attention of the enemy. Charles spoke of this retreat with admiration, and said he had been conquered by Schullemberg.

His fine retreat.

Augustus leaves Poland.

No material advantage however resulted to Augustus, who was again obliged to leave Poland, and fortify the capital of his hereditary dominions, which he expected every moment to see invested. In the mean time, the Russians having recovered their spirits, attacked the Swedes in Livonia with the utmost fury. Narva, Dorpat, and several other towns, were taken, and the inhabitants and garrison treated with great barbarity. An army of 100,000 Russians soon afterwards entered Poland. Sixty thousand Cossacks under Mazeppa entered the country at the same time, and committed every outrage with the fury of barbarians. Schullemberg, perhaps more formidable than either, advanced with 14,000 Saxons and 7000 Russians, disciplined in Germany, and reputed excellent soldiers. Could numbers have determined the event of war, the Swedes must certainly have been at this time overpowered; but Charles seemed to triumph over his enemies with more ease the more numerous they were. The Russians were so speedily defeated, that they were all dispersed before one party had notice of the misfortunes of another. The defeating an army of 40,000 men scarcely obstructed the march of the Swedes, while their astonished enemies looked on these actions as the effects of witchcraft, and imagined that the king of Sweden had dealings with infernal spirits. With these apprehensions they fled beyond the Dnieper, leaving the unhappy Augustus to his fate. Schullemberg, with all his skill and experience, was not more successful. The Swedish general Renschild engaged and defeated him in half an hour, though the Swedes were vastly inferior in number, and their enemies posted in a most advantageous situation. Nothing could be more complete than the victory. This extraordinary victory, indeed, is said to have been owing to a panic which seized the troops of Schullemberg; but it was regarded with admiration, and thought to make the renown of Renschild equal to that of his sovereign. Charles himself was jealous, and could not help exclaiming, "Surely Renschild will not compare himself with me!"

The Russians take several towns in Livonia, and invade Poland.

Astonishing success of Charles against them.

Schullemberg entirely defeated by Renschild.

Charles invades Saxony.

Soon after this victory, which was gained on the 12th of February 1706, Charles entered Saxony at the head of 24,000 men. The diet at Ratisbon declared him an enemy to the empire if he crossed the Oder. But to this declaration no regard was paid: Charles pursued his march, while Augustus was reduced to the condition of a vagrant in Poland, where he possessed not a single town except Cracow. Into this city he threw himself with a few Saxon, Polish, and Russian regiments, and began to erect some fortifications for his defence; but the approach of the Swedish general Meyerfeldt, and the news of the invasion of Saxony, disconcerted all his measures, and plunged him into despair. The Russians indeed were his faithful allies, but he dreaded them almost as much as the Swedes; so that he was reduced to the necessity of writing a letter to Charles with his own hand, begging for peace on whatever terms he thought proper to grant. As he was then at the mercy of the Russians, this transaction was concealed with the greatest care. His emissaries were introduced to the Swedish court in the night-time, and being presented to Charles, received the following answer: that King Augustus should for ever renounce the crown of Poland, acknowledge Stanislas, and promise never to re-ascend the throne, should an opportunity offer; that he should release the princes Sobieski, and all the Swedish prisoners made in the course of the war; surrender Patkul, at that time resident at his court as ambassador for the czar of Russia, and stop proceedings against all who had passed from his into the Swedish service. These articles Charles wrote with his own hand, and delivered to Count Piper, ordering him to finish them with the Saxon ambassadors.

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Augustus begs for peace on any terms.

Charles's answer.

After his defeat at Pultava (see Russia) Charles fled in a mean calash, attended by a little troop inviolably attached to his person, some on foot, and some on horseback. They were obliged to cross a sandy desert, where neither herb nor tree was to be seen, and where the burning heat and want of water were more intolerable than the extremities of cold which they had formerly endured. The whole had almost perished for want of water, when a spring was fortunately discovered. They reached Otchakoff, a town in the Turkish dominions, the pacha of which supplied the king with every necessary. It was, however, some time before boats could be got ready for transporting the whole of the king's attendants; by which accident 500 Swedes and Cossacks fell into the hands of the enemy. This loss affected him more than all his other misfortunes. He shed tears at seeing, across the river Bog, the greater part of his few remaining friends carried into captivity, without having it in his power to assist them. The pacha waited on him to apologise for the delay, and was as severely reprimanded by Charles as if he had been his own subject.

Charles arrives in Turkey after his defeat at Pultava.

The king remained but a few days at Otchakoff, when the seraskier of Bender sent an aga to compliment him on his arrival in the Turkish dominions, and to invite him to that city. Here he was treated with hospitality. The Turks practised to its full extent their generous maxim of regarding as sacred the persons of unfortunate princes who had taken shelter in their dominions; and they perhaps regarded him, notwithstanding his misfortunes, as an ally that might be useful to themselves against the Russians. Every one indeed regarded him in his distress. The French king offered him a safe passage from the Levant to Marseilles, from whence he might easily return to his own dominions. But Charles was too obstinate to receive advice. Puffed up with the notion of imitating Alexander the Great, he disdained to return except at the head of a numerous army; and he yet expected, by means of the Turks, to dethrone his adversary the czar. Negociations for this purpose were carried on in the Turkish divan, and it was proposed to escort Charles with a numerous army to the frontiers of Poland; but the revolution which there took place put an end to all such projects. Augustus thought himself no longer bound to observe the treaty which he had made, than when Charles was at hand to compel him. After the battle of Pultava, he entered Poland, and took every measure, in concert with the czar, for the recovery of his kingdom. Stanislas was not able to encounter such enemies, but was obliged to leave his dominions and fly to Bender, in the disguise of a Swedish officer, in order to share the

Is kindly received, and his hopes of conquering Russia begin to revive.

Augustus recovers the kingdom of Poland.

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The Danes invade Sweden,

fortune of Charles. It was not in Poland alone that the Swedish affairs began to suffer in consequence of the defeat at Pultava. The Danes invaded the province of Schonen with an army of 13,000 foot and 2500 horse. Only 13,000 Swedish forces remained to defend all the territories possessed by Charles in Germany, and of these only a small part was allotted for the defence of Schonen. The regency of Sweden, however, exerted themselves to the utmost to repel this ungenerous invasion; and having collected an army of 12,000 militia and 8000 regulars, despatched them under General Steenboek into Schonen. Some Saxon troops were incorporated in this army; but among these a prodigious desertion took place, which the general found it impossible to prevent; and thus the Danes gained several advantages, and at last took Christianstadt. Their insolence on this success was so great that the Swedes demanded to be instantly led against them. Here the good fortune of Sweden seemed once more to revive.

but are utterly defeated.

The Danes were driven from a very strong situation, with the loss of 8000 killed and taken prisoners, besides a vast number wounded. The king received the intelligence of this victory with the greatest exultation, and could not help exclaiming, "My brave Swedes, should it please God that I once more join you, we shall conquer them all."

In the mean time, Charles, by means of his agents the count Poniatoffski and Neugebar, used his utmost efforts to procure a rupture between the Porte and Russia.

The Turks declare war against the Russians. A. D. 1711.

For a long interval the money bestowed by Peter on the vizirs and janisaries prevailed; but at last the grand signior, influenced by his mother, who was strongly in the interest of Charles, and had been used to call him *her lion*, determined to support his quarrel with Peter. He therefore gave orders to the vizir to fall on the Russians with an army of 200,000 men. The vizir promised obedience, but at the same time professed his ignorance in the art of war, and dislike to the present expedition. The khan of Crim Tartary, who had been gained over by the reputation and presents of the king of Sweden, had orders to take the field with 40,000 of his men, and had the liberty of assembling his army at Bender, that Charles might see that the war was undertaken on his account. See RUSSIA.

The treaty of the Pruth was most violently opposed by Poniatoffski and the khan of Tartary. The former had made the king acquainted with the situation of both armies; on which he instantly set out from Bender, filled with the hopes of fighting the Russians, and taking ample vengeance. Having ridden fifty leagues post, he arrived at the camp just as the czar was drawing off his half-famished troops. He alighted at Poniatoffski's tent; and being informed of particulars, instantly flew in a rage to the vizir, whom he loaded with reproaches, and accused of treachery. Recollecting himself, however, he proposed a method by which the fault might be remedied; but finding his proposal rejected, he posted back to Bender, after having by the grossest insults showed his contempt of the vizir.

The violent behaviour of Charles did not promote his interest. The vizir perceived that his stay in Turkey might prove fatal to himself, and he therefore determined to remove him as soon as possible.

The grand signior desires him to depart.

Succeeding vizirs adopted the same plan; and at last the grand signior himself wrote a letter to Charles, in which he desired him to depart by next winter, promising to supply him with a sufficient guard, with money, and every thing else necessary for his journey. Charles gave an evasive answer, and determined to procrastinate his journey, as well to gratify his own stubborn temper, as because he discovered a correspondence between Augustus and the khan of Tartary, the object of which, he had reason to believe, was to betray him to the Saxons. When he was again pressed to fix the day of his departure, he replied, that he could not think of going before his debts were paid. Being asked how much was necessary for this purpose, he replied, a thousand purses. A purse, it is to be remarked, consists of thirty sequins.

Mean and unjust behaviour of Charles.

Twelve hundred purses were instantly sent to the seraskier at Bender, with orders to deliver them to the king of Sweden, but not before he should have begun his journey. By fair promises, Charles persuaded him to part with the money; after which, instead of setting out, he squandered away his treasure in presents and gratifications, and then demanded a thousand purses more before he would set out. The seraskier was astonished at this behaviour. He shed tears; and turning to the king told him that his head would be the forfeit of having obliged him with the money. The grand signior, on being acquainted with the shameful behaviour of Charles, flew into a rage, and called an extraordinary divan, where he himself spoke; a practice very unusual for the Turkish monarchs. It was unanimously agreed that such a troublesome guest ought to be removed by force, should other means fail.

The Turks resolve to force him to depart.

Positive orders were therefore sent to Charles to depart; and, in case of his refusal, instructions were given for attacking him in his quarters. Nothing could equal his obstinacy on this occasion: in spite of the menaces of his enemies, in spite of the entreaties of his friends, he persisted in his resolution; and at last determined to resist, with 300 Swedes, being the entire number of his attendants, an army of 20,000 janisaries well armed and furnished with cannon.

His desperate resolution to resist.

At length he was attacked in good earnest; though it must be owned, that even in this extremity, the Turks showed their regard to him, and were tender of his safety. Most of the Swedes surrendered at once, perhaps as thinking it the only method of saving the king's life. This conduct, however, had an opposite effect. Charles became the more obstinate, the more desperate his affairs seemed to be.

Is abandoned by all his followers except forty.

With only forty menial servants, and the generals Hord and Dardorff, he determined to defend himself to the last extremity. Seeing his soldiers lay down their arms, he told the generals, "We must now defend the house. Come," added he with a smile, "let us fight *pro aris et focis*." The house had been already forced by the Tartars, all but a hall which was near the door, and where his domestics had assembled. Charles forced his way through the janisaries, attended by the generals Hord and Dardorff, joined his people, and then barricaded the door. The moment he entered, the enemy who were in the house threw down their booty, and endeavoured to escape at the windows. Charles pursued them from room to room with much bloodshed, and cleared the house in a few minutes.

Fights like a madman, but is taken prisoner with all his followers.

He then fired furiously from the windows, killed two hundred of the Turks in a quarter of an hour, so that the pacha who commanded them was at length forced to set the house on fire. This was effected by discharging arrows with lighted matches into the roof; but Charles, instead of quitting his post, gave orders for extinguishing the fire, and he himself assisted with great diligence. All efforts were however vain: the roof fell in, and Charles, with his few faithful companions, was ready to be buried in the ruins. In this extremity one called out that there was a necessity for surrendering. "What a strange fellow!" cries the king, "who would rather be a prisoner with the Turks than mix his ashes with those of his sovereign." Another had the presence of mind to cry out, that the chancery was but fifty paces off, had a stone roof, and was proof against fire. Pleased with the thoughts of again coming to blows, the king exclaimed, "A true Swede! Let us take all the powder and ball we can carry." He then put himself at the head of his troops, and sallied out with such impetuosity, that the Turks retreated fifty paces; but having fallen in the midst of his fury, they rushed upon him, and carried him by the legs and arms to the pacha's tent. This extraordinary adventure, which savours not a little of insanity, happened on the 12th of February 1713. He was now kept prisoner with all his retinue; and in this situation

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he was visited by the unfortunate Stanislas, the dethroned king of Poland.

Begins to think of returning to his dominions.

Charles seemed at last inclined to submit to his fate, and began seriously to think of returning to his kingdom, now reduced to the most deplorable situation. His habitation had been fixed at Demotica, a small town about six leagues from Adrianople. Here he was allowed provisions for his own table and those of his retinue; but only twenty-five crowns a day in money, instead of five hundred which he had received at Bender. During his residence here, he received a deputation from Hesse-Cassel, soliciting his consent to the marriage of the landgrave with Eleonora, princess royal of Sweden; to which he readily agreed. A deputation was also sent him by the regency of Sweden, requesting that he would prepare for returning to his own dominions, which, in his absence, were ready to sink under a ruinous war.

Sets out for Sweden. A. D. 1714.

On the 14th of October 1714, Charles set out for Sweden. All the princes through whose territories he was to pass had given orders for his entertainment in the most magnificent manner; but the king, perceiving that these compliments only rendered his imprisonment and other misfortunes more conspicuous, suddenly dismissed his Turkish attendants, and assembling his own people, bid them take no care about him, but make the best of their way to Stralsund. After this he set out post, in the habit of a German officer, attended only by Colonel During. Keeping the by-roads through Hungary, Moravia, Austria, Bavaria, Wirtemberg, the Palatinate, Westphalia, and Mecklenburg, he arrived on the 21st of November at midnight before the gates of Stralsund. Being unknown, he was admitted with difficulty; but being soon recognised by the governor, the greatest tokens of joy were manifested all over the town.

Distressed situation of Sweden.

Sweden was now in the greatest distress. On the news of the defeat at Pultava, the Danes had invaded Schonen, but were defeated by General Steenboek. This victory did not, however, put an end to the war. The kings of Denmark and Poland, with the czar of Russia, entered into stricter bonds of amity than ever. They dreaded the return of Charles to his own dominions, and apprehended that numberless victories would soon efface the remembrance of Pultava. They determined to make the best use of their time; and perhaps Charles never took a more imprudent resolution than obstinately to remain so long in the Turkish dominions. His return seemed to give new life to the whole nation. Though the number of inhabitants was visibly diminished, the levies which he had ordered were completed in a few weeks; but the husbandmen left to cultivate the earth consisted of the infirm, aged, and decrepid; so that a famine was threatened in consequence of the military rage which had seized all the youth of the kingdom.

The king is unable to retrieve the Swedish affairs. A. D. 1715.

The presence of Charles did not now produce those consequences which the allies had feared. The kingdom was too much reduced to furnish the necessary supplies of men and money; and though the king's courage and military skill were not in the least diminished, the efforts which he made, instead of restoring Sweden to its splendour, served more completely to ruin it. In 1715, Prussia declared against him, on account of his demanding back the town of Stettin, which that monarch had seized. To complete his embarrassment, the elector of Hanover, George I. of Britain, also became his enemy. The forces of Denmark, Prussia, Saxony, and Hanover joined to invest Wismar, while a body of 36,000 men formed the siege of Stralsund; and at the same time the czar, with a fleet of twenty large ships of war, and 150 transports, carrying 30,000 men, threw every part of the Swedish coast into the greatest consternation. The heroism of Charles could not prevail against so many enemies; yet he was still so much dreaded, that the prince of Anhalt, with 12,000 brave troops, did not think himself a match for this furious enemy when at the head of only 2000, till he had intrenched his army behind a ditch, defended by chevaux de frise. It appeared, indeed, that this precaution was not unnecessary; for in the night Charles with his men clambered up the ditch, and attacked the enemy in his usual manner. Numbers, however, at last prevailed, and Charles was obliged to retire, after having seen his favourite Grothusen, General Dardoff, and During, the companions of his exile, killed by his side, he himself being wounded in the breast.

Is encompassed on all sides by enemies.

His desperate valour.

Stralsund besieged,

This rash attempt was made in order to save Rugen, whence the town of Stralsund was supplied with provisions. The place was well fortified, and garrisoned with 9000 men, with Charles himself at their head; but nothing could resist the efforts of the enemy. By the 17th of December it was proposed to give the assault. The attack on the horn-work was desperate; the enemy was twice repulsed; but at last, by dint of numbers, effected a lodgment. The next day, Charles headed a sally, in which he dealt terrible destruction among the besiegers, but was at length overpowered and obliged to retreat into the town. At last his officers, apprehending that he must either fall into the hands of the enemy, or be buried in the ruins of the place, entreated him to retire. A retreat, however, was now almost as dangerous as to remain in the town, on account of the fleets of the enemy with which the sea was covered; and it is thought that this very circumstance induced the king to consent to it. Embarking in a small boat with sails and oars, he passed all the enemy's ships and batteries, and arrived safe at Ystedt in Schonen.

and taken, in spite of the utmost efforts of the king.

Charles invades Norway.

To revenge himself for these losses, Charles invaded Norway with an army of 25,000 men. The Danes were everywhere defeated and pursued with that vigour for which the king of Sweden was so remarkable; but strong reinforcements arriving from Denmark, and provisions failing, he was at last obliged to retire. Soon after this the Swedes lost Wismar; but when every thing seemed hopeless, Baron Goertz, the chief minister and favourite of Charles, contrived to make overtures for a treaty with the czar of Russia, by which the most formidable of all Charles's enemies was taken off. The minister found means to work on the inflexible temper of Charles, by representing to him that the cession of certain provinces to Peter would induce him to assist him in his projects of again dethroning Augustus, and of replacing James on the throne of Britain; which last scheme he had projected out of revenge for the elector of Hanover having seized on the duchies of Bremen and Verden. In consequence of the conferences between the czar and Goertz, the former engaged to send into Poland an army of 80,000 men, in order to dethrone that prince whom he had so long defended. He also engaged to furnish ships for transporting 30,000 Swedes to Germany, and 10,000 into Denmark. This treaty was not however ratified, and the death of Charles put a final stop to all the great prospects of Sweden.

A treaty with the czar of Muscovy projected.

Charles invades Norway.

The king had resolved on the conquest of Norway before he dethroned Augustus; and as no difficulties ever deterred him, he marched his army into that cold and barren country in the month of October, when the ground was covered with frost and snow. With 18,000 men he formed the siege of Fredrickshall, though the severity of the frost rendered it almost impossible to break ground. He resolved to form trenches; and his soldiers cheerfully obeyed, digging into the ground with the same labour as if they had been piercing a rock. On the 11th of December the king visited the trenches in the midst of a terrible fire from the enemy, imagining that his men might be animated by his presence. He took his post in the most dangerous station that he could select, standing on a gabion and leaning with his arm over the parapet, while the enemy were firing chain shot at the very spot where he stood. He was entreated to

His death.

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change his station, but he remained obstinate. At last he was seen to fall mortally wounded, but whether by the enemy or by an assassin has been much disputed, and will probably ever remain matter of doubt. He soon afterwards expired.

Account of the Swedish affairs from the death of Charles XII. to the year 1771.

Charles XII. was succeeded by his sister the princess Ulrica Eleonora, wife to the hereditary prince of Hesse. On this occasion the states took care to make a previous stipulation for the preservation of their liberties, and obliged the princess, before entering on the government, to sign a document to this effect. Their first care was to make peace with Great Britain, which the late king intended to have invaded. In order to prevent their further losses by the progress of the Russian, the Danish, the Saxon, and other arms, the Swedes made many great sacrifices to obtain peace from these powers. The French, however, about the year 1738, formed a dangerous party in the kingdom, which not only broke its internal quiet, but led it into a ruinous war with Russia, by which it lost the province of Finland. Their Swedish majesties having no children, it was necessary to settle the succession; especially as the duke of Holstein was descended from the queen's eldest sister, and was, at the same time, the presumptive heir to the empire of Russia. Four competitors appeared; the duke of Holstein Gottorp, Prince Frederic of Hesse-Cassel, nephew to the king, the prince of Denmark, and the duke of Deux-Ponts. The duke of Holstein would have carried the election, had he not embraced the Greek religion that he might mount the throne of Russia. The czarina interposed, and offered to restore all the conquests she had made from Sweden, excepting a small district in Finland, if the Swedes would receive the duke of Holstein's uncle, Adolphus Frederic, bishop of Lübeck, as their hereditary prince and the successor to the crown. This was agreed to; and a peace concluded at Abo, under the mediation of his Britannic majesty. The peace was so firmly maintained by the empress of Russia, that his Danish majesty thought proper to drop all resentment for the indignity offered his son. The prince-successor married the princess Ulrica, third sister to the king of Prussia; and in 1751 he entered into the possession of his new dignity, which proved to him a crown of thorns. The French had acquired great influence in all the deliberations of the Swedish senate, who of late had been little better than pensioners to that crown. The intrigues of the senators forced Adolphus to take part in the war against Prussia; but as that war was disagreeable, not only to the people, but also to the king of Sweden, the nation never made so mean an appearance; and on Russia's making peace with the king of Prussia, the Swedes followed the example. Adolphus died dispirited in 1771, after a turbulent reign of twenty years, and was succeeded by his son Gustavus.

Accession of Adolphus Frederick. A. D. 1751.

Gustavus III. ascends the throne. A. D. 1771.

The most remarkable transaction of this reign is the revolution which took place in the government in the year 1772, by which the king, from being the most limited, became one of the most despotic monarchs in Europe. Ever since the death of Charles XII. the whole power of the kingdom had been lodged in the states; and this power they had much abused. Gustavus therefore determined either to seize on that power of which they made such a bad use, or to perish in the attempt. The revolution was effected in the following manner. On the morning of the 19th of August 1772, a considerable number of officers, as well as other persons known to be attached to the royal cause, had been summoned to attend his majesty. Before ten he was on horseback, and visited the regiment of artillery. As he passed through the streets he was more than usually courteous to all he met, bowing familiarly to the lowest of the people. On the king's return to his palace, the detachment which was to mount guard that day being drawn up together with that which was to be relieved, his majesty retired with the officers into the guard-room. He then addressed them with all that eloquence of which he is said to have been a master; and after insinuating to them that his life was in danger, he exposed to them in the strongest colours the wretched state of the kingdom, the shackles in which it was held by means of foreign gold, and the dissensions and troubles arising from the same cause which had distracted the diet during the course of fourteen months. He assured them that his only design was to put an end to these disorders, to banish corruption, restore true liberty, and revive the ancient lustre of the Swedish name, which had been long tarnished by a venality as notorious as it was disgraceful. Then assuring them in the strongest terms that he disclaimed for ever all absolute power, or what the Swedes call *sovereignty*, he concluded with these words: "I am obliged to defend my own liberty and that of the kingdom against the aristocracy, which reigns. Will you be faithful to me, as your forefathers were to Gustavus Vasa and Gustavus Adolphus? I will then risk my life for your welfare and that of my country." The officers, most of them young men, of whose attachment the king had been long secure, and who did not perhaps perceive the real tendency of his majesty's request, were allowed no time to reflect, immediately gave their assent, and took an oath of fidelity to him. Only three refused. One of these, Frederic Cederström, captain of a company of the guards, alleged he had already, and very lately, taken an oath to be faithful to the states, and consequently could not take that which his majesty then exacted. The king, looking at him sternly, answered, "Think of what you are doing." "I do," replied Cederström; "and what I think to-day I shall think to-morrow; and were I capable of breaking the oath by which I am already bound to the states, I should be likewise capable of breaking that which your majesty now requires me to take." The king having then ordered Cederström to deliver up his sword, placed him under arrest. His majesty, however, apprehensive of the impression which his proper and resolute conduct might make on the minds of the other officers, soon afterwards softened his tone; and again addressing himself to Cederström, told him, that as a proof of the opinion which he entertained of him, and the confidence which he placed in him, he would return him his sword without insisting on his taking the oath, and would only desire his attendance that day. The undaunted captain continued firm; he answered, that his majesty could place no confidence in him, and that he begged to be excused from the service.

Account of the revolution in 1772, by which he became despotic.

Resolution of a Swedish officer.

While Gustavus was shut up with the officers, senator Ralling, to whom the command of the troops in the town had been given two days before, came to the door of the guard-room, and was told that he could not be admitted. The senator insisted on being present at the distribution of the orders, and sent to the king to desire it; but was answered, he must go to the senate, where his majesty would speak to him. The officers then received their orders from the king; the first of which was, that the two regiments of guards and of artillery should be immediately assembled, and that a detachment of thirty-six grenadiers should be posted at the door of the council-chamber to prevent any of the senators from coming out. But before the orders could be carried into execution, it was necessary that Gustavus should address himself to the soldiers; men wholly unacquainted with his designs, and accustomed to pay obedience only to the orders of the senate, whom they had been taught to hold in the highest reverence. As his majesty, followed by the officers, was advancing from the guard-room to the parade for this purpose, some of them, more cautious, or perhaps more timid, than the rest, became, on a short reflection, apprehensive of the consequences of the measure in which they were engaged: they began to express their fears to the king, that unless some person of greater weight and influence than themselves

The king gains over the soldiers.

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were to take a part in the same cause, he could scarcely hope to succeed in his enterprise. The king stopped a while, and appeared to hesitate. A serjeant of the guards overheard their discourse, and cried aloud, "It shall succeed. Long live Gustavus!" His majesty immediately said, "Then I will venture;" and stepping forward to the soldiers, he addressed them in terms nearly similar to those which he had employed to the officers, and with the same success. They answered him with loud acclamations. One voice only said, No; but it excited no attention.

Secures the senators, and becomes master of the whole power in the kingdom.

In the mean time some of the king's emissaries had spread a report about the town that his majesty was arrested. This drew the populace to the palace in great numbers, where they arrived as he had concluded his harangue to the guards. They testified by reiterated shouts their joy at seeing him safe; a joy which promised the happiest conclusion to the business of the day. The senators were now immediately secured. They had from the window of the council-chamber beheld what was going forward on the parade before the palace; and, at a loss to know the meaning of the shouts which they heard, were coming down to inquire into the cause of them, when thirty grenadiers, with their bayonets fixed, informed them it was his majesty's pleasure they should continue where they were. They began to speak in a high tone, but were only answered by having the door shut and locked upon them. The moment the secret committee heard that the senate was arrested, they separated of themselves, each individual providing for his own safety. The king then mounting his horse, followed by his officers with their swords drawn, a large body of soldiers, and numbers of the populace, went to the other quarters of the town where the soldiers whom he had ordered to be assembled were posted. He found them all equally willing to support his cause, and to take to him an oath of fidelity. As he passed through the streets, he declared to the people, that he only meant to defend them, and save his country; and that if they would not confide in him, he would lay down his sceptre, and surrender up his kingdom. So much was the king beloved, that some of the people even fell on their knees, and many more, with tears in their eyes, implored his majesty not to abandon them.

Summons an assembly of the states;

The king proceeded in his course, and in less than an hour made himself master of all the military force in Stockholm. In the mean time the heralds, by proclamation in the several quarters of the city, summoned an assembly of the states for the ensuing morning, and declared all members traitors to their country who should not appear. Thither his majesty repaired in all the pomp of royalty, surrounded by his guards, and holding in his hand the silver sceptre of Gustavus Adolphus. In a very forcible speech, he lamented the unhappy state to which the country was reduced by the conduct of a party ready to sacrifice every thing to its ambition, and reproached the states with adapting their actions to the views of foreign courts, from which they received the wages of perfidy. "If any one dare contradict this, let him rise and speak." Conviction, or fear, kept the assembly silent, and the secretary read the new form of government, which the king submitted to the approbation of the states. It consisted of fifty-seven articles; of which the five following were the chief. 1. The king has the entire power of convoking and dissolving the assembly of the states as often as he thinks proper. 2. His majesty alone has the command of the army, fleet, and finances, and the disposal of all offices civil and military. 3. In case of an invasion, or of any pressing necessity, the king may impose taxes, without waiting for the assembly of the states. 4. The diet can deliberate on no other subjects than those proposed by the king. 5. The king shall not carry on an offensive war without the consent of the states. When all the articles were recited, the king demanded if the states approved of them, and was answered by a general acclamation. He then dismissed all the senators from their employments, adding, that in a few days he would appoint others; and concluded this extraordinary scene by drawing out of his pocket a small psalm-book, from which, after taking off the crown, he gave out *Te Deum*. All the members very devoutly added their voices to his, and the hall resounded with thanksgiving.

which accepts a new form of government.

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The king makes a good use of his power.

The power which he had thus obtained, he employed for the good of his subjects. He took care that the law should be administered with impartiality to the richest noble and the poorest peasant, making a severe example of such judges as were proved to have made justice venal. He gave particular attention and encouragement to commerce; and being himself a man of letters, was a liberal and enlightened patron of literature and science. He strenuously laboured to introduce into his kingdom the most valuable improvements in agriculture that had been made in foreign countries.

Reforms the army and navy.

But while thus active in promoting the arts of peace, he was not inattentive to the art of war. The fleet, which he found decayed and feeble, he in a few years restored to a respectable footing; and, besides changing the regulations of the navy, he raised a new corps of sailors, and formed them to the service by continual exercise. The army, which, like the navy, had been neglected during the aristocracy, was next to be reformed. The king began by giving cloaks, tents, and new arms to all the regiments. Afterwards, under the direction of Field-marshal Count de Hessenstein, a new exercise was introduced, and several camps were formed, in which the soldiery were manœuvred by the king himself. The sale of military offices, which had been permitted for many years, was entirely suppressed; and the king provided not only for the re-establishment of discipline and good order in the army, but for the future welfare of the individuals who composed it. These warlike preparations were necessary to a plan which he had formed for entirely abolishing the power of the aristocracy, and freeing Sweden from the factions which had long been formed in it by the court of St Petersburg. The change which he had introduced was very inimical to the intrigues of that court; and the Russian ambassador exerted himself openly to bring about a rupture between the king and the discontented nobles. Gustavus ordered him to quit the kingdom in eight days, and immediately prepared for war with Russia. To this apparently rash enterprise he was incited by the Ottoman Porte, at that time unable to oppose the armies of the two empires; and his own ambition, together with the internal state of his kingdom, powerfully concurred to make him lend every assistance to his ancient ally. It is needless for us to enter into a detail of the particulars of that war, the principal circumstances of which have already been noticed under Russia. Suffice it to say, that neither Gustavus Adolphus nor Charles XII. gave greater proofs of undaunted courage and military conduct in their long and bloody wars than were given by Gustavus III. from the end of the year 1787 to 1790, when peace was restored between the courts of St Petersburg and Stockholm. When the court of Copenhagen was compelled, by the means of England and Prussia, to withdraw its troops from the territories of Sweden, the king attacked Russia with such vigour both by sea and land, displayed such address in retrieving his affairs when apparently reduced to the last extremity, and renewed his attacks with such pertinacious courage, that the empress lowered the haughtiness of her tone, and was glad to treat with Gustavus as an equal and independent sovereign.

His conduct in the war with Russia.

A conspiracy formed against the king's life. A. D. 1792.

Sweden now enjoyed peace; but the nobles continued discontented, and a conspiracy was planned against Gustavus under his own roof. He had entered into the alliance that was formed against the revolutionary government of France; and in order to raise an army, which he was to

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lead in person, to co-operate with the emperor and the king of Prussia, he was obliged to negociate large loans, and to impose on his subjects heavy taxes. The nobles took advantage of that circumstance to prejudice the minds of many of the people against the sovereign who had laboured so long for their good. On the 16th of March 1792 he received an anonymous letter, warning him of his immediate danger from a plot that was laid to take away his life; requesting him to remain at home, and avoid balls for a year; and assuring him that, if he should go to the masquerade for which he was preparing, he would be assassinated that very night. The king read the note with contempt, and at a late hour entered the ball-room. After some time, he sat down in a box with Count d'Essen, and observed that he was not deceived in his contempt for the letter, since, had there been any design against his life, no time could be more favourable than that moment. He then mingled, without apprehension, among the crowd; and just as he was preparing to retire in company with the Prussian ambassador, he was surrounded by several persons in masks, one of whom fired a pistol at the back of the king, and lodged the contents in his body. A scene of dreadful confusion immediately ensued. The conspirators, amidst the general tumult and alarm, had time to retire to other parts of the room; but one of them had previously dropped his pistols and a dagger close by the wounded king. A general order was given to all the company to unmask, and the doors were immediately closed; but no person appeared with any particular distinguishing marks of guilt. The king was immediately conveyed to his apartment; and the surgeon, after extracting a ball and some slugs, gave favourable hopes of his recovery. But the prognostication of his medical attendants soon appeared to be fallacious, and on the 28th of March a mortification was found to have taken place. He expired on the following day; and on opening his body there were found within the ribs a square piece of lead and two rusty nails.

The king dangerously wounded.

Death of Gustavus III. A. D. 1792.

The king had by his will appointed a council of regency; but convinced by recent experience how little dependence was to be placed on the attachment of his nobles, and aware of the necessity of a vigorous government in times of such difficulty and danger, he appointed his brother, the duke of Sudermania, sole regent, till his son, then a minor, should attain the age of eighteen years. In his dying moments he desired that all the conspirators, except the perpetrator of his murder, might be pardoned.

Accession of Gustavus IV.

The young king, who was about fourteen at his father's death, was proclaimed by the name of Gustavus IV. The regent soon took the most vigorous and active measures to apprehend and punish the projectors and perpetrators of the murder of his brother. A nobleman of the name of Ankarström confessed himself the assassin, and gloried in the action, which he called liberating his country from a monster and a tyrant. He was executed in a most cruel manner on the 17th of May. Other two noblemen, and two officers, also suffered death; but the rest of the conspirators were either pardoned, or punished only by fine and imprisonment.

From the accession of Gustavus IV. till the revolution which has been recently effected in Sweden, few transactions of any importance have occurred. Soon after the king had assumed the administration of affairs, he engaged warmly in the war against France, and till the time of his deposition continued a most faithful ally of Britain. The efforts of the Swedish monarch towards humbling the power of Bonaparte have been already noticed under the articles BRITAIN and FRANCE; and the war with Russia, in which his alliance with Britain had involved him, has been sufficiently touched in the article RUSSIA. This prince seems to have been endowed with amiable qualities; but he was certainly rash and imprudent, and perhaps in some degree tinctured with insanity. He thus materially injured his kingdom, and alienated the affections of his principal nobles, especially of his uncle the duke of Sudermania.

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Revolution in favour of the duke of Sudermania. A. D. 1809.

In the beginning of March 1809, the plan which appears to have been concerted between the duke of Sudermania and the principal nobility was carried into effect. The king was arrested; the duke assumed the reins of government, and issued a proclamation, announcing that, under existing circumstances, the king was incapable of conducting the affairs of the nation. Gustavus, now in close custody, was easily prevailed upon to abdicate the government. The diet was assembled; the duke of Sudermania was declared king of Sweden, under the title of Charles XIII.; Prince Augustenberg was chosen crown prince; and various changes were introduced into the constitution, confirming the powers of the diet, and removing what the prevailing party held to be encroachments of the crown during the late and preceding reigns. The people, wearied or disgusted by the late king's folly and rashness, readily acquiesced in all the alterations. Peace was then made with Russia; a measure which had become absolutely necessary, as the military force of the kingdom was completely broken, and no means were left for checking the progress of the enemy. By this peace Sweden lost Finland, a country of peculiar importance to her, on account of the supplies of grain which she was accustomed to draw from it; but in the treaty she reserved the right of yearly importing a certain quantity of grain, duty free. Swedish Finland, with Lapmark, now annexed to Russia, was estimated to contain about 120,000 square English miles, with 895,000 inhabitants. On the 6th of January 1810, peace was also concluded with France, which restored Pomerania.

Sweden was now enjoying tranquillity, when the sudden and unexpected death of the crown prince Augustenberg, in April 1810, became a new source of perplexity. The duke of Sudermania was old and in a feeble state of health; and as there was no person within the kingdom who had any title by blood to the throne, it was necessary, for the security of the new order of things, to choose a successor. The threatening position which the acquisition of Finland gave to Russia induced the noblemen who in concert with the court took a lead in this business, to look for some man of military talents. It happened that Bernadotte, prince of Ponte Corvo, who had lately commanded in the north of Germany, had, by his liberal and kind treatment, gained the peculiar esteem of the Swedish officers and soldiers whom he had made prisoners in Gustavus's ill-concerted operations in Pomerania. He was besides highly respected for his military skill; and had been still further raised in general estimation, in consequence of Napoleon having removed him from his command for his lenity and humanity in the exercise of his power. Some of the Swedish officers, to whom his character was known, first conceived the idea of offering him the succession to the crown. The scheme was for some time kept as secret as possible; but it received so much countenance from the most considerable men, that it was at length opened to Bernadotte himself at Paris. He received it as might be expected, and his friends redoubled their intrigues. The prince of Denmark had been proposed, but the ancient enmity against that country was an invincible obstacle to his success. At length, when every thing was prepared, the diet was called, and Bernadotte was with acclamation elected crown prince by all the four orders, on the 21st of July. Of all the changes in the fortune and station of individuals which arose out of the French revolution, this is perhaps the most singular. Bonaparte seized the royal power and dignity for himself, and by force of arms he compelled some of the weaker states to accept his relations and followers as kings. But it does not appear that he was ever consulted as to Bernadotte's elevation, or had the smallest influence in it, except that

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the example given in his own person and that of his followers had contributed to destroy some of the old illusions as to birth and hereditary honours, and had prepared men's minds for great innovations. It was thus that a Frenchman who began his career as a common soldier, was raised to the Swedish throne by the spontaneous choice of a body of nobles, proud of their birth and ancestry.

The appearance of Bernadotte in the Swedish capital was followed by numerous feasts and spectacles. He received congratulations from all the public bodies; and though not immediately called to the throne, was, from the king's infirmities, intrusted with the entire conduct of the government. One of his first acts was to recommend to the diet the introduction of a conscription law like that of France, a measure which certainly hazarded his popularity. It was however adopted; and on this occasion he prevailed with the nobles to make a voluntary surrender of their ancient privilege of exemption from military service, as well as from taxation. Pressed by France and Russia, Sweden, in November 1810, professed her adherence to the continental system, and declared war against Britain. The war however was only nominal, and the British cruisers returned, in most cases, their captures untouched. This state of things continued till Bonaparte was preparing for his great Russian campaign, when the Swedish government, solicited by both parties, and tempted by great offers, at length signed treaties of alliance with Russia and Britain in 1812 and 1813. By these treaties, the two powers mentioned engaged to assist the king in conquering Norway from Denmark. The French, for the purpose of intimidation, had previously seized Pomerania. Bernadotte carried over an army of 30,000 Swedes to Germany in 1813; and being joined by several large bodies of Prussian and German troops, he was encountered by Marshal Ney between Berlin and Leipzig on the 6th September, and, after an obstinate engagement, drove back the French army with the loss of 16,000 men. In the battle of Leipzig, fought on the 18th October, he likewise bore a conspicuous share. After the victory, he continued to act against Marshal Davoust's corps, and against the Danes, till he reduced the latter to the necessity of capitulating. He lost no time in improving this advantage; and by a treaty concluded at Kiel on the 14th January 1814, compelled Denmark to cede Norway, on surrendering to her the possession of Pomerania, and thus securing a great advantage by the exchange of territory. He now advanced to the Rhine; but, satisfied with reducing Napoleon's power, and, from views of interest, most probably adverse to ruining him, he was thought to be rather dilatory in improving his advantages. The success of the allies at length left him at liberty to secure Norway, the prize for which he had fought. As the Norwegians announced their intention of resisting, he crossed the frontier with an army in July, and, by judicious manœuvres, which placed the Norwegian force in his power, he obliged them to capitulate, and obtained possession of the country almost without bloodshed; Norway preserving its ancient constitution, and having states of its own. On the death of Charles XIII. in 1818, Bernadotte ascended the throne as Charles XIV., and was crowned at Stockholm and Drontheim. The subsequent history of Sweden presents few points of special interest. It has been characterized by a rapid and steady advance in prosperity, as will be seen from our account of the present state of the country. Bernadotte and his successors have devoted themselves to the establishment of peace and order among the people, and to the development of the industrial resources of the country, and their labours have been crowned with success. Commerce and the arts and manufactures have made rapid progress, and a very marked change has taken place in the moral and social condition of the people. Charles XIV. died in 1844, in the eightieth year of his age, and was succeeded by his son Oscar I. The present monarch, Charles XV., succeeded his father Oscar in 1859.

Statistics.

Kings and Queens of Sweden.

A.D.	A.D.	A.D.
1129. Swerker I.	1415. Eric XIII.	1660. Charles XI.
1155. Eric X.	1442. Christopher III.	1697. Charles XII.
1162. Charles VII.	1448. Charles VIII.	1719. Ulrica Eleonora and Frederick (of Hesse).
1168. Canute.	1483. John II.	1751. Adolphus Frederick.
1192. Swerker II.	1520. Christiern II.	1771. Gustavus III.
1210. Eric XI.	1523. Gustavus Vasa.	1792. Gustavus IV.
1220. John I.	1560. Eric XIV.	1809. Charles XIII.
1223. Eric XII.	1568. John III.	1818. Charles XIV.
1251. Waldemar.	1590. Sigismund.	1844. Oscar.
1279. Magnus I.	1604. Charles IX.	1859. Charles XV.
1290. Berger II.	1611. Gustavus Adolphus.	
1320. Magnus II.	1633. Christina.	
1363. Albert.	1654. Charles X.	
1389. Margaret.		

(J. F. S.)

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Boundaries.

Sweden occupies the eastern and larger portion of that part of Northern Europe known as the Scandinavian peninsula. It is bounded on the N.E. by Russia, from which it is separated by the rivers Tornea, Muonia, and Kongämä; on the N.W. and W. by Norway, the range of mountains and tablelands, which form the watershed of the peninsula, being, for the most part, the boundary between the two countries; on the S.W. by the Cattegat and Sound, separating it from Denmark, the former from Jutland, the latter from the Island of Zealand; on the S.E. by the Baltic; and on the E. by the Gulf of Bothnia. Sweden is thus chiefly bounded by water, and has a coast-line, exclusive of indentations, of more than 1400 miles. Its coasts are indented with numerous bays and inlets, and skirted by an immense number of islands. They are generally of moderate elevation and rocky; but they are sometimes low and sandy, particularly in the north. Connected with the coast of Sweden, it is deserving of notice, that in many parts a gradual elevation of the land has been observed to be taking place. This was remarked by Celsius so early as the beginning of the last century, and attributed by him to a gradual subsiding of the waters of the Baltic. Von Buch, during his travels in Scandinavia, in the early part of the present century, found at several points on the Norwegian coast, above the sea level, marine shells of species still existing in the neighbouring sea; and from this, and information obtained from the inhabitants, he was led to believe that Celsius was correct in averring, that a gradual change was taking place in the relative level of the land and water; but he concluded that it was occasioned by the rising of the land, and not by the subsiding of the waters. This view has since been confirmed by Sir Charles Lyell, who, in 1834, found the marks made on the rocks at water-level, fourteen years before under the direction of the Royal Academy of Sweden, to be then in some parts four or five inches above it. The rise has taken place principally in the north; at Stockholm, it was very slight; and in the south of Scania it was imperceptible.

Coasts.

Surface.

Sweden is about 900 miles in length from north to south, and is in general from 150 to 200 miles in breadth; lying between 55. 20., and 69. 10. N. Lat.; and 11. 15. and 24. E. Long. As compared with Norway, its surface is tame and uninteresting. In general, it rises gradually from the sea to the highlands on the borders of Norway. In the north, where these highlands are most elevated, the slopes are usually steep and irregular; in the central region, they form extensive plateaux; while in the south, where the highlands are of slight elevation, or altogether cease, the country is mostly flat, with here and there low ranges of hills. In the north, the surface is diversified with mountains, glens, and deep valleys, whereas, in the south, it con-

Statistics.

sists mostly of vast sandy plains interspersed with numerous lakes.

Rivers. Sweden is extremely well-watered by numerous rivers and lakes. From the nature of the country, however, the rivers are generally of small size, and not suited for navigation. The longest are in the north, rising in the Kiölen Mountains, flowing generally from north-west to south-east, and falling into the Gulf of Bothnia. The principal of these, beginning with the most northern, are the Tornea, Calix, Lulea, Pitea, Skelleftea, Windel, Umea, Angerman, Indals, Ljusne, and Dal. None of these much exceed 300 miles in length, and with the exception of the Angerman are not navigable for any distance from their mouths. Several of them traverse, or have their sources in considerable lakes; and form in their course beautiful falls and cataracts. Few of the rivers of Southern Sweden are of any considerable size, and notwithstanding the generally flat nature of the country through which they flow, they are little suited for navigation, being impeded by rocks and rapids, and subject to frequent inundations. There are numerous mineral springs in the country, and some of the watering-places, as Medewi, Ramlösa, Loka, &c., are much frequented.

Lakes. The lakes of Sweden are very numerous, and some of them are of great size. The Wener, which, after the Ladoga and Onega, is the largest lake in Europe, has a length of about 90 miles, and a breadth, where widest, of about 56. The Wetter is 82 miles in length by 16 in extreme breadth. The Mälar Lake extends westward from Stockholm, and is nearly 70 miles in length by from 2 to 20 in breadth. The Heilmar Lake, which lies to the S.W. of Lake Mälar, with which it is connected by a canal, is 35 miles in length by 15 in extreme width. In the north, the lakes are usually long and narrow, some of them being 40 or 50 miles long by 4 or 5 wide.

Geology. The geological structure of Sweden is very simple, and the formations few. Granite and gneiss are the prevailing rocks, especially the former, gneiss being less common here than in Norway. It is, however, very rich in mineral products, the most important of which are iron, copper, cobalt, zinc, lead, antimony, gold, silver, alum, nitre, and sulphur. Iron and copper, the two most important of these, will be afterwards more particularly noticed in treating of the mines of the country. Porphyry, marble, alabaster, limestone, millstone, potter's earth, &c., are also found. Coal has been found in the south near Helsingborg, but only to a small extent, and of very inferior quality.

Climate. The climate of Sweden, from the great extent of the country, of course, varies considerably; but it is upon the whole much milder than might be expected from its high latitude. As compared with Norway, its mean annual temperature is about 2° less; but, being protected on all sides from the extreme cold of the arctic regions, its winters are 5° warmer, while its summers are 1° colder. Thus, at Stockholm, the mean annual temperature is 42°; winter, 25°; summer, 62°. The atmosphere is remarkably dry and clear, and is in this respect a striking contrast to that of Norway; the fall of rain at Stockholm being only 17½ inches per annum. At Stockholm, the longest day is 18½ hours; the shortest nearly 6 hours in length. In the north, the whole surface of the country is covered with snow and ice for five or six months in the year; in the central parts, winter seldom lasts more than three or four months; and, in the south, the climate is very similar to that of northern Germany. In the north, about N. Lat. 71°, the limit of perpetual snow is 2300 feet above the level of the sea; at N. Lat. 64°, it is 4650 feet; at N. Lat. 62°, 5100 feet; and at N. Lat. 60°, 5600 feet. The transition from winter to summer is usually rapid, especially in the north, where it often takes place within the space of a few days.

Forests. The forests of Sweden are extensive, covering about two-sevenths of its entire area. The varieties of timber, however, are few. In the north the pine, birch, and fir are the principal trees; in the central parts, the ash, alder, willow, and maple are also common; and in the south, the oak, beech, elm, and lime are met with. In the plain of Scania, the mulberry, chestnut, pear, apple, and walnut trees flourish. Till lately the forests of Sweden were very much neglected, but now more attention is bestowed upon them, and timber constitutes one of the most important articles of export. They likewise furnish almost the sole article of fuel used in the country.

Agriculture. Agriculture, though little favoured by either soil or climate, has lately been making rapid advances. The improvements, however, are as yet chiefly confined to gentlemen possessed of large estates; the peasant farmers still mostly adhere to the old system. In consequence of the uncertainty of the climate, there are on an average of seven years only three years of good crops, three of indifferent crops, and one of entire failure. In the north scarcely one crop out of three succeeds. It is estimated that only $\frac{1}{47}$th part of the entire area of the country is arable. The most fertile tracts lie north of Lake Wener, between Lake Wetter and the Baltic, and in the plain of Scania. In consequence of the improved state of agriculture, and of the increased growth of the potatoe, not only is the annual produce of grain equal to the consumption, but generally there is a considerable surplus for exportation. In 1858 the quantity of grain exported (principally oats and barley) was 546,700 imperial quarters. In 1822 the quantity of grain produced was 5,867,570 tons; in 1847, 8,398,451; in 1850, 8,791,950; and, in 1858, about 11,000,000 tons. Of potatoes, the quantity produced in 1822 was 2,374,205 tons; in 1847, 5,328,503; in 1850, 4,890,311; and, in 1858, about 7,000,000 tons. The principal crops are rye, barley, oats, wheat, potatoes, peas, hemp, flax, &c. In the north, in consequence of the short summer, almost the only grain crop raised is barley, which is sown and reaped in seven or eight weeks. It is grown as far north as 69°. Rye cannot be grown with advantage north of 66°, and oats do not ripen north of 64°. Wheat does not, in general, succeed north of 62°. The cultivation of the potatoe is very general in all parts of the country, and in the north this root supplies the deficiency of corn. From the poverty of the soil, and the short duration of the summer, agricultural operations, especially during harvest, require the labour of a great number of persons, for whom, during the long winter, there is little or no employment. This must ever form a great obstacle to agricultural improvement, especially in the northern districts.

Cattle. The length of the winter is also unfavourable to the keeping of cattle, for though there are considerable tracts of good meadows, yet, as the cattle require to be housed from four to six, or seven months in the year, their number is very limited. The horses and horned cattle are small; but the former are active and spirited, and the latter afford excellent milk and beef. The sheep are generally of an inferior kind, but great pains have been taken to improve them by crosses with the French, English, and Spanish breeds. Towards N. lat. 63°, sheep disappear, and are superseded by goats, which are most numerous in the woodland districts of Dalarne and Nordland. In Lapland the reindeer and dog are the only domestic animals. In 1850 the number of horses in the country was 384,464; of horned cattle, 1,807,909; sheep and goats, 1,725,274; and pigs, 556,288. In 1822 the numbers respectively were—horses, 378,353; horned cattle, 1,484,984; sheep and goats, 1,477,709; pigs, 471,814: showing, in horses, an increase in 28 years of only 2 per cent., in horned cattle 22 per cent.; sheep and goats scarcely 17, and in pigs about 18 per cent, while the population had increased during that period 32 per cent. In 1855 there were 1,921,568 horned cattle, and 1,792,070 sheep in the country.

Statistics.

Wild animals.

Wild animals are numerous, especially in the northern parts. Among the more common of these may be mentioned the wolf, bear, fox, lynx, glutton, elk, deer, hares, &c. Among wild birds are eagles, falcons, capercailzies, woodcocks, partridges. Both the sea and the fresh waters swarm with fish, which afford employment and subsistence to many of the inhabitants. The fresh waters contain perch, pike, salmon, trout, grayling, char, roach, bleak, &c.; but of these the salmon is the most important, and is caught abundantly in almost all the rivers and lakes. The sea-fish include the sturgeon, cod, lamprey, ray, sole, turbot, pilchard, herring, and the stromming, a small species of herring.

Mines.

Next to agriculture, the mines of Sweden are the chief source of her wealth. Iron exists in great abundance, and is esteemed the best in the world. The mountain Gellivara in Lapland, 1800 feet in height, is one mass of the richest iron ore; but its situation, beyond the arctic circle (in lat. 67. 20. N.), far from the sea, and in an unpeopled region, deprives it of value. Iron ore, however, is found in almost every district of Sweden. The largest quantities of iron are produced in Carlstad, Orebro, Gefle, Falun, and Westeräs; but the best iron is obtained from the mines of Dannemora, in the län of Upsala. The quantity of iron ore raised, during the five years ending 1854, averaged about 300,000 tons annually; the quantity of pig-iron manufactured was nearly 140,000 tons; and of bar-iron about 100,000 tons. The quantity of bar-iron exported in 1858 was 59,449 tons, and of wrought-iron 2405 tons. This was, however, an unfavourable year, for in 1857 the quantity of bar-iron exported was 85,556 tons; and, in 1856, 83,281 tons. Next to iron, copper forms the most important of the mineral products of Sweden. The most important copper mines are those of Falun in Dalarne; but mines are also worked at Otvidaberg in Linköping-län, Areskuta in Jemtland, Hakanbo in Nerike, Bastras in Westeräs-lån, and other places. The amount of copper obtained in 1855 was 1671 tons. Gold is found at Falun, and a few other places, but the quantity is too small to pay the expense of working. The principal silver mine is at Sala in Westeräs, and the produce of that metal, in 1850, was over 405,000 oz. Of lead about 130 tons were produced, and of nickel 320 tons.

Manufactures.

Manufacturing industry has of late years been making great progress in Sweden. The manufactures of cotton, woollen, linen, and silk stuffs, sailcloth, cutlery, and hardware, paper, glass, earthenware, are all actively carried on. At Motala is a large establishment for the manufacture of steam-engines, iron steamers, &c., employing about 800 men, besides a branch establishment at Norrköping, where 400 more are employed. A very large paper-mill has also recently been established at Motala. Near Hudiksvall extensive saw-mills have recently been erected by an English company at a cost of upwards of L.52,000. The best native cutlery is produced at Eskilstuna, but it is much inferior to the British manufacture. Ship and boat-building is carried on to some extent at most of the ports. The distillation of brandy has of late much decreased, in consequence of a rise in the rate of duty, and other restrictions. In 1835 there were no fewer than 85,172 small, and 670 large distilleries; whereas, in 1855, there were only 3456 small, and 397 large; and, in 1858, 2477 small, and 326 large distilleries. The quantity of spirits produced in 1858 was 5,031,958 gallons, 3,442,749 gallons of which were made in the large distilleries. The amount of revenue derived from the distilleries in 1858 was L.293,530. Little or none of the brandy distilled in Sweden is exported, being almost entirely consumed at home. Domestic manufactures are largely carried on, for which the long winter nights are very favourable. The peasantry make not only their own clothes, but likewise their own furniture and agricultural implements. The following table gives the number of the several kinds of manufactories, the number of workmen employed therein, and the value produced thereat in 1851:—

Manufactories.	Number.	Workmen.	Value.
Cotton and linen	31	1,023	L.55,463
Cloth	156	4,377	470,369
Silk	17	805	75,805
„ ribbon	11	101	4,023
Yarn, linen, and cotton (by machine)	14	2,175	273,291
Sailcloth	12	1,148	31,191
Stockings and socks	18	372	11,332
Sugar	21	679	391,986
Tobacco	79	1,277	134,816
Paper	91	1,299	76,839
Leather	519	1,686	109,721
Dyeing	444	1,639	54,386
Calico printing	20	138	7,370
Glass	17	909	60,376
Porcelain	2	650	33,703
Stone and earthenware	49	332	9,801
Oil mills	65	208	52,841
Porter breweries	1	71	16,260
Wax candles	2	6	846
Stearine candles	2	57	5,280
Soap	12	45	12,040
Rope	23	175	6,904
Clocks and watches	137	313	2,915
Playing cards	11	86	2,994
Paper hangings	14	128	5,668
Chemical manufactories of colours and acids	20	63	4,050
Carriages	19	127	6,676
Chemical tinder-boxes	7	311	5,737
Mechanics workshops	23	857	35,313
Linen yarn spinners	1	118	9,244
Various smaller works	699	2,073	58,222
Total	2,537	23,248	L.2,025,467

In 1854 there were 2413 manufactories employing 25,082 persons, and producing goods to the value of L.2,121,525. The amount of taxes paid by manufacturers on account of their businesses was L.3893.

Trade.

The trade of Sweden is only now beginning to develop itself, having been kept back by the unwise restrictions imposed upon it by the government. These having now, in some measure, been relaxed, commerce is beginning to progress. In 1842 the total value of the imports was L.1,438,130; of the exports, L.1,620,802: in 1849, imports, L.2,126,750; exports, L.2,195,500: 1852, imports, L.2,420,750; exports, L.2,304,833: 1854, imports, L.4,369,750; exports, L.4,400,000: 1856, imports, L.5,880,250; exports, L.5,135,166: and, in 1857 (an unfavourable year) imports, L.4,738,333; exports, L.4,357,417. At the close of the year 1854, the total number of sailing vessels amounted to 2783, of 236,296 tons burden, being a decrease of 42 vessels upon the previous year, but an increase of tonnage to the amount of 6044 tons. During the same year 44 foreign built vessels, of 10,548 tons, were naturalized in Sweden. At the close of 1857 the number of merchant vessels belonging to Sweden was 8190, with 295,410 tons. "I may here mention," says the British consul, in his report on the trade of Sweden during the year 1855, "the very great increase that has taken place in the carrying trade of Sweden since the alteration in the navigation laws in 1849. The number of Swedish vessels employed to carry freight from foreign countries to Englane was 28, tonnage 4176; whereas, in 1854, that number had increased to 212 vessels, with a tonnage of 42,198 (in 1858 the number was 351 vessels, with 77,698). I would at the same time remark, that in consequence of the superior education of the masters and mates of Swedish mercantile vessels, the subordination and steadiness of their crews, combined with great care in loading and unloading their cargoes, they and the Norwegians have become the favourite carriers with merchants of all nations. This pre-

Statistics. ference is not to be attributed to a lower rate of freight although they offer that advantage also; but to the confidence reposed in the zeal and intelligence of the masters and crews of those vessels." "The general foreign commerce of Sweden attained an extent during the year 1854 to which it had never reached before, the amount of imports and exports having exceeded that of the preceding year by about 50 per cent., while it more than doubled the average amount of the five previous years. The value of goods exported in 1854 exceeds that of the imports by L.887,166; while, on the other hand, the value of bullion imported into the country exceeds that of the export to an almost equal amount, viz., L.856,083. This unusual circumstance is chiefly caused by the increased exportation of grain. After deducting the importations in 1854, the whole export of wheat, barley, rye, oats, and peas amounted to L.666,666." In 1856 the total imports from foreign countries amounted (as already stated) to L.5,880,250, and the exports to L.5,135,166, a marked contrast to 1846, when the total imports from foreign countries were L.1,717,000, and the exports L.2,073,000. During the last four years very considerable steps have been taken in the direction of free trade, especially as regards the principal object of Swedish industry, iron and steel, upon the export and import of which heavy restrictions were imposed previously to 1856. The commerce and industry of Sweden, during the years 1857 and 1858, were, as might have been supposed, considerably affected by the monetary crisis which prevailed in Europe and America. The following table shows the amount of trade carried on by Sweden with foreign countries during 1857:—

Countries.	Entered.		Left.		Value.	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Imports.	Exports.
					L.	L.
Norway	812	40,004	571	21,166	491,750	147,250
Finland	674	29,258	384	17,314	92,666	102,833
Russia	363	34 246	80	3,972	419,417	17,083
Prussia	217	14,748	221	13,088	177,000	130,833
Denmark	2,450	52,962	3,692	147,182	265,417	452,916
Mecklinburg	6	520	134	11,908	1,166	38,583
Hanseatic Towns	460	52,418	409	36,256	1,143,416	951,416
Holland	42	6,872	69	10,280	85,916	58,500
Belgium	11	1,644	91	19,490	14,083	50,583
Great Britain	1,154	203,606	1,496	306,410	825,166	1,365,500
France	54	11,640	585	136,296	75,583	469,166
Spain	79	21,230	79	20,082	42,166	75,666
Portugal	38	6,286	66	12,180	20,850	104 000
Italy	30	7,496	18	4,612	25,833	110,666
Austria	3	228	1	202	10,000	3,250
United States	20	10,116	23	12,742	355,833	164,000
West Indies	12	3,500	1	250	126,000	333
Brazil	31	7,240	34	8,222	368,500	41,750
East Indies and Australia	16	5,660	39	21,940	197,666	40,500
Other countries	...	...	130	34,954	...	115,915
In ballast	3,563	432,290	1,764	164,404	...	...
Total in 1857	10,037	921,964	9,787	1,002,950	4,738,333	4,357,416

The foreign trade is principally confined to the ports of Stockholm and Gottenburg.

The following table gives the principal exports from the Swedish ports during each of the years ending November 1856, 1857, and 1858:—

Articles.	1856.	1857.	1858.
Bar iron (tons)	83,280	85,556	59,449
Wrought iron ,,	2,540	2,397	2,405
Other metals ,,	3,515	5,140	7,203
Beams and spars (pieces)	596,556	632,990	544,252
Deals and planks (doz.)	1,014,637	1,129,285	943,892
Deal and batten ends ,,	146,942	148,456	94,448
Masts and poles ,,	12,236	15,646	14,188
Grain of all kinds (qrs.)	355,563	309,784	546,736
Tar (gals.)	1,464,787	1,043,252	860,623

The trade of Sweden with the United Kingdom has within the last few years been rapidly increasing. The following remarks from the report already quoted bear upon the year 1854—"The value of the import trade, which in 1845 amounted to L.200,916 and in 1850 increased to L.277,666, has since risen without interruption. No preceding year however shows so important an increase as that of 1854, when the value of the imports, which in 1853 amounted to L.472,750, rose to L.772,000, in consequence of the increased importation of almost every article. The most remarkable increase is to be observed in the importation of cotton yarn, which more than doubled that of any preceding year. The importation of coal has increased by nearly three hundred per cent. during the last ten years, and the importation of raw cotton from Great Britain, which in the year 1850 amounted to 1,649,160 lbs., had risen in 1854 to 6,675,915 lbs. The value of the exports to Great Britain, which in 1853 amounted to L.1,182,166 (exclusive of the silver coin which was sent to England in that year), rose in 1854 to L.1,924,416, or nearly as much as the whole exports of Sweden in the year 1845. This important increase is chiefly attributable to the unusually great exportation of grain, which amounted to 244,040 quarters, or 131,495 more than the exportation of the preceding year, as well as to the high prices obtained for grain. The export of timber and tar was also much greater in 1854 than in any former year." The following tables give the value of the principal articles of commerce between Sweden and the United Kingdom:—

Exports.

Articles.	Computed real value.			
	1855.	1856.	1857	1858
	L.	L.	L.	L.
Iron, unwrought, in bars.	528,133	559,807	577,998	296,102
,, bloom	3,100	7,726	17,262	10,512
Steel, unwrought	7,116	29,994	37,165	31,313
Timber, not sawn or split	352,978	254,426	310,985	254,954
,, deals, boards, battens, &c.	1,043,954	756,669	484,789	518,356
,, lath and firewood	33,629	34,178	32,413	18,822
Tar	141,079	25,191	8,870	1,388
Corn, wheat	131,511	35,068	12,445	20,495
,, barley	22,930	11,277	49,398	71,684
,, oats	446,633	240,169	297,733	470,585
,, other kinds	39,408	676	2,560	6,992
Bones	2,382	1,630	2,195	3,758
Oil seed-cake	20,220	10,604	9,266	12,392
All other articles	42,098	64,446	69,181	52,191
Total	2,825,171	2,031,861	1,912,260	1,769,544

Imports.

Produce and Manufactures of the United Kingdom.	Declared real value.			
	1855.	1856.	1857.	1858.
	L.	L.	L.	L.
Apparel	4,728	26,156	9,655	7,917
Coal, cinders, and culm	48,447	67,179	79,461	66,785
Copper	6,468	8,122	8,057	6,697
Cotton goods	26,758	26,907	15,415	10,280
,, yarn	146,262	101,163	75,508	37,057
Hardware and cutlery	14,117	22,356	21,479	12,701
Iron, wrought and unwrought, including unwrought steel	88,909	140,992	100,504	130,765
Machinery	83,888	87,991	111,123	59,051
Tin and tin plates	5,709	7,226	6,765	5,807
Woollen goods	63,347	71,618	48,708	22,744
,, yarn	1,437	3,655	1,529	7,617
All other articles	55,314	70,332	81,495	60,723
Total	545,384	629,697	559,699	428,144

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Foreign and Colonial Produce and Manufactures.	Computed real value.			
	1855.	1856.	1857.	1858.
	L.	L.	L.	L.
Coffee	574	1,717	83	23,723
Cotton, raw	137,011	56,155	49,221	117,983
Guano	92,111	53,099	25,700	1,135
Hides, untanned	19,009	22,752	20,898	8,849
Indigo	21,125	23,748	13,387	14,785
Rum	3,264	12,580	1,034	222
Sugar, unrefined	10,725	56,606	15,808	21,733
Tea	5,836	3,668	414	906
Wine	13,560	11,028	11.274	5,534
Wool	19,319	13,137	17,949	3,170
All other articles	39,881	46,305	40,573	23,241
Total	279,515	300,795	196,341	221,281

Roads.

The internal commerce of Sweden is very considerable, and enjoys several advantages. The roads throughout the country are generally good, and for four or five months in the year the whole country is covered with snow, which renders the conveyance of goods by sledges easy and expeditious. The great extent of sea-coast also affords great facilities for internal trade as there are few provinces that are not washed by the sea. The most important canal of Sweden is the Gotha canal which connects the Cattegat and Baltic, and was completed in 1832. It traverses Lakes Wener and Wetter, and has a total length of 260 miles. Another canal connects the river Arboga, which flows into Lake Mälar, with Lake Hielmar. The Södertelge Canal connects Lake Mälar with the Baltic, while the Strömsholms canal unites it with the mineral region of Dalecarlia, terminating in Lake Barken. On this lake is situated the town of Smedjebacken, which is almost entirely composed of forges and ironworks. The first railway constructed in Sweden—that between Nora and Orebro, 23 miles in length—was opened on 5th March 1856, and since that time several others have been opened or are in course of construction. A branch line from Dylta, on the Orebro-Nora line, 12 miles long, connects these towns with Arboga, and a short line connects the two towns of Malmö and Lund. A line between Stockholm and Gottenburg is in course of formation, and is open for traffic from Gottenburg to Toreboda, a distance of about 113 miles. The railway between Gefle and Falun is nearly completed, and is open for traffic for two-thirds of its length.

Canals.

Railways.

Inhabitants.

The inhabitants of Sweden are Swedes, Fins, and Laplanders. The Swedes are a branch of the same family as the Danes and Norwegians, and speak a dialect of the same language, considerably modified, however, in consequence of the long political separation and international enmity of the two nations. Books are translated from the one language to the other, but the language of the peasantry in Norway and Sweden does not differ more than broad Scotch and Cockney English. The roots of the words, construction and idioms, are the same in both, or have a common origin. The Fins are supposed to have at one time occupied the whole country, and to have been driven to the forests and fastnesses of the North by an irruption of Goths some centuries before our era. They are now few in number, and are to be found as colonists, here and there, in some of the northern provinces. The Laps also inhabit the north, but they are said not to amount to more than 4000.

In 1751, the population of Sweden amounted to 1,785,727; in 1800, it was 2,347,303; in 1830, 2,888,082; and in 1850, 3,482,541. Sweden is divided into three large districts, viz., Norrland in the north, Swealand or Sweden Proper in the centre, and Götaland or Gothland in the south; and into 24 läns or provinces, which with their areas and populations at the end of 1850 and 1855 were as follows:—

Läns.	Area in English square miles.	Population.		Chief Towns.	Population.
		1850.	1855.		1855.
SWEALAND—					
Stockholm	2,902	114,643	117,193	Södertelje	1,332
Upsala	2,067	89,323	90 828	Upsala	8,006
Westeras	2,660	96,661	98,941	Westeras	4,085
Nyköping	2,505	120,113	123,689	Nykoping	3,956
Orebro	3,260	137,660	142,863	Orebro	5,807
Carlstadt	6,935	221,885	232,521	Carlstadt	4,128
Fahlun	12,247	151,497	158,755	Fahlun	4,618
GÖTALAND—					
Malmo	1,779	253,084	268,664	Malmö	15,808
Christianstadt	2,427	189,627	196,121	Christianstadt	5,594
Halmstadt	1,900	105,726	110,815	Halmstadt	3,072
Carlscrona	1,130	107,827	111,255	Carlscrona	14,513
Wexio	3,779	136,623	143,707	Wexio	2,960
Jonköping	4,283	163,426	166,462	Jönköping	6,684
Calmar	4,256	202,178	212,565	Calmar	7,554
Lynköping	4,247	222,484	230,601	Lynköping	5,733
Mariestadt	3,312	199,897	208,771	Mariestadt	2,195
Wenersborg	5,031	246,136	254,505	Wenersborg	3,289
Gottenburg	1.889	187,583	196,390	Gottenburg	29,164
Wisby	1,225	44,572	46,985	Wisby	4,852
NORRLAND—					
Gefleborg	7,553	120,158	126,368	Gefle	9 587
Hernosand	9,497	99,558	107,717	Hernosand	3,103
Ostersund	19,113	52,271	56,041	Ostersund	1,144
Umea	29,356	70,758	75,994	Umea	1,654
Pitea	32,984	55,751	63,629	Pitea	1,545
Lakes	3,553	...	...	...	...
Stockholm City.	...	93,070	97,952	...	...
Total	169,880	3,482,541	3,639,332	...	...

Most of these läns have other names, as Westeras, Westmanland; Nyköping, Södermanland; Carlstadt, Wermland; Fahlun, Kopparberg; Halmstads, Halland; Carlskrona, Blekinge; Wexio, Kronsberg; Lynkoping, Östergothland; Mariestad, Skaraborg; Wenersborg, Elfaborg; Wisby, Gottland; Hernosand, Westernorrland; Ostersund, Jemtland; Umea, Westerbottens; Pitea, Norrbotens. The following are the other towns having in 1855 more than 2000 inhabitants:—Eshilstuna (4031) in the län of Nyköping; Norrkoping (17,116) and Wadstena (2236) in Lynköping; Westervik (5038) in Calmar; Carlshamn (5214) in Carlscrona; Lund (7254), Ystadt (5056), Landscrona (4833), and Helsingborg (4473) in Malmö; Warberg (2360) in Halmstadt; Uddewalla (3859) in Gottenburg; Boras (2815) in Wenersborg; Lidköping (2883), and Skara (2096) in Mariestadt; Christinshamn (2002) in Carlstadt; Sala (3308) and Arboga (2387) in Westeras; Hudiksvall (2266) and Söderhamn (2183) in Gefleborg; and Sundsvall (3661) in Hernosand. At the beginning of 1859 Stockholm had 101,502 inhabitants, Gottenburg 30,576, Norrkoping 18,062, Malmö 16,823, and Carlscrona 14,513. The population of the 90 towns of Sweden had increased from 378,394 in the end of 1855 to 398,142 in the beginning of 1859. In 1855, the male population was 1,764,118, the female 1,875,214; in 1850, males 1,687,248, females, 1,795,293. Of the male population in 1850, 10,074 were engaged in trade and commerce; 12,566 in the merchant service; 37,808 in manufactures; 55,465 in arts and handicrafts; 40,514 in the army and navy; 8917 landed proprietors; 166,308 owners and cultivators of land; 40,621 tenants; 96,810 peasants on private land; 17,026 peasants on crown land; 80,215 able-bodied cottagers, &c.; 832,145 sons of peasants, labourers, &c., above 10 years of age; 2664 gardeners, &c.; 3430 islanders and fishermen; 25,232 domestic servants; 5530 clergymen, professors, and masters of universities and public schools.

Classes.

The people of Sweden are divided into four classes—the nobility, clergy, burghers, and peasants. The aristocracy of Sweden is among the oldest in Europe, and consists of about 2400 families, numbering in all about 11,000 persons of both sexes. They at one time exercised

Nobles.

Statistics. great power and possessed a fifth part of the kingdom, but now their landed possessions are estimated at under L.6,000,000, which gives an average of less than L.2500 to each family. Hence many of this class are very poor; yet so great is their pride and so absurd are their notions as to what may compromise their personal dignity, that as a class they repudiate all commercial or industrial pursuits, and prefer remaining in a state of penury rather than make an effort to relieve themselves by means which their false ideas proclaim to be derogatory. Every office in the state, about the court, and in the army, is eagerly sought for by the aristocracy, while appointments that require any deep knowledge of the sciences, or demand profound study, are generally left to those of more plebeian birth. Not that this arises from any want of capacity in the higher ranks, but from their strict adherence to the rules and traditions of caste.

Clergy. Next in order after the nobility is the clergy, at the head of whom is the archbishop of Upsala; besides whom there are eleven bishops. There are in all nearly 1300 beneficed clergymen, while about 1900 more are attached to the universities and other educational establishments, or are not invested with full pastoral charges, the whole with their families amounting to about 15,000 persons male and female. The fixed revenues of the church are derived from property valued at about L.85,000; but independent of this, the clergy receive incomes from tithes, official grants, and some casual sources which produce sufficient funds to give a comfortable and even liberal stipend to every incumbent. The established religion is Lutheran, and the clergy as a whole, are a highly educated, intelligent, and respectable body of men. Charges of immorality are seldom brought against them, and even complaints of laxity of principle are not frequent. They conscientiously discharge the routine duties of their office, but they possess little of that true spirit of Christianity by which alone the preaching of the gospel can be made effectual. Baptism and confirmation are indispensable to the holding of any office, or even to the possession of civil rights. A Swede cannot marry before being confirmed; neither can he take oath as a witness in any court. Hence it is that the sacred ordinances of religion have come to be generally regarded as mere forms, necessary to the enjoyment of certain privileges, and true religious feeling and pure morality are at a very low ebb. A religious spirit, however, has been manifesting itself lately in certain parts of Sweden; and a dissenting sect known as Läsere or readers, from their reading the Scriptures, are becoming numerous, especially in the north. They meet with great opposition from the clergy, for though Protestant, the Established Church in Sweden is an eminently persecuting church, and as such is supported by the civil laws. The exercise of other religious worships is indeed permitted under certain restrictions, but no one but a member of that church can hold any office, and dissenters are debarred from the enjoyment of many privileges; while every proselyte from the national creed is subject to fine, imprisonment, confiscation of property, and even to banishment. In 1856, certain proposals were laid before the diet in the royal speech, for the purpose of granting some degree of toleration to other sects, and in particular for the abrogation of the punishment of banishment for apostacy; but such was the influence of the clergy that the measure was negatived in the houses of assembly. The archbishop and bishops are nominated by the king from a list of candidates presented to him by each diocese. Literary, scientific, or administrative talents are qualifications quite as likely to assist their possessor to a bishopric as any amount of piety or deep theological lore. The Swedish clergy possess an unlimited control over the national education of the country which is under the immediate direction of each diocesan consistory, a body invested with considerable powers, composed of the principal clergy, and presided over by the bishop. It appoints all schoolmasters, disposes of many clerical offices, and presents pastors to nearly all the livings not in the royal gift. It also unites judiciary with administrative powers, judging in all causes relating to the spiritual concerns of the church, or education, adjudicating in cases where the clergy are guilty of any dereliction in their ecclesiastical duties, and deciding in complaints against the parochial assemblies.

Burgesses. The third class is the burgesses, in which there are about 70,000 persons of both sexes possessing real property to the amount of about L.3,000,000. They are members of guilds or handicrafts in the cities, or iron manufacturers, or have been in the magistracy. The privileges secured to this class have acted very injuriously upon the industry and trade of the country. Connected with every trade or craft is a guild or corporation, the members of which are by law secured in the possession of certain important rights and privileges. The fourth order, that of peasants, comprises in all about 2,250,000 persons, and possesses landed property to the value of about L.15,000,000.

Peasants. These peasants are a well-educated, intelligent, prudent, and industrious class of people. They are all land-owners, and by their wealth they are gradually absorbing much of the land that is passing from the hands of the nobility. It is calculated that between 1831 and 1841 land to the value of L.1,500,000 was sold or mortgaged from the demesnes of the Swedish nobility.

Besides these four orders there are upwards of 1,200,000 persons in Sweden without any representatives in the legislature. These consist chiefly of the labouring population, but they also include a numerous body possessing considerable landed and personal property, members of the learned professions, distinguished literary and scientific men, and others who have amassed fortunes by their talents and industry. (See *Danes and Swedes*, by C. H. Scott, London, 1856; from which work we have principally derived the preceding account of the several classes of the people.)

The Diet. The diet or parliament of the kingdom is composed of representatives of each of the four orders. The chief of every noble family has by right a seat in the diet, and has even the power of appointing a substitute in case of non-attendance. Usually, however, not more than 400 attend the meetings of the diet. This arises partly from the inability of many of them to bear the expenses; and also from a feeling of pride which leads them to abstain from taking a part in public affairs. The clerical order is represented at the diet by 72 members, of whom the archbishop of Upsala, the eleven bishops, and the *pastor primarius* of Stockholm, are *ex officio* members, the others being elected by and from the clergy of the dioceses. Among these are included a certain number of lay professors from the universities and the academy of sciences; but those from the last must be neither of noble blood nor hold any but purely civil rank. The clergy are the most independent and influential of the four estates, and hence they exercise a great influence over the proceedings of the diet. The burgesses rank as the third order, and elect 102 representatives to the diet. To be eligible for election the candidate must belong to the order of burgesses, be twenty-five years of age, and profess the Lutheran faith. The peasants, or fourth order, are represented at the diet by 150 members. The diet assembles at Stockholm every fifth year, and usually sits for three or four months. The representatives of each of the three lower orders are paid by their constituents during the sitting of the diet. Each body assembles separately for discussion and deliberation, and an ordinary measure is carried if three out of the four orders pass it; but all constitutional questions must receive the sanction of the whole. When a measure is supported or opposed by two of the orders, it is either dropped or submitted for decision to a committee composed of an equal number of members from each order. The king nominates the presi-

Statistics. dent of each of the three orders of nobles, burghers, and peasants, and possesses an absolute veto on all decrees affecting the constitution passed by the diet; but has no controlling power over their deliberations. He has the right to introduce measures for their consideration, but cannot impose new taxes nor contract loans without their sanction.

Government. The government is a hereditary monarchy in the male line. The council of state is nominated by the king, and is composed of ten members, including a minister of justice, a minister of foreign affairs, and the heads of each of the departments of finance, the interior, marine, ecclesiastical affairs, and war. The king cannot decide in any matter of government without consulting the council, except in such as refer to military or diplomatic affairs. The king is Commander-in-Chief of the Forces by land and sea, but no requisition of men or money can be made for purposes of war without the full consent of parliament. Careful provision is made for the impeachment of the Council of State if they are found to have counselled the king to unconstitutional measures, or have themselves transgressed the laws of the kingdom. The liberty of the press is one of the fundamental provisions of the constitution.

The 24 läns of Sweden are subdivided into 117 *faegderier*, or districts, each comprising one or more *härader*, or cantons. At the head of each län is a governor, who is charged with its civil and military jurisdiction and the receipt of the revenue. Every canton is under the superintendence of an executive officer. There are 264 harad courts, or courts of original jurisdiction, with a judge presiding over each. These courts sit three times a year, and 12 peasants are elected by the peasantry of each härad to serve as jurymen for two years. There are three royal judicial courts, viz., at Stockholm, Jönkopping, and Christianstad. The supreme court of justice, or final court of review, is composed of 12 councillors, and presided over by the chancellor of justice.

Education. Elementary instruction is very generally diffused in Sweden. It is reckoned that of the whole population, even including the Laps, the proportion of grown-up persons unable to read is less than one in a thousand. Parents in even the humblest circumstances are able to give instruction to their children in reading and writing; and every adult must give proof of ability to read before he can exercise any act of majority. This general diffusion of elementary instruction is ascribed to the zeal of Gustavus Vasa (1523-1560) and his immediate successors. John III., in 1574, ordered that any nobleman having no knowledge of book-learning should forfeit his nobility. Charles XI., in 1684, required the clergy to have every Swedish subject taught to read, and decreed that no marriage should be celebrated unless the parties had previously taken the Lord's Supper; and that none should be allowed to communicate who could not read and was not instructed in religion. In 1842 a law was passed commanding the erection of a school in each parish; but owing to the sparseness of the population, this was found to be in many cases impracticable, and hence the necessity in many parts for ambulatory schools. According to the census of 1850, there were 143,526 children receiving instruction at the parochial schools; 126,178 at ambulatory schools; 6228 at public schools; 17,465 at private schools, and 128,996 at home; making in all 422,393 children receiving instruction. There are also in most of the towns gymnasia or grammar schools for preparing students for the universities. In 1856 a new law was promulgated, with the view of establishing an efficient system of secondary education. At Stockholm and Gottenburg there are normal schools for the training of teachers. There are two universities in the country, those of Upsala and Lund. The Upsala university was founded in 1477 by Sten Sture the elder. It received its greatest endowments from Gustavus Adolphus, and has continued to be the leading university in Sweden. It has faculties of philosophy, law, medicine, and theology; and in 1859 had 31 professors and 1451 students. The annual expenditure is about L.17,500. The Lund university was founded in 1668, and has also four faculties. The number of students in 1859 was 610; professors, 28; substitutes, 18. The annual expenditure is about L.14,300. Every one, before entering the church or practising either law or medicine, is compelled to take his degree; while candidates for many government offices are required to take degrees in philosophy previous to entering upon a particular study of the sciences necessary to a proper fulfilment of their duties. The examinations are all of a high standard, and well adapted to test the qualifications of the individuals submitted to them.

Crime. The prevalence of immorality and crime in a country like Sweden is not a little remarkable. The general diffusion of education and religious instruction, and the pursuits of the people being chiefly agricultural, would lead one to expect a low rate of crime. Such, however, is very far from being the case. In 1835 the number of persons prosecuted for criminal offences was 26,275, of whom 21,262 were convicted, 4915 acquitted, and 42 under examination; there being thus 1 prosecution for every 114 of the population, and 1 conviction for every 140. The number of prisoners in Stockholm in 1850 was 3394, or 1 to 28 of the population; while in the whole of Sweden the proportion of prisoners was 1 to 261 of the population. This high rate is doubtless in some measure to be accounted for from certain peculiarities in its criminal code. Thus there are many offences of a very venial kind, which cannot with any propriety be called crimes, considered and punished as such in Sweden; but even after making every allowance for such cases, there still remains enough to show that crime in Sweden is unusually high. Illegitimacy is very prevalent in Sweden, especially in Stockholm and the other towns. In Stockholm in 1850 the total births were 3190, of whom 1424, or nearly one-half, were illegitimate; in the other towns the total number of births were 7805, of whom 1538 were illegitimate; while in the country districts, of 99,404 births, only 7358 were illegitimate; making for the whole country a total of 100,079 legitimate, and 10,320 illegitimate.

Army. The Swedish army is composed of four different kinds of troops, viz., the enlisted or regular troops, the *indelta*, the Gothland militia, and the conscription. The regular troops (*värfrade*) amount to about 7692 men, of whom nearly two-thirds are artillery and 1000 cavalry. They usually serve for six years. The *indelta* is composed of men furnished and supported by the landed proprietors. Every holder of a certain amount of crown-land is bound to provide a man, to whom he assigns a croft of land with a cottage, and pays a small annual money allowance. The croft is cultivated by the soldier himself while at home, and during his absence on service by the landholder for his behoof. Once a year during four weeks they are called out for drill. They are retained as long as they are considered fit for service. This force numbers about 33,400 men. The Gothland militia is specially for the defence of that island, and amounts to about 7620 men. The conscription or militia is composed of males between the ages of 20 and 25, all of whom are bound to serve or procure substitutes. They are assembled once a year for drill and exercise, and amount to about 95,000 men. The total force amounts to 144,000 men, besides officers.

Navy. The navy of Sweden consists of 10 ships of the line, 6 frigates, 4 corvettes, 4 brigs, 9 steam-corvettes, 20 war schooners, 77 large and 122 smaller gun-boats, with other crafts, making in all 897 vessels of all kinds. The permanent seamen at command of the government amount to about 8000. They are maintained in the same manner as the

indelta troops, by assignments of land. Including conscripts, the whole naval force may be raised to about 24,000 men.

Revenue. The revenue for each of the three years ending 1860 was estimated at L.1,450,670, of which L.449,140 was from land-tax and other perpetual revenues, and L.1,001,530 from customs, stamps, and other taxes voted at every diet. The ordinary expenditure for each of these years was estimated at L.1,397,726; but besides this there was an extraordinary expenditure extending over the three years of L.1,462,927, which was to be met by reserved funds and others, estimated to amount to L.1,573,609. (D. K.)

SWEDENBORG, Emanuel, was born at Stockholm, in Sweden, in January 1689. His father was bishop of Skara in West Gothland; member of a society for the propagation of the Gospel, formed on the plan of that of England; and president of the Swedish Church in Pennsylvania and London. To this last office he was appointed by Charles XII. who seems to have had a great regard for the bishop, and to have continued that regard to his son. Of the course of young Swedenborg's education we have procured no account; but from the character of the father, it may be supposed to have been pious; and by his appearing with reputation as an author when but twenty years of age, it is proved to have been successful. His first work was published in 1709; and the year following he sent into the world a collection of pieces on different subjects, in Latin verse, under the title of *Ludus Heliconius, sive Carmina Miscellanea quæ variis in locis cecinit.* The same year he began his travels, first into England, afterwards into Holland, France, and Germany, and returning to Stockholm in 1714, he was two years afterwards appointed to the office of assessor in the Metallic College by Charles XII., who honoured him with frequent conversations, and bestowed upon him a large share of his favour. At this period of his life Swedenborg devoted his attention principally to physic and mathematical studies; and in 1718 he accompanied the king to the siege of Frederickshall, where he gave an eminent proof that he had not studied in vain. Charles could not send his heavy artillery to Frederickshall, from the badness of the roads, which were then rendered much worse than usual by being deeply covered with snow. In this extremity Swedenborg brought the sciences to the aid of valour. By the help of proper instruments he cut through the mountains and raised the valleys which separated Sweden from Norway, and then sent to his master two galleys, five large boats, and a sloop, loaded with battering pieces, to be employed in the siege. The length of this canal was about 2½ miles. The execution of this great work, however, did not occupy all his time. In 1716 he had begun to publish essays and observations on the mathematical and physical sciences, under the title of *Dædalus Hyperboreus;* and he found leisure during the siege to complete his intended collection, and also in the same year to publish an introduction to algebra, under the whimsical title of the *Art of the Rules.*

At the siege of Frederickshall he lost his royal patron; but he found another in Ulrica Eleonora, the sister and successor of that hero, by whom, in 1719, he was created a baron. His promotion did not lessen his ardour for the sciences; for he published in the same year *A Method to fix the Value of Money, and to determine the Swedish Measures in such a way as to suppress all the Fractions and facilitate the Calculations.* About the same time he gave the public a treatise on *The Position and Course of the Planets;* with another on *The Height of the Tides, and Flux and Reflux of the Sea;* which, from information gathered in different parts of Sweden, appeared to have been greater formerly than when he wrote.

As Swedenborg continued, under the new sovereign, to hold the office of assessor to the Metallic College, he thought it necessary, for the discharge of his duty, to make a second journey into foreign countries, that he might himself examine their mines, particularly those of Saxony and Harts. During these travels, which were undertaken for the improvement of the manufactures of his native country, he printed at Amsterdam *Prodromus Principiorum Naturalium sive novorum Tentaminum Chemiam et Physicam experimentalem geometrice explicandi; Nova Observata et Inventa circa Ferrum et Ignem, præcipue Naturam Ignis elementarem, una cum nova Camini Inventione; Methodus nova inveniendi Longitudines Locorum terra marique ope Lunæ; Modus construendi Receptacula Navalia vulgo en Dockybynadder; Nova Constructio Aggeris Aquatici; Modus explorandi Virtutes Navigiorum;* and at Leipzig and Hamburg, *Miscellanea Observata circa Res Naturales, præsertim Mineralia, Ignem, et Montium Strata.* This journey was made, and these tracts published, in the compass of a year and a half; and perhaps there has not been another man, Linnæus excepted, who has done so much in so short a time. After his return in 1722, Swedenborg divided his time so equally between the duties of his office and his private studies, that in 1733 he finished his grand work, entitled *Opera Philosophica et Mineralia* and had it printed under his own direction in 1734, partly at Dresden and partly at Leipzig. During the same year he also went to inspect the mines of Austria and Hungary. The work is divided into three volumes folio. The title of the first is *Principia Rerum Naturalium, sive novorum Tentaminum Phænomena Mundi elementaris philosophice explicandi;* of the second, *Regnum Subterraneum, sive Minerale de Ferro;* and the third, *Regnum Subterraneum, sive Minerale de Cupro et Orichalco.* The whole is written with great strength of judgment; and the work is ornamented with plates to facilitate the comprehension of the text.

In the year 1729 he was enrolled among the members of the Society of Sciences at Upsala, and was, probably about the same time, made a fellow of the Royal Academy of Sciences at Stockholm; nor were strangers less willing than his own countrymen to acknowledge the greatness of his merit. Wolfius, with many other learned foreigners, was eager to court his correspondence. The Academy of St Petersburg sent him, on the 17th of December 1734, a diploma of association as a corresponding member; and soon afterwards the editors of the *Acta Eruditorum,* published at Leipzig, recognised in his works some acceptable contributions to useful knowledge.

By many persons the approbation of learned academies would have been highly valued, but by Baron Swedenborg it was considered as of very little importance. "Whatever of worldly honour and advantage may appear to be in the things before mentioned, I hold them," says he, "but as matters of low estimation, when compared to the honour of that holy office to which the Lord himself hath called me, who was graciously pleased to manifest himself to me, his unworthy servant, in a personal appearance, in the year 1743, to open in me a sight of the spiritual world, and to enable me to converse with spirits and angels; and this privilege has continued with me to this day. From that time I began to print and publish various unknown *Arcana,* which have been either seen by me or revealed to me, concerning heaven and hell, the state of men after death, the true worship of God, the spiritual sense of the Scriptures, and many other important truths tending to salvation and true wisdom. (*Short Account of the Hon. E. Swedenborg.*)

Swedenborgians.

After this extraordinary call, Swedenborg dedicated himself wholly to the great work which, he supposed, was assigned him, studying diligently the Word of God, and from time to time publishing to his fellow-creatures such important information as was made known to him concerning another world. Among his various discoveries concerning the spiritual world, one is, that it exists not in space. "Of this," says he, "I was convinced, because I could there see Africans and Indians very near me, although they are so many miles distant here on earth; nay, that I could be made present with the inhabitants of other planets in our system, and also with the inhabitants of planets that are in other worlds, and revolve about other suns. By virtue of such presence, I have conversed with apostles, departed popes, emperors, and kings; with the late reformers of the church, Luther, Calvin, and Melanchthon, and with others from distant countries." (Swedenborg's *Universal Theology*, vol. i. p. 87.) Notwithstanding the want of space in the spiritual world, he tell us, "that after death a man is so little changed that he even does not know but he is living in the present world; that he eats and drinks, and even enjoys conjugal delight, as in this world; that the resemblance between the two worlds is so great, that in the spiritual world there are cities, with palaces, and houses, and also writings and books, employments and merchandises; that there are gold, silver, and precious stones there." "In a word," he says, "there is in the spiritual world all and everything that there is in the natural world, but that in heaven such things are in an infinitely more perfect state. Such was his zeal in the propagation of these peculiar doctrines, that he frequently left his native country to visit distant cities, particularly London and Amsterdam, where all his theological works were printed at great expense, and with little prospect or probability of a reimbursement. "Wherever he resided when on his travels, he was," says one of his admirers, "a mere solitary, and almost inaccessible, though in his own country of a free and open behaviour. He affected no honour, but declined it; pursued no worldly interest, but spent his time in travelling and printing, in order to communicate instruction and benefit to mankind. He had nothing of the precise in his manner, nothing of melancholy in his temper, and nothing in the least bordering on enthusiasm in his conversation or writings." He died at London, March 29, in the year 1772; and after lying in state, his remains were deposited in a vault at the Swedish church, near Radcliff-Highway.

SWEDENBORGIANS. Among the first disciples of the Swedenborgian faith were two clergymen of the Church of England, the Rev. Thomas Hartley, who translated the work on *Heaven and Hell;* and the Rev. John Clowes, translator of the *Arcana Cœlestia.* In December 1783, eleven years after Swedenborg's decease, an advertisement brought 5 persons to meet together for reading and conversation, which number had increased to 30 in 1787. About this time the formation of a definite religious society was commenced; provision was made for public worship; and a system of ministerial ordination was adopted. At the fifteenth conference, held in Manchester in August 1822, there were 8 ministers and 37 delegates, representing 24 congregations. At the census of 1851, the number of congregations was ascertained to be 50, of which the greater number were in Lancashire and Yorkshire. It is considered, however, by members of the body, that the mere number of their chapels gives a very inadequate idea of the prevalence of their opinions; many, they say, ostensibly connected with other churches, entertain the prominent doctrines of the New Church. The principal societies for disseminating the doctrines of the New Church in England are, the "Swedenborg Printing Society," established in 1810, and the "Missionary and Tract Society," established in 1821.

The doctrines held by the New Church of Emmanuel Swedenborg will be seen from the following "Articles of Faith." These were not written by Swedenborg, but were drawn up by order of the Annual Conference of Ministers and Laymen, by whom the affairs of the body, as at present constituted, are managed.

Swedenborgians.

"The Articles of Faith of the New Church, signified by the New Jerusalem in the Revelation, are these:—

"1. That Jehovah God, the Creator and Preserver of heaven and earth, is Love itself and Wisdom itself, or Good itself and Truth itself; that He is One both in Essence and in Person, in whom, nevertheless, is the Divine Trinity of Father, Son, and Holy Spirit, which are the Essential Divinity, the Divine Humanity, and the Divine Proceeding, answering to the soul, the body, and the operative energy in man; and that the Lord and Saviour Jesus Christ is that God.

"2. That Jehovah God himself descended from heaven as Divine Truth, which is the Word, and took upon him human nature, for the purpose of removing from man the powers of hell, and restoring to order all things in the spiritual world, and all things in the Church; that He removed from man the powers of hell, by combats against and victories over them, in which consisted the great work of redemption; that by the same acts which were His temptations, the last of which was the passion of the cross, He united in His humanity, Divine Truth to Divine Good, or Divine Wisdom to Divine Love, and so returned into His divinity, in which He was from eternity, together with and in His glorified humanity; whence He for ever keeps the infernal powers in subjection to Himself; and that all who believe in Him, with the understanding from the heart, and live accordingly, will be saved.

"3. That the Sacred Scripture, or Word of God, is Divine Truth itself, containing a spiritual sense heretofore unknown, whence it is divinely inspired, and holy in every syllable; as well as a literal sense, which is the basis of its spiritual sense, and in which Divine Truth is in its fulness, its sanctity, and its power; thus, that it is accommodated to the apprehension both of angels and men; that the spiritual and natural senses are united by correspondences, like soul and body, every natural expression and image answering to and including a spiritual and divine idea; and thus that the Word is the medium of communication with heaven, and of conjunction with the Lord.

"4. That the government of the Lord's Divine Love and Wisdom is the Divine Providence, which is universal, exercised according to certain fixed laws of order, and extending to the minutest particulars of the life of all men, both of the good and of the evil; that in all its operations it hath respect to what is infinite and eternal, and makes no account of things transitory, but as they are subservient to eternal ends; thus, that it mainly consists with man in the connection of things temporal with things eternal; for that the continual aim of the Lord, by His Divine Providence, is to join man to Himself, and Himself to man, that He may be able to give him the felicities of eternal life; and that the laws of permission are also laws of the Divine Providence, since evil cannot be prevented without destroying the nature of man as an accountable agent; and because, also, it cannot be removed unless it be known, and cannot be known unless it appear; thus, that no evil is permitted but to prevent a greater; and all is overruled by the Lord's Divine Providence for the greatest possible good.

"5. That man is not life, but is only a recipient of life from the Lord, who, as He is Love itself and Wisdom itself, is also Life itself; which life is communicated by influx to all in the spiritual world, whether belonging to heaven or hell, and to all in the natural world, but is received differently by every one, according to his quality, and consequent state of his reception.

"6. That man, during his abode in the world, is, as to his spirit, in the midst between heaven and hell, acted upon by influences from both, and thus is kept in a state of spiritual equilibrium between good and evil; in consequence of which he enjoys freewill, or freedom of choice, in spiritual things as well as in natural, and possesses the capacity of either turning himself to the Lord and His kingdom, or turning himself away from the Lord, and connecting himself with the kingdom of darkness; and that, unless man had such freedom of choice, the Word would be of no use; the Church would be a mere name; man would possess nothing by virtue of which he could be conjoined to the Lord, and the cause of evil would be chargeable on God himself.

"7. That man at this day is born into evil of all kinds, or with tendencies towards it; that therefore, in order to his entering the kingdom of heaven, he must be regenerated or created anew; which great work is effected in a progressive manner, by the Lord alone, by charity and faith as mediums during man's co-operation; that as all men are redeemed, all are capable of being regenerated, and consequently saved, every one according to his state; and

that the regenerate man is in communion with the angels of heaven, and the unregenerate with the spirits of hell; but that no one is condemned for hereditary evil, any further than as he makes it his own by actual life; whence all who die in infancy are saved, special means being provided by the Lord in the other life for that purpose.

"8. That repentance is the first beginning of the Church in man; and that it consists in a man's examining himself both in regard to his deeds and his intentions, in knowing and acknowledging his sins, confessing them before the Lord, supplicating Him for aid, and beginning a new life; that to this end, all evils, whether of affection, of thought, or of life, are to be abhorred and shunned as sins against God, and because they proceed from internal spirits, who in the aggregate are called the Devil and Satan; and that good affections, good thoughts, and good actions are to be cherished and performed, because they are of God and from God; that these things are to be done by man as of himself; nevertheless, under the acknowledgment and belief that it is from the Lord, operating in him and by him; that so far as man shuns evils as sins, so far they are removed, remitted, or forgiven; so far also he does good, not from himself but from the Lord; and in the same degree he loves truth, hath faith, and is a spiritual man; and that the Decalogue teaches what evils are sins.

"9. That Charity, Faith, and Good Works are unitedly necessary to man's salvation; since charity without faith is not spiritual but natural, and faith without charity is not living but dead, and both charity and faith without good works are merely mental and perishable things, because without use or fixedness; and that nothing of faith, of charity, or of good works, is of man, but that all is of the Lord, and all the merit is His alone.

"10. That Baptism and the Holy Supper are sacraments of Divine institution, and are to be permanently observed,—baptism being an external medium of introduction into the Church, and a sign representative of man's purification and regeneration, and the Holy Supper being an external medium of those who receive it worthily, of introduction as to spirit into heaven, and of conjunction with the Lord; of which also it is a sign and seal.

"11. That immediately after death, which is only a putting off of the material body, never to be resumed, man rises again in a spiritual or substantial body, in which he continues to live to eternity; in heaven if his ruling affections, and thence his life, have been good; and in hell if his ruling affections, and thence his life, have been evil.

"12. That *now* is the time of the Second Advent of the Lord, which is a coming not in Person, but in the power and glory of his Holy Word. That it is attended, like His first coming, with the restoration to order of all things in the spiritual world, where the wonderful Divine operation, commonly expected under the name of the last judgment, has in consequence been performed; and with the preparing of the way for a New Church on the earth—the first Christian Church having spiritually come to its end or consummation through evils of life and errors of doctrine, as foretold by the Lord in the Gospels; and that this New or Second Christian Church, which will be the Crown of all churches, and will stand for ever, is what was representatively seen by John, when he beheld the holy city, New Jerusalem, descending from God out of heaven, prepared as a bride adorned for her husband."

In Sweden, Germany, France, America, and the British colonies, the faith of Swedenborg has taken partial root. Richer of Nantes has used his eloquence in favour of the new faith; Moet and Tulk have likewise translated Swedenborg into French. The greatest of his German followers is Dr Tafel, and the greatest of his English disciples is J. J. Garth Wilkinson.

SWEERTS, Jacques Thierri, a Dutch general, born at Gorcum in 1759. At an early age he entered the army, and in 1792 had risen to the rank of colonel. In the following year he served with distinction in the campaign between his country and France; but on the conquest of Holland and the flight of the stadtholder, to whom he was warmly attached, he left the service, and remained in retirement till 1813. On the retreat of the French from Holland, the provisional government raised Sweerts to the rank of general; and in that capacity he did much to bring about the restoration of the Orange family. William Frederick, on his accession, appointed him governor of the palace at the Hague, where he died in 1820.

SWIETAN, Gerard Van, an eminent Dutch physician, was born at Leyden in 1700. He studied at Louvain, and subsequently at Leyden, where he soon became the favourite pupil of Boërhaave. Having graduated in medicine, he was soon after appointed to a professorship, but objection was taken to his being a Roman Catholic, and he was forced to resign his claim. In 1745 he was chosen first physician to Maria Theresa of Austria, and he used all his influence for many years to improve the scientific standing of the city of Vienna. The work by which he is now chiefly know to physicians is his *Commentaria in Hermanii Boerhavii Aphorismos de cognoscendis et curandis morbis*, 5 vols. 4to, 1741–42. Swietan was created a baron of the empire of Austria by Maria Theresa. He died in 1772, and a statue has been erected to his memory in the hall of the University of Vienna.

SWIFT, Jonathan, D.D., Dean of St Patrick's, the most original writer of his own, and perhaps the greatest satirist of any age, was born in Hoey's Court, Dublin, November 30, 1667. Like Pope's, his family was of Yorkshire origin; in the time of Charles I. the representative of one branch had obtained a peerage which expired with him. The first of his own immediate ancestors known to us was a clergyman, rector of St Andrew's, Canterbury, from 1569 to 1592, whose son succeeded him in that living, and whose grandson was the Rev. Thomas Swift, vicar of Goodrich in Herefordshire, renowned for his eccentricity, his mechanical ingenuity, and above all for his stubborn devotion to Charles I., and the persecutions he underwent in consequence. Plundered thirty-six times, ultimately ejected from his living, he died in 1658, leaving his thirteen children a small and greatly impoverished landed estate, and the questionable advantage of a substantial claim on the gratitude of the restored sovereign. More fortunate than most who have kings for debtors, his eldest son Godwin soon obtained the Attorney-Generalship of the Palatinate of Tipperary. This piece of good fortune naturally attracted other members of the family across the channel,—among them Jonathan, one of the youngest of nine brothers, but already husband of Abigail Ericke of Leicester, a lady of descent more ancient and means more limited than his own. A student of law, but never called to the bar, Jonathan appears to have subsisted for some years on windfalls and casual employments. At length (1665) he became steward of the King's Inns (answering to the inns of court in England), an office of small emolument. Two years afterwards he died suddenly, leaving an infant daughter, and a widow pregnant with the future Dean of St Patrick's. So embarrassed had his circumstances been, that although considerable debts were owing to the estate, Mrs Swift was for the moment unable to defray the expense of his interment. Thus Swift's first experience of life was that of a dependant on the charity of his uncles, more particularly of Godwin. It is easy to conceive the effect of perpetual indigence and mendicancy on a spirit like his, and the inevitable bitterness of the situation was aggravated by the grudging manner in which the Tipperary official seemed to dole out his parsimonious help. In fact, the apparently prosperous relative was the victim of unfortunate speculations, and preferred the reproach of avarice to the acknowledgment of the humiliating truth. A virulent resentment became ingrained into the youth's whole nature, and though ultimately acquainted with the real state of the case, he never mentioned his uncle with kindness or respect. Other relatives did more to merit his regard. Yet he took no pride in his Irish connections or nativity, and a singular adventure in his infancy seems to have afforded him a pretext for insinuating that he was really born in England. When he was but two years old, his nurse, a native of Whitehaven, was recalled to that town by an illness in her family. So attached had she become to her charge, as to clandestinely carry him away with her. Mrs Swift was induced to consent to his remaining with her for a time, and the child spent three years in

Cumberland. By his return his education had made considerable progress, and in the next year he was sent to the grammar school at Kilkenny. There can be no question as to the author of *Gulliver* having been a remarkable child, but unfortunately only one anecdote of his school-days has been preserved. It is the story, graphically narrated by himself, of his having once invested the whole of his pocket-money in the purchase of an old horse condemned to the knacker's yard, his momentary triumph over his school-fellows, and his mortification on discovering the uselessness of his acquisition; an anecdote highly characteristic of his daring, pride, and ambition, and from which, instead of the moral he professed to discover, he might have derived an augury of the majestic failure of his life.

In his fifteenth year, and equipped, as is probable, with no more than the literary *supellex* usually brought away from a country grammar-school, Swift was matriculated at Trinity College, Dublin. The history of his residence there is the history of many another youth of parts, fallen upon an unpropitious era in the annals of learning, and restrained, by the very mental superiority which would have triumphed in any worthy competition, from contending for a garland of dead leaves. At that period, the logic of the schoolmen was the beginning, the middle, and the end of Dublin university education. Swift subsequently became as finished a classical scholar as an irregular training would allow; his understanding proved fully capable of apprehending the principles and the utility of those mathematical studies to which his taste by no means naturally inclined; but his reasoning powers must have been less remarkable than was the case, had they allowed him to fancy them assisted by the study actually enforced upon him. He might undoubtedly have accommodated himself to this had he so willed; a stronger proof of his contempt and distaste, therefore, could not well be produced than the ignorance which, on standing for his bachelorship in February 1686, he displayed of the very definition of a syllogism. The degree for some time withheld was at length conferred *speciali gratia*, and the mortifying record stands against his name to this day in the college books. This disgrace, never ascribed to incapacity by any reader of the Dean of St Patrick's, the college contemporaries of poor uncouth Jonathan Swift would have thought it absurd to attribute to any other cause. Swift doubtless incurred the contempt of the whole university; and it is in the ferocity of his wounded pride that we must seek the explanation of the irregularities which marked the latter part of his academical career. Within little more than two years after his humiliation, the future champion of establishments, civil and ecclesiastical, had undergone no fewer than twenty-two penalties for breaches of discipline, besides the degradation of a public apology to the junior dean, Dr Owen Lloyd. Barren as his residence was of university honours, it is by no means likely that his time elapsed in indolence, or that his freaks and irregularities absorbed the whole energy of his mind. His subsequent period of intense study will hardly account for the whole extent of desultory information evinced by his writings, and, if we can rely on a tradition referring the first draught of the *Tale of a Tub* to this epoch, it must be allowed that his mental powers were developed with a very unusual precocity.

In 1688 Swift quitted the university, and, after a brief residence with his mother at Leicester, entered the family of Sir William Temple as amanuensis, on a salary, it is said, of L.20 per annum. A distant relationship between his mother and Lady Temple appears to have recommended him to this post, which his pride must have struggled to accept, and which it hardly suffered him to retain. The relations of patron and dependent are at best delicate and precarious; and if Swift was of all men the first to wince under any slight offered to his dignity, the precise and finical Temple was of all the last to condescend to any abatement of his own. As minister and diplomatist, Temple had rendered great and durable services; if he afterwards abstained from public affairs, it was chiefly from a doubt whether his ungrateful country deserved salvation at such illustrious hands. If he solaced his voluntary ostracism by a comparison with the elegant retirement and lettered ease of Cicero, it did not therefore occur to him to compare his obscure Irish secretary with the Roman orator's amanuensis Tiro, who had, at least, invented short-hand. We who know that in the patron's place the dependent would have governed the nation, need not be surprised at finding, full twenty years afterwards, the iron of servitude still rankling in the latter's haughty soul. He nevertheless made himself useful to his employer, who on one occasion rendered him the medium of a confidential communication to King William, who had consulted Temple on the bill for triennial parliaments, then sanctioned by both branches of the legislature. Swift did his best to enforce Temple's arguments in favour of the measure, and was in after life wont to refer to the failure of his rhetoric as the most useful lesson his vanity had ever received. Struck, it would seem, rather by the physical than the mental endowments of the robust young Irishman, William offered him a troop of horse, a proposal which appears to have been subsequently commuted into a promise of church preferment. Swift had already proceeded to the degree of M.A. at Oxford, and the execution of his design to embrace the ecclesiastical profession was hastened by a quarrel with Temple, occasioned by the latter's reluctance to contract any definite engagement to provide for him. Throwing up his employment, he passed (1694) over into Ireland, but found his views impeded by the refusal of all the bishops to ordain him without some certificate of the regularity of his deportment while in Temple's family. Five months passed ere he could bring himself to solicit this favour from his old patron, which he ultimately did in a letter submissive in appearance, but charged to the full with smothered rage and intense humiliation. Forgiveness was easy to one in Temple's place and of Temple's disposition, and he not only despatched the requisite testimonials, but added a recommendation which obtained for Swift the living of Kilroot, in the diocese of Down and Connor. His residence here was not fated to be of long duration. Temple, who knew his value and had not parted with him willingly, soon let him understand that a return was open to him, and Swift, whose resentment was cooled by time and soothed by the discovery of his indispensableness, lent an unreluctant ear to the overture. He continued to reside with Sir William till the latter's death in 1698; nor does their intimacy appear to have been troubled by any further disagreement. A story representing his return from Ireland as a flight necessitated by a disgraceful action, has been fully exposed as a crazy calumny invented long after his death; another ascribing it to a generous relinquishment of his living in favour of a more needy clergyman, would seem, like more than one other tradition respecting him, to be less supported by any convincing testimony than by his Irish biographers' ideas of the abstract fitness of things.

Lord Macaulay has justly pointed out the familiarity with public affairs acquired by Swift at Moor Park as one main cause of his subsequent distinction as a politician, and here, too, he laid the foundation of his literary renown. Report asserts him to have read regularly for eight hours every day; and we have his own authority for his having, as early as 1691, "written and burned, and written again, more on all manner of subjects than perhaps any man in England." His fortitude was probably more commendable than his fecundity; at least the only relics of these early days belong to a species of composition in which he was little qualified to excel. Nature had denied him the poet's eye, the poet's

ear, and the poet's soul; nor would he, probably, have sought the laurel from a generation less hopelessly unfeeling, unimaginative, and unmusical. At a period, however, when the merit of the poet was rated by his intellectual vigour, Swift might climb without much fear of a fall. If his strains were no better poetry than the effusions of Pomfret and Stepney, they were at all events much better prose, and if tried simply by the standard of his other works, are frequently entitled to no inconsiderable praise. Some pieces, such as *Baucis and Philemon*, are models of easy familiar elegance; the conception of others is highly ingenious; another class, of which the *Petition to Harley* may be considered as the type, blend the grace of idyl with the grace of comedy. Nothing can be more perfect in its kind than the *Description of a City Shower*, unless it be the *Grand Dispute respecting Hamilton's Bawn;* and Swift's satirical and epigrammatical powers could only gain point by submitting to metrical restraint. Poetry worthy of the name he did not and could not write; and his only serious attempt in this direction—the luckless series of *Pindaric Odes*—is chiefly memorable for the severe and unforgiven remark it called forth from his kinsman Dryden—"Cousin Swift, you will never be a poet." Swift's first prose composition betrayed his resentment. In the *Battle of the Books*, a satirical contribution to the controversy on the *Letters of Phalaris*, written, or rather purloined from a French prototype, about 1697, his sarcasm for the first and last time recoiled upon himself. The satire against Dryden and Bentley wants, indeed, nothing but truth to be excellent; but the picture of the former in his monstrous helmet, and the latter in his patchwork mail, yield in ludicrousness to the idea of the author of the *Pindaric Odes* presuming to ridicule the author of *Absalom and Achitophel*, and the inglorious student of Trinity College, Dublin, entering the lists against the pride of Trinity College, Cambridge, on a question of classical scholarship. It is, however, to his credit that his learning was somewhat greater than that of any other writer on his side, and his pretensions incomparably less.

Swift's next literary labour, though accomplished with credit, proved less serviceable to his fortune than he had anticipated. This was his edition of Temple's posthumous works, a charge bequeathed to him as a valuable legacy. They appeared with a dedication to King William, which was to have made the editor a prebendary. A petition to this effect miscarried, as he always believed, through the negligence or ill-will of the nobleman who undertook to present it. He may have been mistaken, as William's esteem for Temple, notoriously not very great, still surpassed his regard for Swift and complimentary dedications. Be this as it may, he had become too important to be overlooked, and soon obtained the post of secretary and chaplain to Earl Berkeley, one of the Lords Justices of Ireland. The better half of this appointment, however, escaped him on his arrival in that country, his secretaryship being transferred to a Mr Bushe, on the pretext of the incompatibility of such a post with clerical functions. Bushe, indeed, seems to have been much better qualified to realise the popular ideal of a dispenser of official patronage; for when Lord Berkeley had at length an opportunity of recompensing Swift's disappointment by the gift of the deanery of Derry, the secretary's influence was successfully exerted in favour of another clergyman, who had gained his interest by the judicious outlay of a thousand pounds. With bitter indignation Swift threw up his chaplainship, but was ultimately reconciled to his patron by the presentation to the rectory of Agher, in Meath, with the united vicarages of Laracor and Rathbeggin. For the first time in his life he might now call himself his own master, and had an opportunity of exhibiting, free from suspicion of external constraint, that stern regard to duty which constituted the noblest and not the least prominent feature of his character. In an age of general laxity—in a priest of an alien church, whose most energetic servants commonly succumbed to the mortifying conviction of their uselessness, and the detestation they excited among the people for whom they laboured—the parishioners of Laracor found a clergyman more censurable for the ostentatious discharge than the easy neglect of his duty, and heard, or might have heard, service three times a week. The energy, however, which probably gained the respect, certainly failed to influence the convictions of his Catholic flock. We have his own authority for reckoning his average congregation at "half a score;" and on one occasion his clerk Roger was his only auditor. In fact, his exertions in the pulpit were more meritorious than his achievements; he entirely lacked the fire, the self-oblivion, the expansive geniality of the orator. He himself characterised his discourses as "pamphlets;" and if meant to imply their arid and argumentative character, the criticism is indisputably just. It must be added that they are no models for pamphleteers even, and his resolution to exchange theology for politics must appear fully justified on a comparison of these inconclusive essays with another performance of the same period. The *Discourse on the Dissensions in Athens and Rome*, written in the Whig interest, and intended as a dissuasive from the pending impeachment of Somers and three other noblemen, received the honour, extraordinary for the maiden attempt of a young politician, of being universally attributed to Somers himself, or to Burnet, the latter of whom found a public disavowal necessary. Three years later appeared a more remarkable work. Clearness, cogency, masculine simplicity of diction, are conspicuous in the pamphlet, but true creative power told the *Tale of a Tub*. "Good God! what a genius I had when I wrote that book!" was his own exclamation in his latter years. Johnson correctly signalises a distinction between the style of this and of his other humorous writings; at the same time, the difference lies rather in accidentals than essentials. Its merits and faults are the merits and faults of youth—the youth of a Titan, who extravagates and luxuriates in the wantonness of strength, and in careless magnificence showers away the energies which maturity would have circumscribed within a single channel, and directed to a definite end. Viewed simply with reference to its literary characteristics, the work may be called a prose *Don Juan;* and as in that marvellous hybrid between epos and satire, ostentatious planlessness, laxity of structure, and digression for digression's sake, become ultimately somewhat fatiguing. As the fascination of Byron's poem for the general reader is summed up in Julia and Haidee, so, of all the humorous ideas lavished in the *Tale of a Tub*, the three supernatural coats and Lord Peter's quintessential loaf have alone taken a firm hold of the popular imagination. Either, it is true, is sufficient for one man's fame. As to the charges of profanity drawn down upon Swift by the reckless exuberance of his humour, it is easier to understand how they should have come to be made than why his biographers should have condescended to refute them.

Before the publication of the *Tale of a Tub*, Swift had taken a step destined to exercise a most important influence on his life, by inviting two ladies to Laracor. Hester Johnson, a dependent of Sir William Temple's, whose acquaintance he had made in the latter's family, and whom he has immortalised as "Stella," came over with her *chaperon*, Mrs Dingley, and was soon permanently domiciled in his neighbourhood. The melancholy tale of Swift's attachments will be more conveniently narrated in another place, and is only alluded to here for the sake of chronology. Meanwhile the sphere of his intimacies was rapidly widening. He was a frequent visitor to London, and counted Pope, Steele, and Addison among his friends. The success of his pamphlet gained him ready access to all Whig circles; but already his confidence in that party was shaken,

and he was beginning to meditate that change of sides which has drawn down upon him so much but such wholly unjustifiable obloquy. The true state of the case may easily be collected from his next publications—*The Sentiments of a Church of England Man*, and *On the Reasonableness of a Test.* The vital differences among the friends of the Hanover succession were not political, but ecclesiastical. From this point of view, Swift's sympathies were entirely with the Tories. As a minister of the Church, he felt his duty and his interest equally concerned in the support of her cause; nor could he fail to discover the inevitable tendency of Whig doctrines, whatever caresses individual Whigs might bestow on individual clergymen, to abase the whole Establishment, by dispelling the last gleams of that aureole of mystic reverence so irrecoverably dimmed at the Reformation. Utterly incapable of either rising to an elevated conception of religion, or of regarding the interests of the Church from a cosmopolitan point of view, he considered her as a corporation, and advocated her cause in the spirit of an attorney. One of his pamphlets, written about this time, contains his recipe for the promotion of religion, and is of itself a sufficient testimony to the extreme materialism of his views. Censorships and penalties are among the means he recommends; and to him the city owes in great measure the fifty new churches of which it is now a problem how to get rid. His pen was exerted to better purpose in the *Argument against Abolishing Christianity*, a piece of irony most consummate and inimitable.

From February 1708 to April 1709 Swift was in London, urging the claims of the Irish clergy to an increased endowment upon the Godolphin administration. His having been selected for such a commission shows that he was not yet regarded as a deserter from the Whigs, although the ill success of his representations probably helped to make him one. By November 1710 he was again domiciled in London, and in the first pages of his remarkable *Journal to Stella* we find him depicting the decline of Whig credit, and complaining of the cold reception accorded him by Godolphin, whose penetration had doubtless detected the precariousness of his allegiance. Within a few weeks he had become the lampooner of the fallen treasurer, the bosom friend of Oxford and Bolingbroke, and the writer of the *Examiner*, a journal established as the exponent of Tory views. He was now a power in the state, the intimate friend and recognised equal of the first writers of the day, the associate of ministers on a footing of perfect cordiality and familiarity. By his own account, his credit had procured the fortune of more than forty deserving or undeserving clients; and the envious but graphic description of his demeanour preserved to us by Bishop Kennet,[1] attests the real dignity of his position no less than the airs he thought fit to assume in consequence. The cheerful, almost jovial, tone of his letters to Stella evinces his full contentment; nor was he one to be moved to gratitude for small mercies. To understand this extraordinary influence, never since vouchsafed to a politician precluded by his profession from serving his party with his voice as well as his pen, two or three circumstances peculiar to the time must be taken into account. Since the age of Anne, the immense extension of the area of politics has necessitated a proportionate division of labour among political writers. No one pen could discuss, no single understanding embrace, the various subjects of which the press now takes cognisance. Every influential journal possesses a large staff of contributors, and must represent some nice shade or peculiarity of opinion. In Swift's time journalism was a more simple matter. Daily papers merely reported the news of the day; the higher class journals appeared weekly, and were then entirely occupied with a single essay, or, in our present parlance, leading article. The sole authorship of such a publication was consequently quite possible to a writer of moderate industry, and the enlistment of such a partisan in that day corresponded to the establishment of a new weekly organ in ours. Till Swift's accession to their cause, moreover, the preponderance of intellect had been decidedly against the Tories. To have found a writer capable of combating and even overthrowing Addison and Steele, was for the ministry of that day what the miraculous advent of a new *Times*, antipodal to the old in all but talent, would now be to an administration powerfully assailed by that journal. Given Swift's indispensableness to the ministers, he had it in his power to determine the nature of his social relations with them; and it will readily be inferred that he was not the man to rest contented with anything short of precise and almost ostentatious equality. Here, again, the circumstances of the time were in his favour. Like the France of Louis Philippe, the England of Anne was the paradise of political adventurers. Ancient names were erased or eclipsed, old notabilities ostracised, the leading men held positions to which they could not have aspired at a more settled period, and which fresh adventurers were preparing to occupy in their turn. This community of character, of history, and of destiny, engendered a frank and genial tone in political circles. Men were quick to discern and esteem in others the qualities which had wrought out greatness for themselves. As officers and privates become intimates on the field of battle, so servility and assumption were forgotten in the excitement of the time.

Great as was Swift's merit towards his party as conductor of the *Examiner*, it was surpassed by that belonging to him as author of the two famous pamphlets, *The Conduct of the Allies*, and *The Barrier Treaty*, devoured rather than read by the nation. Here, again, circumstances were highly favourable to him. For eight years the great captain of the age had fed the country with a succession of triumphs, till exultation had become satiety. One last poignant and exquisite relish remained—to be told that all these conquests had been made for ungrateful allies, and that England was the worst used as well as the most victorious nation upon earth. To have profited by Marlborough's genius was much; to have found a pretext for disowning obligation even more. The victor of Blenheim's private character was more assailable than his military conduct, and it was easy for Swift to extenuate the popular ingratitude which must soon have manifested itself, with a justification or without. The necessity of peace had, indeed, become as clear as the futility of expecting peace at the hands of Godolphin and Marlborough; so that Swift unquestionably rendered his country a service, while he wreaked his fury on the fallen statesmen with the sinister exultation of a morose and unbelieving nature, delighting in nothing more than the abasement of great achievements and great names.

Generous men like Oxford and Bolingbroke cannot have been unwilling to reward so serviceable a friend, especially when their own interest lay in keeping him in England. Notwithstanding, therefore, some dubious expressions in Swift's letters, natural to the deferred hope, we need not doubt their having actually used their best efforts to obtain for him the vacant see of Hereford. Swift, however, had formidable antagonists in the Archbishop of York, whom the *Tale of a Tub* had scandalized, and who had previously frustrated the instances of Godolphin for his promotion, and in the Duchess of Somerset, whom he had inconsiderately lampooned. Charles the Second had not been more amenable than Anne to the influence of female favourites, and it must be considered a proof of the strong interest made for Swift, that she was eventually persuaded to appoint him to the deanery of St Patrick's, Dublin, vacant by the

[1] Kennet particularly notices his zeal in procuring subscribers for the works of "one Mr Pope (a Papist")."

removal of Bishop Sterne to Dromore. In June 1713 he set out to take possession of his benefice, from which he was speedily recalled by the dissensions between the chiefs of his party. His exertions in behalf of the Irish clergy, it should be observed, had been fully successful with the Tory ministry, and his disgust was not small on finding the gratitude of his clients incommensurate with their obligations.

He found affairs in a desperate condition on his return. The Queen's demise was evidently at hand, and the same instinctive good sense which had ranged the nation on the side of the Tories, when Tories alone could terminate a fatiguing war, rendered it Whig when Tories manifestly could not be trusted to maintain the Protestant succession. In any event the occupants of office could merely have had the choice of risking their heads in an attempt to exclude the Elector of Hanover, or of waiting patiently till he should come and eject them from their posts; yet they might have remained formidable, could they have remained united. To the indignation with which he regarded Oxford's refusal to advance him in the peerage, the active secretary added an old disgust at the treasurer's pedantic and dilatory formalism, as well as his evident propensity, while leaving his colleague the fatigues, to engross for himself the chief credit of their administration. Their schemes of policy diverged as widely as their characters; Bolingbroke's brain teemed with the wildest plans, which Oxford might have more effectually discountenanced had he been prepared with anything in their place. Swift's endeavours after an accommodation were as fruitless as unremitting. There is no necessity so evident, no community of interest so radical, no entreaty so powerful, as to reconcile an able man to one whom he despises, or a proud man to one by whom he feels himself despised. Swift's mortification was little likely to temper the habitual virulence of his pen, which rarely produced anything more acrimonious than the attacks he at this period directed against Burnet and his former friend, Steele. One of his pamphlets against the latter (*The Public Spirit of the Whigs*) was near involving him in a prosecution; some invectives against the Scotch having proved so exasperating to the peers of that nation, that they repaired in a body to the Queen to demand the punishment of the author, of whose identity there could be no doubt, although, like all Swift's writings, except the *Proposal for the Extension of Religion*, the pamphlet had been published anonymously. The immediate withdrawal of the offensive passage, and a sham prosecution instituted against the printer, extricated Swift from his danger.

Meanwhile the crisis had arrived, and the discord of Oxford and Bolingbroke had become patent to all the nation. Foreseeing, as is probable, the impending fall of the former, Swift retired to Upper Letcombe, in Berkshire, and there spent some weeks in the strictest seclusion. This leisure was occupied in the composition of his remarkable pamphlet, *Free Thoughts on the State of Public Affairs*, which indicates his complete conversion to the bold policy of Bolingbroke. The utter exclusion of Whigs as well as Dissenters from office, the remodelling of the army, the imposition of the most rigid restraints on the heir to the throne,—such were the measures which, by recommending, Swift tacitly admitted to be necessary to the triumph of his party. If he were serious, it can only be said that the desperation of his circumstances had momentarily troubled the lucidity of his understanding; if the pamphlet were merely intended as a feeler after public opinion, it is surprising that he did not perceive how irretrievably he was ruining his friends in the eyes of all moderate men. Bolingbroke's daring spirit, however, recoiled from no extreme, and, fortunately for Swift, he added so much of his own to the latter's MS., that the author was obliged to recall a production which might not improbably have cost him his liberty and his benefice. This incident but just anticipated the revolution which, after Bolingbroke had enjoyed a three days' triumph over Oxford, drove him into exile and prostrated his party, but enabled Swift to perform the noblest action of his life. Almost the first acts of Bolingbroke's ephemeral premiership were to order him a thousand pounds from the exchequer, and despatch him the most flattering invitations. The same post brought a letter from Oxford, soliciting Swift's company in his retirement; and, to the latter's immortal honour, he hesitated not an instant in preferring the solace of his friend to the offers of St John. When, a few days afterwards, Oxford was in prison and in danger of his life, Swift begged to share his captivity; and it was only on the offer being declined that he finally directed his steps towards Ireland, where he was very ill received. The draught on the Exchequer was intercepted by the Queen's death.

Oxford was not the only friend for whom Swift proved capable of entertaining a fraternal regard; his intimacy with Pope and Arbuthnot was creditable to all three. At the epoch of the fall of Marlborough they had joined in writing *The History of John Bull*, of which, however, by far the largest share belongs to Arbuthnot, whose broad, genial humour, better adapted to conciliate the reader's sympathy than to overawe him by a display of intellectual power, is as unlike as possible to Swift's scathing thunderbolts, and deluges of gall and vitriol. On one chapter, indeed, that recommending the education of all blue-eyed children in depravity for the public good, it is impossible to avoid the verdict, *Aut Decanus aut Diabolus*. Some time before the fall of the Tory administration, the three friends were again united in writing *Martinus Scriblerus*, a satire whose pleasing geniality again betrays Arbuthnot's principal share in its composition. Swift may have contributed one of the digressions, and two passages in ridicule of his old enemies the mediæval logicians. In the masterly *Treatise on the Bathos*, the finical but intense touch of Pope is very observable. Swift's literary partialities occasioned several other satirical pamphlets, such as the cruel attack on John Dennis: he is more agreeable, though not more amusing, when following the bent of his own humour in ridiculing the impostures of the almanac-makers and the eccentricities of Whiston, and otherwise treading with no unequal pace in the track of "Eupolis atque Cratinus, Aristophanesque poetæ." Many of his best poems belong to this period; a more laboured work, his *Memorial* to Harley, recommending the regulation of the English language by an academy, is chiefly remarkable as evincing the deference paid to French taste by the most original English writer of his day. To sum up the incidents of this eventful section of his life, it was during it that he lost his mother and sister; the first, always most tenderly beloved and dutifully honoured, by death; the second by an imprudent marriage, which, though making her a liberal allowance, he never forgave.

Swift's misfortunes had hitherto been no other than may well befall whoever embarks on the tempestuous ocean of politics, but the real tragedy of his life was now at hand. We have already mentioned his invitation of Hester Johnson and Mrs Dingley to Ireland. Both before and after his elevation to the deanery of St Patrick's, these ladies continued to reside in his vicinity, and superintend his household during his absences in London. Such an intimacy could not but originate unfavourable surmises, nor would the most charitable easily conjecture why, with his evident delight in the society of Stella (a dark-haired and symmetrical beauty, endowed with excellent sense and charming temper, and not more brilliant of eye than wit, albeit a grievous offender against all rules of orthography), he did not at once secure it to himself by the simple expedient of matrimony. It may, perhaps, appear in the sequel

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that his conduct was not incapable of explanation, but it proved none the less the fatal embitterment of his life, and Stella's, and yet another's. During his long residence in London, he had involuntarily kindled a consuming passion in the breast of Esther Vanhomrigh, the Vanessa of his poetry and correspondence, daughter of a deceased commissioner of stores, and then residing in Bury Street, with her mother and sister. The relation he in the first instance assumed towards this young lady was, without doubt, that of an instructor and literary mentor. Instinct might suggest, were experience silent, the facility with which the teacher's interest and the pupil's affection may glide into emotions of a warmer cast. In this instance, the lovers were matched like coin and die. Of genuine love, at least of the pure essence of the passion, disengaged from all alloy of duty or personal advantage, Swift was constitutionally incapable. The finest and most exquisite emotions were dead in him, or had never lived. His breast never admitted, or rather never needed to exclude, any feeling incapable of expression in precise language, or of vindicating itself at the bar of reason.[1] To him a wife would have been nothing more than a friend in a peculiar relation, for which, after all, he could see no necessity, and he probably found Stella and Vanessa's cravings for a closer bond both puzzling and vexatious. So remarkable a deficiency in one portion of the mental organisation supposes an excessive development in some other. In Swift, the atrophy of the affections was compensated by the excrescence of intellectual pride. The surest way to his heart was to suffer him to domineer, and, like most of her sex, Vanessa was a born idolatress. Her character, sufficiently unfolded in the letters first published by Sir Walter Scott, is that of a being all compact of enthusiasm and imagination. These were the genii that had first reared her a splendid image of masculine perfection, and then filled up the abyss between her ideal and Swift. If no submission could disarm his tyranny, neither could any severity satiate her passion for martyrdom. If his arrogance rejected the idea of sacrifice for another's sake as humiliation, her fervour would have cooled before a shrine that required no victim. She speaks of his frowns with rapture, and reserves her agonies for his indifference. Such intensity of passion may well have captivated a mind formed to appreciate impetuous strength; such self-abandonment may have momentarily eclipsed the quiet self-devotion of the absent Stella. In the earlier part of his journal, addressed to the latter, Swift lays bare his feelings with an impassioned unrestraint which renders it the best authority for his character in our possession. The concluding portions are comparatively frigid; Vanessa's advances were clearly not discouraged as they should have been. Yet his regard for Stella was not extinct, nor his ties such as he could break without infamy. For fourteen years Stella had cheered, comforted, amused him. For fourteen years she had lived on patiently in the hope of one day becoming his wife, careless of the slur her equivocal position was casting on her reputation. That nothing might be wanting to his obligations, he had already (in 1706) been the means of her declining an advantageous offer of marriage; his understanding would not allow him to overlook his duty, or his conscience to acquiesce in its non-performance. If, while a mysterious obstacle prevented his marriage, his weakness allowed him to become irremediably entangled with Vanessa, the misery of his victims cannot have surpassed his own. He probably hoped that his return to Ireland would enable him to break off the connection, but he hoped in vain. Vanessa's mother died, and she followed him. Thus was he involved in the most miserable embarrassment; still for a time he continued to temporise. At length, unable to bear any more Stella's mute reproach, and his own consciousness of wrong, he gave a reluctant consent to a private marriage, which was accordingly performed in the Deanery garden by the Bishop of Clogher. This was in 1716. At the same time, he insisted on their union being kept a strict secret, justifying a demand really dictated by tenderness for Vanessa, and probably by another reason which he did not explain, on the most futile and frivolous pretexts. Never more than a nominal wife, the unfortunate Stella commonly passed for his mistress till the day of her death, bearing her doom with uncomplaining resignation, and consoled by unquestionable proofs of the permanence of his affection, if his strange feeling for her deserves the name. Meanwhile, his efforts were directed to soothe Miss Vanhomrigh, to whom he addressed *Cadenus*[2] *and Vanessa*, the best of his poems, and for whom he sought to provide honourably in marriage, without either succeeding in his immediate aim or in thereby opening her eyes to the hopelessness of her passion. In 1717, probably at his instance, she retired from Dublin to Marley Abbey, her seat at Celbridge. For three years she and Swift remained apart, but in 1720, on what occasion is uncertain, he began to pay her regular visits. Sir Walter Scott found the Abbey garden still full of laurels, several of which she was accustomed to plant whenever she expected Swift, and the table at which they had been used to sit was still shown. But the catastrophe of her tragedy was at hand. Worn out with his evasions, she at last (1722) took the desperate step of writing to Stella, demanding to know the nature of her connection with him, and this terminated the melancholy history as with a clap of thunder. Stella replied by the avowal of her marriage, sent her rival's letter to Swift, and retired to a friend's house. Swift rode down to Marley Abbey with a terrible countenance, petrified Vanessa by his frown, and departed without a word, flinging down a packet which only contained her own letter to Stella. Vanessa died within a few weeks.

Five years afterwards (January 1727) Stella followed her to the grave. Two months of intense agony, spent by Swift in seclusion in the south of Ireland, had procured his forgiveness; and the anguish which the gradual decay of her health evidently occasioned him is sufficient proof of the sincerity of his attachment, as he understood it. It is a just remark of Mr Thackeray's, that he everywhere half-consciously recognises her as his better angel, and dwells on her wit and her tenderness with a fondness he never exhibits for any other topic. Yet he could never overcome his repugnance to acknowledge their union till she lay on her deathbed, when he was heard by Mrs Whiteway (his cousin, a lady of fortune and talent, who, though not residing with him, superintended his household during his latter years) to say, *Well, my dear, if you wish it, it shall be owned.* She answered, *It is too late.* A lock of her hair is preserved, with the inscription in Swift's handwriting, most affecting in its apparent cynicism, *Only a woman's hair!*

Though the subject is delicate and invidious to the last

[1] His *debut* as a lover had been unlucky. In 1694, while in Ireland, he had been smitten with a Miss Jane Waryng, whom he straightway proceeded to idealise as "Varina," and woo in the high-flown style of the age. Varina then discouraged his suit on the ground of ill-health, but, two years afterwards, finding her constitution improved, or her matrimonial prospects uncertain, she made him advances in her turn. Swift's mind had also changed, and he could find no better way out of his dilemma than an ill-bred and insulting letter, affecting to accept her proposition on terms which he knew must put further correspondence out of the question.

[2] An anagram of *Decanus*. Some one observed to Stella that this Vanessa must have been an extraordinary woman on whom the Dean could write so finely. "I do not see that," returned Stella, "for" (alluding to one of Swift's satirical pamphlets, a burlesque on Boyle), "all the world knows that the Dean can write finely upon a broomstick!"

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degree, it would be a cruel offence against Swift's memory to refrain from adverting to the strong probability of the mysterious impediment to his union with Stella having been of a physical and, therefore, an insuperable description. External evidence of this is necessarily wanting, but the internal seems almost to amount to a moral certainty. Without recourse to such a hypothesis, his conduct appears inexplicable. The obstacles he alleged are palpable evasions; his attachment to Vanessa will neither account for his reluctance to contract a marriage with Stella before his acquaintance with her rival, nor for his refusal to acknowledge it after the latter's death. On the supposition alluded to (powerfully corroborated by the entire absence of erotic sentiment from his writings) the grounds of his conduct are sufficiently obvious, and it can only be said that he preferred the ruin of Stella's happiness to an avowal which nothing short of absolute compulsion has ever extorted from any man. It should also be remembered that his natural insensibility to the refinements of passion must have rendered it very difficult for him to realise the misery he was occasioning. His conduct to Vanessa certainly remains unaffected by these considerations, and if there be any to whom the voluntary and enthusiastic homage of beauty is without allurement, these have undoubtedly earned the right to pronounce a severe condemnation. Yet even they should reflect that human actions are properly estimated by their intrinsic character, not by their consequences. Thousands have committed similar errors, unexpiated by similar remorse; but the pangs of *their* Vanessas have proved amenable to time and reason, and their biographers (if any) have taken no cognisance of the matter. The fervour of Vanessa's passion was a terrible misfortune for Swift; let it not be made his crime. Without actually mitigating his culpability, a happier *denouement* would have disarmed the austerity of his censors. It is obvious that on our theory (which is also Sir Walter Scott's), the supposition of a criminal intercourse between Swift and either Stella and Vanessa falls to the ground of itself. On any theory, it is unsupported by evidence, and inconsistent with his character.

During the interval between the deaths of Vanessa and Stella, Swift made three excursions to England, from the last of which he was recalled by the tidings of Stella's illness. The same period witnessed the two greatest literary successes of his life.

While yet hoping to gain an establishment in England Swift had paid little attention to Irish affairs. His residence at Dublin familiarised him with misery and misgovernment, and having begun by hating and despising the Irish, he finished by identifying himself with their cause. In the pamphlet entitled *A Proposal for the Universal Use of Irish Manufactures* (1720) he expressed himself with a boldness that occasioned the prosecution of his printer. The iniquitous conduct of the chief-justice secured a conviction; but public feeling rose to a height that intimidated the government, and no sentence was passed. This proved but the prelude to more momentous incidents. In 1723, a bribe to George the First's mistress obtained for a person named Wood the privilege of coining L.108,000 in halfpence and farthings, and circulating the same throughout Ireland. The Irish Parliament and executive not having been consulted at all, the patent proved as exasperating to the Protestant governing class as to the oppressed Catholics. It was then that Swift sent forth the seven famous letters subscribed M. B., Drapier.[1] These culminating productions of his pamphleteering genius must not be judged with reference to the abstract merits of the question they discussed. Wood was not a villain, or his coinage spurious, or his patent ruinous or even pernicious to the country. Ireland was assailed, not in her pocket, but in her independence, which would have been no less affronted had Wood proposed to distribute his coins at half-price. Under cover of an attack on him, Swift denounced the whole system of government, and first of Irishmen raised the cry, Ireland for the Irish! It elicitted a burst of feeling comparable to that which Charles the First had excited in England by levying ship-money, or James the Second by imprisoning the seven bishops. Soon Swift took a wider range, and denounced abuses without disguise. The public enthusiasm accompanied him, and Walpole was told that it would take 10,000 men to effect his arrest. His printer was an easier victim. Swift visited his prison in disguise, and listened unmoved to the solicitations of the honest tradesman's friends that he would deliver himself by revealing his employer. The might of public opinion soon brought more effectual and honourable relief. Ere long the captive was liberated, the patent withdrawn; and if Ireland suffered more than ever from a want of small currency, she had, at all events, the satisfaction of a victory over the Saxon. The Drapier was toasted at every table,[2] his head was made a sign, medals were struck, and clubs instituted in his honour, and the affection of his countrymen, for once wisely as well as warmly bestowed, never forsook him till his death.

It was in 1726 that *Gulliver* rendered Swift immortal. This, with *Robinson Crusoe* and *Pilgrim's Progress*, belongs to the class of books whose very diffusion reacts against their celebrity. The inimitable simplicity of these works at once brings them into the hands of every child, kindles the rapture with which every child peruses them, and occasions the indifference with which he in after-life confounds them with the other amusements of his infancy. Let the adult reader recur to them, and he will find that, like the miraculous coats in the *Tale of a Tub*, the companion of his boyhood has grown up with his own intellectual stature, and proves as adapted to his maturity as to his nonage. What seemed in *Gulliver* the capricious freak of fancy now appears as the most terrible of satires; the Genie emancipated from the vase. Other satirists have branded human vices; Swift makes war on humanity itself. In Lilliput or in Brobdingnag, in his laughter or his rage, human deformity is still his theme; man the object trampled upon in his passion, or dissected by his more deliberate virulence. The four parts of *Gulliver* are related as strophe and antistrophe, the second and fourth overwhelming with undisguised invective the vices which the first and third had exhibited indirectly, as by a parable. None of them could have been the work of one endowed with any elevation of mind, any perception of the lovely, or any insight into the methods and purposes of Providence; still less of one destitute of a glowing love of rectitude and hatred of evil. It is needless to dilate on the literary merits of a work unrivalled at once for the charm of invention and the deception of reality, whose gaiety can even procure oblivion of the furious sarcasm that lacerates as with a lash of wires. Lucian is left behind, and Voltaire surpassed by anticipation. Yet something of a mechanical character always marks the pro-

[1] Draper.

[2] The following text was popularly applied when Swift appeared in danger of prosecution:—"And the people said unto Saul, Shall Jonathan die, who hath wrought this great salvation in Israel? God forbid: as the Lord liveth, there shall not one hair of his head fall to the ground, for he hath wrought with God this day. So the people rescued Jonathan, that he died not." (1 Sam. xiv. 45.) A confidential servant, entrusted with the secret of the Drapier's identity, once remained so long out on a frolic as to cause serious apprehensions of his having gone to betray his master. On his return, the Dean turned him out of his house, declaring that he would not be intimidated into submitting to insolence from any of his domestics. The man's fidelity was proof against temptation and resentment, and when the danger was over, Swift received him again into his service, and treated him with marked kindness ever after.

ductions of ungenial minds. Gravity in absurdity is the great peculiarity of Swift's humour, and the power of his imagination is less conspicuous in the multiplicity of his ideas than in the inexhaustible variety he contrives to elicit from a single thought.

The Drapier had shaken Ireland, but *Gulliver* amazed all who could read English. Though the publication had been anonymous, the authorship could not remain a secret, and Swift began to hope that he might yet again play a part on the theatre of politics. The journeys to England, already mentioned, had been undertaken with this end in view, the influence on which he principally relied being that of Mrs Howard, the accomplished mistress of George the Second. She seems to have been really desirous of assisting him, but to have wanted the power. It is no disgrace to Swift's penetration that he should have failed to appreciate the tacit understanding established between the royal pair, by which Caroline had, so to speak, bartered her consort's hand for his head, the control over his affections for the management of his affairs. This grand mistake of relying on the mistress instead of the wife, would of itself have proved ruinous to his negotiation, even without the underhand opposition of Sir Robert Walpole, who gave him fair words, but secretly resolved to take good care how he promoted one who might be so formidable. At last his good understanding with the court was destroyed by the audacious forgery of some one who addressed insolent letters to the queen in his name, insisting on the claims of a certain Mrs Barber to her patronage. Full of mortification, he resigned himself to be the *frondeur* of the Irish, instead of the confidant of the English administration. In one viceroy, Lord Carteret, he found a congenial spirit, who frequently attended to his applications in favour of deserving persons, and received and returned his sarcasms with good humour. "You will not put me on such a board, my lord, because you know that I would neither job, nor bribe, nor be bribed, nor waste the public money, nor suffer other people to do any of these things." "What you say," replied Carteret, "is perfectly true, and therefore you must excuse me." At other times his pleasantry was exercised at the expense of the ecclesiastical authorities, whom he hated with all the fury of one who thought he ought to be in their place, and whose attempts to aggrandise themselves at the expense of the inferior clergy he resisted with the ferocity of a tiger and the stubbornness of a mule. "It is quite a mistake," he would say, "to blame the English government for sending us bad bishops; it is invariably careful to select men of the purest morals and most fervent piety. The misfortune is, that as these exemplary prelates cross Hounslow Heath on their way to their dioceses, they are invariably stopped and murdered by the highwaymen, which unprincipled persons assume their robes and their patents, and come over here in their place, to the injury and scandal of true religion among us!" He was also long active as a pamphleteer; one of his productions of this period, the mock proposal to fatten the children of poor persons for the market, being perhaps the most masterly piece of irony he ever produced. He likewise commenced a periodical in conjunction with Sheridan, of which but few numbers were published, and set on foot a scheme for relieving the distresses of the poorer orders by means of small loans, which does not appear to have been unsuccessful, and occasioned many most amusing adventures, which will be found detailed in Sir Walter Scott's *Biography*. His last public appearance was on a financial question, in opposition to a scheme for regulating the gold currency proposed by the real ruler of Ireland, Archbishop Boulter. On the day the measure took effect the cathedral-bells were rung backwards, and a black flag waved from the tower. For a time it was necessary to guard the primate's house, but when no evil effects from his policy were discoverable, the agitation died away. Swift had all his life been subject to violent attacks of giddiness and deafness, occasioned probably by water on the brain, but, as he fancied, by a surfeit of fruit at Moor Park. This year (1736) as he was writing the most virulent of his pieces, the satire against the Irish Parliament entitled the *Legion Club*, the fit seized him so fearfully that on his recovery he determined to lay aside the pen for ever. Nearly all the remainder of his existence was destined to be passed in pain, aggravated by the perceptible decay of his faculties, the consciousness of defeat in the great conflict of his life, a growing distaste for society, and an incapacity for intellectual recreation from the failure of his sight and his obstinate resolution not to wear glasses. It was the peculiar misery of his bodily suffering to engender mental torture, which re-acted on the body in its turn. Sources of consolation open to the weak and humble were closed against his haughty spirit; his austerity rejected the sympathy which his affliction would have commanded; his pride disdained the literary greatness which, in the eyes of most, richly recompensed the disappointments of his life. He permitted, however, the publication of an imperfect edition of his works, and in 1738 sent another anonymous pamphlet into the world, the *Polite Conversation*, written several years previously. It is a satire on the insipidity of commonplace social intercourse, a collection, one would think, of all the vapid trivialities and vulgar proverbs he had ever heard in his life, thrown into a dramatic form with wonderful ingenuity, and garnished with a contemptuous preface. His memory and observation are equally displayed in another work designed for publication at this time, but withheld till after his death, the ironical *Directions to Servants*. The imperturbable gravity of this performance is worthy of *Gulliver*, and the amazement with which we must view the immense accumulation of minute particulars is increased on discovering that it is, after all, only a fragment. During the last days of Anne he had written the history of the *Peace of Utrecht*, subsequently continued to the queen's death, and this he now intended to publish, but was dissuaded by his friends, who dreaded the effect of his revelations, and the uncompromising ferocity of his attacks on the living and the dead. It appeared ten years after his decease, without creating much sensation. The correspondence of his declining years is very interesting, especially his own letters and papers; the latter portion painfully affecting from the evidence of constantly increasing infirmity it contains. Johnson has commented severely on his and his friends' self-satisfaction and contempt for the rest of the world; but this is the universal failing of literary cliques. The poems he wrote between the death of Stella and the interruption of the *Legion Club* are not all calculated to do honour to his memory. Many are trivial, others coarse and extravagantly indecent. A kind of cynicism grew upon him in his latter years, and was increased by the gradual deterioration of his society. As his faculties and political importance declined, he found his equals in station less and less disposed to submit to his despotism, and was driven to tyranize over parasites, for whose amusement he sometimes produced that of which it would be charity to suppose him afterwards ashamed. Yet the *Yahoo* had been an imagination of better days, and quite in keeping with the utter want of refinement which, in strange contrast with the scrupulous attention he paid to his person and apparel, marked both his moral and intellectual character. Some of his best friends, as the witty blunderer Sheridan, he drove from him in his perverseness; others he was near alienating by his freaks, as when he cut down a favourite tree of Sir Arthur Acheson's, and had to purchase his pardon by an elegant apology in verse. Still, and long after he could do no more for Irish liberty by voice or pen, the popular veneration was as strong as ever. His birthday was celebrated by illuminations, and when he was

menaced by the bully Bettesworth, all Dublin seemed to rise as one man in his defence. In Mrs Whiteway he had a most sincere and judicious friend, whose affection he returned, and of whose value, though he sometimes tried her patience, he was fully conscious. Nothing in Lear surpasses the pathos of the last letter he addressed to her.

"I have been very miserable all night, and to-day extremely deaf and full of pain. I am so stupid and confounded, that I cannot express the mortification I am in both of body and mind. All I can say is, that I am not in torture, but that I daily and hourly expect it. Pray let me know how your health is, and your family. I hardly understand one word I write. I am sure my days will be very few—few and miserable they must be.—I am, for those few days, yours entirely, J. SWIFT.

"If I do not blunder, this is Saturday, July 26, 1740."

Early in 1741 it became necessary to place him under restraint, and appoint guardians for his person and property. Much of 1742 was passed in furious madness, aggravated by intense bodily suffering from boils and tumours. Release from pain brought a momentary interval of lucidity. The causes of his insanity were rather physical than mental. After his death his brain was found loaded with water, and an operation, if it had not killed him, would probably have restored his reason. Nothing was attempted, and he quickly sank into a lethargy, which, with a few occasional gleams of consciousness, continued to his death. It is a melancholy comfort to peruse the few affecting anecdotes which go to prove that his faculties were rather suspended than destroyed[1]—

"After the Dean had continued silent a whole year in this helpless state of idiocy, his housekeeper went into his room on the 30th of November in the morning, telling him that it was his birthday, and that bonfires and illuminations were preparing to celebrate it as usual; to this he immediately replied, 'It is all folly, they had better let it alone.'

"Upon his housekeeper removing a knife, as he was going to catch at it, he shrugged up his shoulders and said, 'I am what I am,' and in about six minutes repeated the same word two or three times.

"In the year 1744, he now and then called his servant by his name, and once attempted to speak to him; but not being able to express his meaning, he showed signs of much uneasiness, and at last said, 'I am a fool.' When the same servant was breaking a hard, large coal, he said, 'That is a stone, you blockhead.'

"From this time he was perfectly silent till October 19, 1745, and then died, without the least pang or convulsion, in the seventy-eighth year of his age."

He was interred in his cathedral, with this epitaph, written by himself—"Hic depositum est corpus Jonathan Swift, S.T.P., hujus ecclesiæ cathedralis decani: ubi sæva indignatio ulterius cor lacerare nequit. Abi, viator, et imitare, si poteris, strenuum pro virili libertatis vindicem." With a presentiment of his fate, he had bequeathed his fortune to found an hospital for idiots and lunatics.

As with all authors of genuine merit, Swift's character as a writer is the counterpart of his character as a man. It may be summed up in a phrase—strength without elevation. Nature intended him for the prince of satirists and pamphleteers, and her wisdom was not more conspicuous in what she gave than in what she denied. Satirists and politicians must not see too far. It is not their business to search out principles, but to lash the ephemeral follies, or criticise the no less ephemeral transactions of their own day. Swift has done nothing for the science of politics. The force of his political essays is of genius, but their substance mere shrewdness and common sense. In all his political writings there is hardly anything like a theory, an abstract principle, or a speculation. His suggestions are mere expedients; his expedients coarse and material. Of abstract right, as distinguished from personal integrity, he seems to have had no conception. Disabilities on dissenters seem to him as much in place as saddles on horses. Liberal in his estimate of human action, his views of human opinion are prejudices below the dignity of superstitions. He habitually postpones mankind to his country, his country to his party, and his party to himself. This narrowness of thinking intensified his powers. Like a river in a rapid, his mighty intellect foamed with irresistible force through its contracted channel. To considerations of an elevated nature he is inaccessible, and the antagonist who descends to his own ground is swept away. He overthrows, tramples, breaks in pieces, and tears to tatters. Miserably shorn of some of the highest prerogatives of the human mind, the genius he still possesses cannot be contemplated without awe and admiration. It is like the interrupted pile of Babel—the foundation of a structure that should have reached to heaven. In audacity of demeanour and majesty of port he yields to none of the giants of mind. Milton in his singing robes does not offer a grander image of intellectual force than Swift bespattering ex-ministers, and ringing the changes on bad halfpence. It was as though some sublime spirit, a second Faust, had parted with his better soul for thirty years of uncontrolled dominion. What seems his weakness to us was his strength among his contemporaries. He walked with his age, and did not outrun it. His lip breathed ever in the popular ear; he did not, advanced out of sight, halloo feebly from a distance. Even with us, his narrowness of view redeems his one grand and classical production from disgust. The misanthropy of *Gulliver* would be detestable, were it not so intensely real. Could the book possibly be the production of one of large views or elevated soul, it would be the production of one who had sinned against light, and deliberately sat down to libel and blacken his species. Swift is terribly in earnest, and writes as much in sorrow as in anger. His style is the image of his mind. In conciseness, directness, in plain sense and nervous vigour, it is worthy of the great writers of the preceding generation. But he has not their high thoughts to dress up in appropriate majesty, and disdains to trick out his own petty ones. He writes level to the capacities of his readers, spurning impassioned appeal and metaphor. After Barrow or Taylor, a paragraph of his is like a cathedral after the Reformation—the gorgeous windows shattered, the imposing ritual discarded, the arches blocked up with very comfortable pews. The homeliness of his predilections corresponded to the homeliness of his language; in all his volumes there is not one allusion to Shakspeare. On the other hand, his *Pindaric Odes* are the sole instance he has given of absurdity or affectation. Efforts after sublimity or picturesqueness have sometimes made other writers verbose, meretricious, nonsensical. Swift lay under no temptation to such *dulcia vitia*. Whatever he says is, for him, absolutely and literally, not merely figuratively or transcendentally, true; and so great is the power of earnestness, that his invectives against obscure scoundrels, or diatribes on the passing interests of the day, may even now be read with more pleasure than many a work of genuine imagination. In what may be called his mental build, he is startlingly original; but, strictly examined, his imagination will appear more distinguished for energy than fecundity. The original ideas he does possess are very striking, and he usually makes the most of them, and that with the careless

[1] His last composition was an epigram on a building shown to him when he was taken out for an airing:—

"Behold a proof of Irish sense,
Here Irish wit is seen,
When nothing's left that's worth defence,
They build a magazine!"

Swift.

profusion of a fountain sending forth its waters, not like a gold-beater, covering the amplest possible space with the thinnest possible leaf. Yet he is a master of permutation and combination; he rarely lets an idea go till he has drained it to the very marrow. A thought which with another might have flashed for a moment in an epigram, may with him be heard detonating and exploding throughout a whole pamphlet, and each report adds something to the general effect. Still there is nothing strained or far-fetched about his wit or his argument; he is never ingenious for ingenuity's sake. He is as clear-headed and prompt as copious; each of his numberless strokes falls at the right moment, and in the right place; by the time he has done his adversary (for all his writings are directly or indirectly polemical) is a mangled mass of bruises and blood.

As the characteristic of his writings is vigour without loftiness, so the definition of his moral nature is rectitude without amiability. His virtues were many and great, but coarse, rude, and exaggerated, like well-formed letters blotted by a hasty writer. He possessed the noblest independence of character, but knew not how to assert it without rage against his superiors, and arrogance towards his inferiors and equals. In truth, he had so little faith in excellence, that he hardly believed in his own superiority, unless demonstrated by the envy or the servility of others. The most punctual of men in the fulfilment of all his obligations, he discharged them so harshly and ungraciously that no one, probably, has ever been influenced by his example. Excessively charitable, though frugal and acquisitive,[1] he rarely gave without affronting the recipient. He was one capable of warm attachments, who spoke uncivilly of his friend to his face, and unkindly behind his back; the benefactor of his domestics, and their tyrant; the lover of two women, whose hearts he broke. He possessed not the least delicacy or refinement of sentiment; and his behaviour to others, especially to females, showed that he expected none from them. His virtues were unattractive, his failings repulsive; yet he was capable on occasion of generous deed or magnanimous forbearance. If he sometimes acted as a selfish or cold-hearted man might have done, the reason consisted partly in the overweening self-esteem that blinded him to his own faults, but more in the sluggish imagination that disqualified him from realising the feelings of others. If his frowns and his bitterness brought misery among his intimates, in his writings they were usually employed for the public good. No writer has scourged so many villains, scoffed at so many blockheads, exposed so many impostures, or assailed so many abuses. He was marvellously obtuse on many points of morality and policy; but where he did see evil, he hated it like one who had crossed his ambition. There is something wonderfully massive and sterling in his character; he was above taking pains with his virtues, and allowed himself no affectation but that of some faults he did not possess. His fierceness and austerity of disposition are unspeakably imposing. Others have undergone more romantic vicissitudes of fortune, but few careers are illumined with so wild and tempestuous a splendour. His prosperity is dazzling; his misery appalling. He is not to be thought of without wonder, and reverence, and repugnance, and pity most of all. He is a volcano—fearful in the long suppression of its smouldering fires; amazing in its sudden blaze and gigantic illumination; most awful of all in its silence and ashes, and stupendous, solitary gloom.

Swift's religious sentiments have furnished occasion for much dispute. The prayers found in his handwriting, indeed, sufficiently establish his piety, and the exceptions taken to the levities of his satiric writings can only have originated in a profound ignorance of the nature of humour and humourists. It is impossible, however, to get rid of an indefinable impression of a certain uncomfortableness in his relations towards the established religion. There is no reason to suppose him unconvinced by the external evidences of Christianity, which in his day had hardly been impugned. But no Christian minister has displayed less of the meek spirit of his creed; and the consciousness of a secret disharmony with what he was forced to inculcate and outwardly revere, will probably account for his uneasiness without imputing to him any definite opinion at variance with his station in the church.

Swimming.

In person Swift was tall and commanding, with aquiline features, a swarthy complexion, but an eye "as azure as the heavens." The expression of his countenance was stern in his gayest mood, and when angered his scowl was awful.

Swift was not the man to encourage a Boswell, and his own correspondence is the best authority for his life. Of his contemporaries, we are principally indebted to his indiscriminating panegyrists, Delany and his own nephew Deane, and his detractor, Lord Orrery, whose malevolence is said to be owing to the discovery of the slight value the Dean set on his acquaintance. Hawkesworth compiled the particulars of his life, and published what was the standard edition of his works till the appearance of Sir Walter Scott's in 1814. This edition can hardly be rendered more complete, and is not likely to be soon superseded. The biography prefixed is based on Hawkesworth, but far more copiously and elegantly written. At the same time, it displays more diligence than vigour or penetration, and the author's good-nature has certainly made him too indulgent to his hero. Dr Johnson's biography in the *Lives of the Poets* is the opposite of Sir Walter Scott's in all respects; a condensation of Hawkesworth instead of an expansion; pregnant with acute observations on Swift's private and literary character, but darkened throughout by an antipathy[2] that greatly impairs its value. In our own day, Mr Thackeray has made Swift the subject of an essay, most keen in its criticism, most brilliant in its composition, and full of that geniality and compassion which Swift alone wanted to have been as admirable as formidable, and as happy as famous. (R. G.)

SWIMMING, the art of floating one's self on water, and at the same time making a progressive motion through it. As swimming is not natural to man, it is evident that at some period it must have been unknown among the human race. Nevertheless there are no accounts of its origin to be found in the history of any nation; nor are there any nations so barbarous but that the art of swimming is known among them, and that in greater perfection than among civilized people. It is probable, therefore, that the art, though not absolutely natural, will always be acquired by people in a savage state, from imitating the brute animals, most of whom swim naturally. Indeed so much does this appear to be the case, that very expert swimmers have recommended it to those who wished to learn the art, to keep some frogs in a tub of water constantly beside them, and to imitate the motions by which they move through that element.

Swimming not natural to man.

The theory of swimming depends upon one very simple principle; namely, that if a force be applied to any body, it will always move towards that side where there is the least resistance. Thus, if a person standing in a boat pushes with a pole against the side or any other part of the

Depends on a simple principle.

[1] One of his last acts as Dean was to refuse a bargain which would have profited him to the detriment of his successors.

[2] It is, perhaps, not impossible that Johnson's dislike to Swift may have arisen from his horror of insanity, which he always dreaded for himself, and which he would gladly attribute, in Swift's case, to the perversion of the latter's temper. The resemblance between his own character and Swift's, and the nature of their infirmities, was certainly sufficiently close to alarm him.

vessel in which he stands, no motion will ensue; for as much as he presses in one direction with the pole, just so much does the action of his feet, on which the pressure of the pole must ultimately rest, push the vessel the other way: but if, instead of the side of the vessel, he pushes the pole against the shore, then only one force acts upon it, namely, that of the feet; which being resisted only by the water, the boat begins to move from the shore. Now the very same thing takes place in swimming, whether the animal be man, quadruped, bird, or fish. If we consider the matter simply, we may suppose an animal in such a situation that it could not possibly swim: thus, if we cut off the fins and tail of a fish, it will indeed float in consequence of being specifically lighter than the water, but cannot make any progressive motion, or at least but very little, in consequence of wriggling its body; but if we allow it to keep any of its fins, by striking them against the water in any direction the body moves the contrary way, just as the boat moves the contrary way to that in which the oars strike the water. It is true, that as the boat is but partly immerged in the water, the resistance is comparatively less than when a frog or even any other quadruped swims; but a boat could certainly be rowed with oars though it were totally immerged in water, only with less velocity than when it is not. When a man swims, he in like manner strikes the water with his hands, arms, and feet; in consequence of which the body moves in a direction contrary to the stroke. Upon this principle, and on this only, a man may either ascend, descend, or move obliquely in any possible direction, in the water. One would think, indeed, that as the strength of a man's arms and legs is but small, he could make but very little way by any stroke he could give the water, considering the fluidity of that element. Nevertheless it is incredible what expert swimmers will perform in this way; of which Dr Forster gives a most remarkable instance in the inhabitants of Otaheite, whose agility, he tells us, was such, that when a nail was thrown overboard, they would jump after it into the sea, and never fail to catch it before it reached the bottom.

As to the practice of swimming, there are but few directions which can be given. The great obstacle is the natural dread which people have of being drowned; and this it is impossible to overcome by any thing but accustoming ourselves to go into the water. With regard to the real danger of being drowned, it is but little; and on innumerable occasions arises entirely from the terror above mentioned, as will appear from the following observations by Dr Franklin.

Observations by Dr Franklin.

"1st, That though the legs, arms, and head, of a human body, being solid parts, are specifically somewhat heavier than fresh water, yet the trunk, particularly the upper part, from its hollowness, is so much lighter than water, as that the whole of the body, taken together, is too light to sink wholly under water, but some part will remain above until the lungs become filled with water; which happens from drawing water into them instead of air, when a person in the fright attempts breathing while the mouth and nostrils are under water.

"2dly, That the legs and arms are specifically lighter than salt water, and will be supported by it; so that a human body would not sink in salt water though the lungs were filled as above, but from the greater specific gravity of the head.

"3dly, That therefore a person throwing himself on his back in salt water, and extending his arms, may easily lie so as to keep his mouth and nostrils free from breathing; and by a small motion of his hands may prevent turning, if he should perceive any tendency to it.

"4thly, That in fresh water, if a man throws himself on his back near the surface, he cannot long continue in that situation, but by a proper action of his hands on the water. If he uses no such action, the legs and lower part of the body will gradually sink till he comes into an upright position, in which he will continue suspended, the hollow of the breast keeping the head uppermost.

"5thly, But if in this erect position the head is kept upright above the shoulders, as when we stand on the ground, the immersion will, by the weight of that part of the head that is out of the water, reach above the mouth and nostrils, perhaps a little above the eyes; so that a man cannot long remain suspended in water with his head in that position.

"6thly, The body continued suspended as before, and upright, if the head be leaned quite back, so that the face looks upwards, all the back part of the head being then under water, and its weight consequently in a great measure supported by it, the face will remain above water quite free for breathing, will rise an inch higher every inspiration, and sink as much every expiration, but never so low as that the water may come over the mouth.

"7thly, If therefore a person unacquainted with swimming, and falling accidentally into the water, could have presence of mind sufficient to avoid struggling and plunging, and let the body take this natural position, he might continue long safe from drowning, till perhaps help would come; for as to the clothes, their additional weight while immersed is very inconsiderable, the water supporting it; though when he comes out of the water, he would find them very heavy indeed."

His method of learning to swim,

The method of learning to swim is as follows. The person must walk into water so deep that it will reach to the breast. He is then to lie down gently on the belly, keeping the head and neck perfectly upright, the breast advancing forward, the thorax inflated, and the back bent; then withdrawing the legs from the bottom, and stretching them out, strike the arms forwards in unison with the legs. Swimming on the back is somewhat similar to that on the belly, but with this difference, that although the legs are employed to move the body forwards, the arms are generally unemployed, and the progressive motion is derived from the movement of the legs. In diving, a person must close his hands together, and, pressing his chin upon his breast, make an exertion to bend with force forwards. While in that position, he must continue to move with rapidity under the surface; and whenever he chooses to return to his former situation, he has nothing to do but to bend back his head, and he will immediately return to the surface.

It is very common for novices in the art of swimming to make use of corks or bladders to assist in keeping the body above water. Some have utterly condemned the use of these; Dr Franklin however allows that they may be of service for supporting the body while one is learning what is called the *stroke*, or that manner of drawing in and striking out the hands and feet that is necessary to produce progressive motion. "But," says he, "you will be no swimmer till you can place confidence in the power of the water to support you: I would therefore advise the acquiring that confidence in the first place, especially as I have known several who, by a little of the practice necessary for that purpose, have insensibly acquired the stroke, taught as it were by nature.

and of acquiring confidence.

"The practice I mean is this. Choosing a place where the water deepens gradually, walk coolly into it till it is up to your breast: then turn round your face to the shore, and throw an egg into the water, between you and the shore; it will sink to the bottom, and be easily seen there if the water is clear. It must lie in the water so deep as that you cannot reach it to take it up but by diving for it. To encourage yourself in order to do this, reflect that your progress will be from deeper to shallower water; and that at any time you may, by bringing your legs under you, and standing on the bottom, raise your head far above the wa-

Swimming.

ter: then plunge under it with your eyes open, throwing yourself toward the egg, and endeavouring, by the action of your hands and feet against the water, to get forward till within reach of it. In this attempt you will find that the water buoys you up against your inclination; and it is not so easy a thing to sink as you imagined; that you cannot but by active force get down to the egg. Thus you feel the power of the water to support you, and learn to confide in that power; while your endeavours to overcome it, and to reach the egg, teach you the manner of acting on the water with your feet and hands; which action is afterwards used in swimming to support your head higher above water, or to go forward through it."

Swimming a pleasant and useful exercise.

As swimming is a healthy exercise and a pleasant amusement, and as a dexterity in it may frequently put it in a man's power to save his own life and the lives of his fellow-creatures, perhaps of his dearest friends, it can neither be useless nor uninteresting to consider a few of the evolutions which a swimmer must be master of, that he move in any direction without difficulty, without danger, and without being unnecessarily fatigued.

How to turn to the right or left.

There are several different ways of turning one's self in swimming. You may do it in this way: turn the palm of the right hand outwards, extend the arm in the same manner, and make a contrary movement with the left hand and left arm; then, by a gradual motion, incline your head and whole body to the left side, and the evolution will be finished. There is another way, which is easier still. Bend your head and body toward that side to which you are going to turn. If you wish to turn to the left, incline the thumb and the right hand toward the bottom, bend the fingers of the right hand, stretch it out, and use it for driving away the water sidewise, or, which is the same thing, for pushing yourself the contrary way. At the same time, with your left hand, the fingers being close, push the water behind you, and all at once turn your body and your face to the left, and the manœuvre will be accomplished. If you wish to turn to the right, you must do with your right hand what you did with your left, and with your left what you did with your right. You must be careful when turning yourself never to stretch out your legs, and be sure that the water be so deep that you be in no danger of hurting yourself.

How to turn from the belly to the back.

When you are swimming on your belly, and wish to turn on your back, draw your feet in quickly, and throw them before you; stretch out your hands behind you, and keep your body firm and steady. When you wish to turn from swimming on your back, fold your feet at once under your body, as if you were throwing them to the bottom, and at the same instant dart your body forwards, that you may fall upon your belly.

The eyes ought to be turned towards heaven.

In swimming, the eyes ought to be turned towards heaven. This is a most important rule, and to the neglect of it many of the accidents which befall swimmers are owing. For when they bend their eyes downwards, they insensibly bend their head too, and thus the mouth being too deep in the water, may admit a quantity of it in breaking; besides, the more the body is stretched, it covers a greater part of the surface of the water, and consequently its specific gravity is less. Any person who will make the experiment will find it impossible to dive while he keeps his head erect and his eyes fixed on the heavens.[1]

How to swim on the back,

The easiest posture in swimming is lying on the back. When you wish to swim in this posture, lay yourself softly on your back, and raise your breast to the surface of the water, keeping your body extended in the same line. Put your hands easily over the upper part of your thighs, and throw out your legs and draw them in alternately, keeping them within two feet of the surface. In this way you may advance in any direction you please. You may perhaps not like having so much of your head under water; there is, however, no way of swimming so easy, so safe, and so little fatiguing. If you wish to swim with great rapidity, you may use your arms as well as your feet; and you will find this the easiest way of breaking the force of the waves.

and advance forward.

In swimming on the back, one may advance forward as well as backward. For this purpose the body must be kept straight and extended; the breast inflated, so that the hollow of the back may assume a semicircular form. The hands must recline over the upper parts of the thighs. It is also necessary to raise the legs one after another, and draw them in strongly towards the hams, and then leave them suspended in the water. This way of swimming is not only pleasant, but may serve to rest you when fatigued.

How to swim on one side.

When you are tired with swimming on your back and belly, you may swim on one side. When you wish to do this, sink a little your left side and raise your right; you will immediately find yourself on your left side. Move then your left hand without either raising or sinking it; you have only to stretch it and draw it back, as in a straight line, on the surface of the water. Independently of the pleasure which this kind of motion will give you, you will have the satisfaction of seeing both sides of the river.

How to swim on the belly without the assistance of the hands.

It is possible to swim on the belly without the assistance of the hands. For this purpose you must keep your breast erect, your neck straight, and fix your hands behind your head, or upon your back, while you move forward by employing your feet. This way is not without its advantages. It is an excellent resource when the arms are seized with a cramp, or with any indisposition which makes it painful to exert them. This in some cases may be preferable to swimming on the back; for while in that attitude, one cannot see before them without turning every instant. If one of your legs be seized with a cramp, take hold of it with the hand opposite to it, and use the other hand and leg to advance or support yourself.

How to swim with the hands joined.

A very ancient and graceful mode of swimming, is that of swimming with the hands joined. When you wish to put this in practice, join your hands, keeping the thumbs and fingers towards heaven, so that they may appear above the water; then draw them back and push them forwards alternately from your breast. This method of swimming may be useful in several circumstances, but above all if you are entangled with grass or weeds. Your hands will then open a passage for you.

With the hands elevated.

As a person may sometimes have occasion to carry something in his hand in swimming, which he is anxious to preserve from the water, he may swim easily with one hand and hold a parcel in the other, as Cæsar swam with his Commentaries at Alexandria; or one may swim with both hands elevated. To perform this well, the swimmer must raise his breast, and keep it as much inflated as he can, at the same time that he supports the arms above the water. It must not be concealed that this method of swimming is attended with some danger to one who is not dexterous at the art; for if one should imprudently draw in his breast

[1] An interesting question occurs here, which deserves to be considered. Since the body, when spread upon the surface, can be supported with so little exertion, and frequently without any at all, as in swimming on the back, how comes it to pass that a person when drowned sinks and frequently rises again some time afterwards. The reason is this. In the act of drowning, the lungs are filled with water, and consequently the body, being specifically heavier, sinks. It is well known that the human body contains a great quantity of air. This air is at first compressed by the water; and while this is the case, the body remains at the bottom; but as soon as the air by its elasticity endeavours to disengage itself from the compression, the body is swelled and expanded, becomes specifically lighter than the water, and consequently rises to the top.

Swindon || Switzerland.

when his arms are raised, he would immediately sink to the bottom.

How to rise to the surface after diving.

When a man plunges into the water, and has reached the bottom, he has only to give a small stroke with his foot against the ground in order to rise; but an experienced swimmer, if he misses the ground, has recourse to another expedient, which is very pretty, and which has not been much considered. Suppose him at a considerable depth, when he perceives that he cannot reach the bottom. In such a case, he first puts his hands before his face, at the height of his forehead, with the palms turned outwardly; then holding the fore part of his arm vertically, he makes them move backwards and forwards from right to left; that is to say, these two parts of his arms, having the elbow as a kind of pivot, describe very quickly, both the hands being open and the fingers joined, two small portions of a circle before the forehead, as if he would make the water retire, which he in fact does; and from these strokes given to the water there results an oblique force, one part of which carries the swimmer upwards.

SWINDON, a market-town of England, Wiltshire, on a hill 19 miles N.E. by N. of Devizes, and 80 W. of London. It consists of 5 principal streets, which are broad, regular, and neat; and it contains many good buildings. There are a handsome town-hall and market-house, an elegant gothic parish church, other places of worship belonging to Wesleyans and Independents; national, British, and infant schools, a library, and reading-room. Swindon is a principal station of the Great Western Railway, which has a locomotive-engine factory here, employing 1500 hands. In connection with this factory, a new town, called New Swindon, has sprung up, containing a church, schools, and mechanics' institute of its own. Pop. of the parish, 4876.

Swinemunde || Switzerland.

SWINEMÜNDE, a town of the Prussian monarchy, province of Pomerania, near the mouth of the Swine in the Baltic, 30 miles N.N.W. of Stettin. It has broad streets, lined with well-built houses, and contains a court of law, public offices, baths, and assembly rooms. There are here docks; and a harbour, that has been recently enlarged and improved, as it is the port of Stettin. The trade and navigation of the place are considerable. Pop. 5446.

SWINESHEAD, a decayed market-town of England, in the county and 25 miles S.E. of Lincoln. The sea formerly extended up to the town, and there was a harbour near the present market-place. This has become silted up, and Swineshead is now about 2 miles distant from the nearest point of the sea. There are here a free school, several charities, and a large and handsome church. Formerly there was at Swineshead a Cistercian abbey, and it was in this house that King John took refuge, after losing his baggage in attempting to ford the Wash, shortly before his death. Pop. of the parish, 2044.

SWINFORD REGIS, or KING'S SWINFORD, a village and parish of England, Staffordshire, on the Dudley and Stourbridge and Staffordshire and Worcestershire Canals, 3 miles W.S.W. of Dudley. The chief buildings are an elegant modern parish church, a chapel of ease, places of worship of Independents, Baptists, Primitive and Wesleyan Methodists. The parish occupies an extensive area, in a district rich in iron and coal, and contains many iron-works, collieries, potteries, brick and tile works, &c., with a population of 27,301.

SWITZERLAND.

Boundaries

SWITZERLAND (*La Swisse*, *Schweiz*, *Svizzera*), the most mountainous country in Europe, lies between 45. 48. and 47. 49. N. Lat., and 5. 55. and 10. 30. E. Long., having France on the W. between Basle on the Rhine and Geneva on the Rhone, the boundary line being formed by one of the ridges of the Jura Mountains, and by the River Doubs, an affluent of the Rhone. On the S. are Savoy, Piedmont, and Lombardy, from which it is separated by the Lake of Geneva, and high ranges of the Alps. To the E. are the principality of Lichtenstein, the Vorarlberg, and the Tyrol. Canton Ticino and some small portions of the Grisons are on the south side of the main chain of the Alps. On the N. lie Würtemberg, Lake Constance, and Baden. The town of Constance, with a limited tract about it on the south of the lake, belongs to Baden, while the Canton of Schaffhausen, and a small portion of that of Zürich, lie to the north of the Rhine. The greatest length of the country is from E. to W., in Lat. 46. 30., where it is 200 miles in extent; and its greatest breadth,—about the 9th parallel of E. Long.,—is 135 miles. Between Switzerland and Sardinia the boundary line is strongly defined, except towards the west, where the Canton of Geneva is partially surrounded by Savoy, Chablais, and Faucigny, lately ceded by Sardinia to France. Towards the eastern extremity of the Lake of Geneva, where a high range of the Alps terminates on the banks of the lake near St Gingolph, the line runs southward along this range until it reaches the mountain-knot of Mont Blanc. Thence it runs eastward along the higher portion of the Pennine Alps to Mont Rosa, where it turns to the N.E. along the Lepontine Alps to the great mountain-mass enveloping the Pass of St Gothard. From this point it trends southward, and afterwards S.E. to the Lago Maggiore. From this lake the line passes southward to the western arm of the Lake of Lugano, the central portion of which lake belongs to Switzerland, whilst the south-western and north-eastern extremities belong to Lombardy. A tract of land, extending several miles to the south of the lake, is also included in Switzerland. About 4 miles to the east of the town of Lugano commences a mountain-range, which, passing to the north, separates the valley of St Giacomo, belonging to Lombardy, from that of Misocco, which belongs to Switzerland. This range meets the principal chain of the Rhaetian Alps at the Pass of the Splügen. After proceeding a few miles only along this chain, the line extends to the east and south along a lateral range, crosses the valley of Bregaglia a few miles above Chiavenna, and meets the Bernina range, forming the southernmost of the three chains of the Rhaetian Alps. The valleys of Poschiavo and Münster, on the southern side of the range, belong, however, to Switzerland; while that of Livigno forms a portion of Lombardy, so that the line here does not follow the water-parting. From the southern extremity of the valley of Münster, bordering on the Tyrol, the line passes nearly due north, and, crossing the valley of the Inn, meets the central chain of the Rhaetian Alps. Passing S.W. along this, it meets the lateral chain called the Rhäticon, which runs N.W. between the Prätigau, belonging to Switzerland, and the Montafoner valley, which belongs to Austria. The mountains of the Rhäticon terminate on the Rhine to the north of Meyenfeld. Up to the point where it enters the Lake of Constance, the Rhine forms the boundary between Austria and Switzerland. The Lake of Constance separates Switzerland from Bavaria and Würtemberg, the harbour of Lindau forming the chief point of communication with the former, and that of Friedrichshafen with the latter kingdom. The entire length of boundary is 1040 miles, composed as follows,—602 miles of mountains, 235 of plains, and 203 of water.

Political divisions.

The confederation of Switzerland at present consists of twenty-two sovereign states or cantons, the areas of which, with number of inhabitants, and other statistical data, are given in the following table:—

Cantons.	Area in Sq. Miles.	Population in 1816.	Population in 1838.	Population in 1850.	Number of Families.	Number of Proprietors.	Surface.	Chief Industry.	Chief Towns.	Population in 1850.	Remarks.
Aargau............	501	143,960	182,755	199,852	35,806	33,770	Tableland sloping towards the Rhine. To the N.W. offsets of the Jura............	Agriculture, and manufactures of salt, straw-hats, cotton, linens, and hardware	Arau..............	4,627	
Appenzell.........	152	55,000	50,876	54,893	15,086	7,252	Highlands, offsets the lower Alps.............................	Agriculture, pastures, and cottons, muslins, and silks..	Appenzell ...... Herisau.......... Trogen	2,910 8,387 2,611	
Basle	184	45,900	65,424	77,583	14,160	11,233	Offsets of the Jura..............	Agriculture, pastures, silks, ribbons, cottons, gloves, paper, salt, iron and copper works	Basle .... Liesthal..........	27,313 3,032	
Berne...............	2,543	291,200	407,913	458,301	87,219	59,556	Tablelands and fine valleys. To the N.W. the Jura, S.E. the High Alps..................	Agriculture and manufactures, chemicals, iron, strawplatting	Berne..............	27,758	
Fribourg...........	563	67,814	91,145	99,891	20,206	18,477	Tableland and valleys sloping to the N.; to the S. mountainous....................	Agriculture, pastures, Gruyères cheese, Kirschwasser, strawplatting, and tanneries	Fribourg.........	9,065	
Gall, St...........	758	130,301	158,893	169,625	36,579	25,015	Offsets of the Rhætian Alps; valleys slope to the N. and N.W.............................	Agriculture, vineyards, cattle, cottons, silks	Gall, St...........	11,234	
Geneva	91	44,000	58,666	64,146	15,275	7,088	Hills and plains...................	Agriculture, trade and banking, straw-hats, watches, jewellery, and wine............	Geneva...........	36,354	Old Town.........29,108 North. suburbs 2,130 S.W. & E. „ 5,126
Glaris................	279	26,575	29,348	30,213	7,197	5,059	Valley of the Linth between the High Alps..................	Pasture & fruit, Schabzieger cheese, cottons, strawplatt...	Glaris	4,082	
Grisons.............	2,665	73,200	84,506	89,895	20,156	20,901	Valleys in the High Alps	Agriculture and pastures......	Coire..............	5,943	
Lucerne	586	86,700	124,521	132,843	22,572	13,646	Tableland intersected by ridges; Mount Pilate, an offset of the Alps to the S...	Agriculture, strawplatting....	Lucerne	10,068	
Neuchâtel	250	49,722	58,616	70,753	15,028	6,386	Fine valleys between the Jura ranges.......................	Agriculture, pasture, vineyards, strawplatt., watches, jewellery, cottons, and lace	Neufchâtel	7,727	
Schaffhausen.....	115	30,000	32,582	35,300	7,961	6,262	Hills and valleys	Agriculture, vineyards, cattle, tanneries and ironworks, cottons	Schaffhausen...	7,710	
Schwyz.............	338	28,900	40,650	44,168	8,937	5,994	Highlands and valleys.........	Agriculture and pastures, strawplatting	Schwyz...........	2,414	
Soleure.............	254	47,882	63,196	69,674	13,593	11,907	Fertile valleys amid the Jura	Agriculture, fruit, vineyards, pasturage, iron and marble works	Soleure...........	5,370	
Thurgau...........	268	78,533	84,126	88,908	16,852	14,908	Tableland and hills; slopes towards Lake Constance	Agriculture, vineyards and orchards, cottons and linens	Frauenfeld......	3,544	
Ticino	1,033	88,793	113,923	117,759	24,714	20,874	Highland and valleys; slopes towards Lake Lugano	Agriculture, pasture, and vineyards, strawplatting	Bellinzona ...... Locarno .... Lugano	1.926 2,676 5,142	
Unterwalden......	262	21,200	22,571	25,138	5,700	3,774	In the Alps........................	Cattle and fruit	Sarnen .... Stanz	1.299 1,877	
Uri...................	420	14,000	13,519	14,505	2,851	2,133	In the Alps, valley of Reuss	Cattle and fruit	Altorf	2,112	
Valais	1,658	62,809	76,590	81,559	17,768	31,640	An elongated valley between two lofty chains of the Alps, with transverse valleys......	Agriculture and pasture, vineyards, fruit, lead, anthracite coal..........................	Sion...............	3,516	
Vaud	1,180	145,215	183,582	199,575	44,304	37,936	Highlands in the Jura and the Alps, with hills and plains sloping to Lakes Leman and Neuchâtel	Agriculture, vineyards, salt, iron, strawplatting, tobacco	Lausanne........	20,000	Town and suburbs ....14,500 Adjacent dwellings .... 2,200 Entire district..22 636
Zug	85	14,300	15,322	17,461	3,210	2,085	Tableland sloping to the N., intersected by hills............	Agriculture and orchards	Zug	3,302	
Zurich..............	684	182,123	231,576	250,698	49,929	36,552	Tableland and hills, following the direction of the water-courses towards the Rhine...	Agriculture and vineyards, cottons, silks, cutlery, strawplatting, steam-engines, &c.	Zurich	17,040	
Total............	15,179[1]	1,728,127	2,190,258	2,392,740	485,087	...				...	

[1] According to extracts from five volumes published between 1854 and 1858 by command of the federal government, under the title of *Materials for the Statistics of Switzerland*, and kindly furnished by Professor Paul Chaix of Geneva, the agricultural districts, comprising fields, meadows, and vineyards, may be reckoned at 31 per cent. of the whole; forests at 18 per cent.; and mountain-pastures at 20 per cent. Glaciers and snows are calculated to include ·12, lakes ·05, roads ·1, and buildings ·04, being together about ·31 of the entire area of 1732 sq. leagues.

This country was anciently called Helvetia, from its first known inhabitants; its more modern name is supposed to be derived from the canton of Schwytz, the cradle of Swiss independence. Little is known of the inhabitants of Switzerland till about one hundred years before Christ, when the Cimbri, a race of barbarians inhabiting the northern regions of the Chersonnesus Cimbrica, now known as North and South Jutland or Sleswig, crossed the Rhine, and extended their conquests into Gaul. Several of the Helvetian tribes, tempted by the immense spoils gained by the Cimbri, entered into an alliance with them, and carried their united ravages nearly to the mouth of the Rhone. In this extremity, the Gauls applied for assistance to the Romans, who speedily sent a powerful army to their assistance, under the command of the consul, Lucius Cassius. This force, however, was suddenly attacked on the banks of the Lake of Geneva by the Tigurini, a tribe of the Helvetii, led by a young general named Divico. The Romans were totally defeated, the consul and his lieutenant, Piso, left dead on the field, and the survivors only permitted to retreat after they had given hostages and marched under the yoke. Emboldened by this success, Divico rejoined the Cimbri, and with their united forces crossed the Alps and entered Italy itself, where, however, they were defeated by Marius with tremendous slaughter, and the few who escaped sought refuge among the fastnesses of the Helvetian mountains.

The Helvetii defeated by Cæsar.

For nearly half a century after this decisive defeat, the Helvetii confined themselves to their own country. But the recollection of rich pastures and fertile plains outlived the terror of the Roman arms, and made them resolve once more to quit their rocky fastnesses. After spending three years in preparation, they set out with their wives and families, cattle and possessions, led by the same Divico who had commanded their fathers fifty years before. The number who marched out on this expedition is computed at 368,000 souls, of whom 92,000 were able-bodied warriors.

The Roman province of Gaul was at that time under the government of Julius Cæsar, and that consummate general no sooner heard of the emigration of the Helvetians, than he took effectual measures to defeat their plans. After some abortive attempts at negociation, he attacked and defeated them in two engagements, with tremendous slaughter. Their strength and spirit were completely broken, and, overwhelmed with shame and grief, their numbers reduced to scarcely 100,000, they returned to their desolated country and rebuilt their ruined habitations. In order to watch and overawe them, Cæsar erected a fortress at Noviodunum (Nyon), on the banks of the Lake of Geneva, and established several other garrisons in different parts of the country.

Helvetia subjected by the Romans;

The Helvetii were at first the allies of the Roman people, but in the reign of Augustus they were reduced to complete subjection, and their country remained in the condition of a Roman province for upwards of three centuries, and underwent various reverses of fortune, according to the prosperous or adverse fortune of the empire to which it was subject. When the innumerable swarms of barbarians, issuing from the unknown regions of the north and east, overran Italy and destroyed the Roman empire, Switzerland also became their prey. The Goths established themselves in that portion of the country which bordered on Italy; the Burgundians, a tribe of the Wendes, from the shores of the Baltic, fixed their residence on both sides of the Jura, on the Lake of Geneva, and in the Lower Valais, as far as the Aar; and the Allemanni took possession of the country to the eastward of that country, and of great part of Germany.

The Burgundians having been defeated by the Huns under Attila, about the year 450 allied themselves with the Visigoths, a Scandinavian tribe, and adopted the Visigoth chief as their king. They afterwards extended their dominion into Gaul, along the banks of the Rhone and Saone, and gave their name to the fine country which still bears it. After having located themselves in Gaul and in Western Helvetia, a more regular system of society can be clearly traced among them.

The Allemanni, more ferocious than the Burgundians, devastated the valleys of Helvetia, and reduced the country to a wilderness, so that, gradually, vast marshes and forests overspread those parts, at present so beautiful, around the Lakes of Constance and of Zurich.

and by the Franks.

After this state of affairs had continued some time, a new swarm of adventurers obtained the ascendency. These were the Franks, another race from the north, who, after traversing the Netherlands, gained possession of the whole of Gaul, and pouring their resistless myriads into Switzerland, forcibly dispossessed the inhabitants, and at length, after various changes, succeeded in obtaining exclusive dominion over the whole of Rhætia and Helvetia. The Franks introduced into Helvetia the feudal system and other peculiar institutions and laws of the Teutonic tribes. To them also, under Clovis, the inhabitants were indebted for the adoption of Christianity, which contributed powerfully to the progress of civilization, and the revival of the country from its waste and desolate state. Switzerland remained subject to the Franks till after the death of Charlemagne, when, in consequence of the feuds of that monarch's successors, the vast empire which he had founded was entirely dismembered, and Switzerland was portioned out between France, Italy, and Germany. Rhætia and the country between the Lake of Constance and the Rhine, the Aar and St Gothard, in which German was the current language, were united to Suabia; while Geneva, the Valais, Neuchâtel, and the present country of Berne, Soleure, Fribourg, and Vaud, the districts in which Romance was the prevailing language, were united to Savoy, under the denomination of Little Burgundy. But this arrangement was of short duration, for the disorders and confusion produced by the continued wars enabled the provincial governors to throw off all allegiance to their feudal superiors, or to secure real independence while yielding nominal obedience. Switzerland was thus divided into a great number of petty states, generally engaged in hostilities with each other, and seldom uniting among themselves unless when menaced by some great and common danger. Such a case presented itself in the reign of the Emperor Henry I., surnamed the Fowler. An immense horde of barbarians, known by the name of Hungarians, issued from the east and the shores of the Black Sea, and overran Germany and Italy, burning and destroying wherever they came. In order to protect the inhabitants from the fury of these ruthless invaders, Henry built walls around a number of defensible places, to which all, in case of need, might fly for the security of their lives and property. In this manner Zürich, St Gall, Basle, and various other places, rose from petty hamlets to towns of considerable strength and numerous population. About the same period, the bailiffs of the emperor built and fortified Berne, Fribourg, and various other towns. A ninth of the free and nobler class of inhabitants were required to occupy these national fortresses, and they received the same political organization and rights as the more ancient cities of Germany. This was the first foundation of the class of burghers, who in process of time came to be a third estate in the kingdom. In proportion as the wealth and importance of the towns augmented, the citizens were eager to extend their rights and privileges. They availed themselves of every opportunity to purchase their emancipation from the feudal dominion of the bishops, abbots, and monasteries, to whose authority they had long been subjected; and in a short time the burghers were able to bid defiance to the nobles, and even to balance the political weight of the clergy.

Divided into petty states.

History.

Subject to the house of Austria.

The affairs of Switzerland continued in this state, without any material alteration, until the year 1273, when Rudolph of Hapsburg, whose castle was situated in the canton of the Aar, and who, besides possessing manorial rights and great influence in Schwytz, had held the office of imperial bailiff of several towns, was elected Emperor of Germany. This prince, though inhabiting a distant country, continued throughout his life to be strongly attached to Switzerland. He conferred new honours on its nobles, and granted additional privileges to its towns, or confirmed those which they already enjoyed. Rudolph was succeeded by his son Albert, whose ambition and rapacity soon alienated the affections of both his German and his Swiss subjects. Two of the imperial bailiffs, Hermann Gessler and Beringar of Landenberg, who were appointed over the Waldstätten (the three cantons of Schwytz, Unterwalden, and Uri), subjected the inhabitants to every species of insolence and oppression. Gessler, in particular, was guilty of so many acts of wanton cruelty, that he was at length shot through the heart by the famous William Tell, who thus paved the way for the deliverance of his countrymen. Curiously enough, a similar case occurs in ancient Scandinavian history, as recorded by Saxo Grammaticus. Three patriots, whose names are still revered throughout the republic, Werner Stauffacher, from the canton of Schwytz, Walter Furst of Uri, and Arnold Melchthal, from Unterwalden, had formed a conspiracy against the Austrian governors; and their measures were concerted with such wisdom, and executed with so much courage and intrepidity, that they obtained possession of every fortress of any considerable strength or importance. Shortly after this revolt of the forest cantons, the Emperor Albert was murdered by his nephew and some other nobles; but his son, Duke Leopold, marched against the cantons with a powerful army. The Schwytzers waited his arrival at Morgarten, on the slope of the mountain Sattel, and, notwithstanding the disparity of their forces, routed the Austrians with great slaughter on the 15th of November 1315; and it was with no small difficulty that the duke himself escaped, leaving most of his officers, and an immense number of his soldiers, dead upon the field.

The Swiss revolt from the Austrians, A.D. 1315.

The three cantons of Uri, Unterwalden, and Schwytz, having thus by their courage and virtue, achieved their independence, held a meeting on the 8th of December 1315, at which they entered into a solemn compact, and thus laid the foundation of the Swiss Confederation.

In 1332, the inhabitants of Lucerne formed a perpetual league with the Waldstätten; and in 1351 the citizens of Zürich, having thrown off the yoke of the aristocracy, joined the Swiss republic; and, on account of the power and wealth of the town, it was promoted to the chief rank. Glaris came next; Zug joined the confederation in 1352; and Berne in the following year. To the latter, in consideration of its importance, was assigned the second place of precedence.

The above-mentioned eight cantons, Schwytz, Uri, Unterwalden, Lucerne, Zürich, Glaris, Zug, and Berne, remained for more than a century the federative republic of the Swiss. With few interruptions, the republic enjoyed tranquillity until the year 1375, when a mixed English and French army of adventurers, under a French nobleman, Enguerrand de Coucy, a cousin of Leopold of Austria, and married to the English princess Isabella, advanced on the Limmat as far as Wettingen. Surprised, however, at night by the Swiss, they were dispersed, and the Lord de Coucy retreated into Alsace.

Defeat of Leopold, A.D. 1386.

Duke Leopold III. of Austria viewed the extending confederation with jealousy and alarm, and various quarrels having taken place between him and the cantons, hostilities were at length commenced. The duke, with a numerous force, chiefly composed of cavalry, marched rapidly towards the interior of the country, and, on the 9th of July 1386, encountered the Swiss in the neighbourhood of Sempach. The battle was long and fiercely contested, but at length the Swiss patriots gained a complete victory; the duke himself was slain, and more than 600 of the higher and lower nobility, with about 2000 of their less distinguished adherents, were left dead on the field.

Two years after the battle of Sempach, the Austrians took Näfels, a small town in the canton of Glaris. The garrison retreated from the town as far as Mount Rute where they took up a strong position, and awaited the approach of the enemy on the 9th of April. The Austrians maintained the fight for some time with great ardour, but were in the end overthrown and put to flight. The bridge of Wesen, on the Linth, was broken down by the weight of the fugitives, and above 3000 common soldiers, and 183 knights, were slain in the battle, or drowned in the lake and in the river. These defeats induced Duke Leopold IV., in 1389, to enter into a truce with the cantons for seven years, during which the Swiss contrived by various means to extend their territory and to increase their power.

Again defeat the Austrians, A.D. 1388.

This truce was renewed in 1394 for twenty years more, and was faithfully kept on both sides until 1415. At the commencement of the fifteenth century, the house of Austria possessed yet in Switzerland, Aargau, Fribourg, Rapperschwyl, Thurgau, and Winterthur. The house of Savoy owned the Pays de Vaud. The Valais and the valleys of Rhaetia belonged to their feudal nobles. The Abbot of St Gall and the Counts of Toggenburg in the east, and the Bishop of Basle and Counts of Neuchâtel in the west, were powerful neighbours of the eight Swiss Cantons. In the north existed still the independent imperial towns of Basle, Schaffhausen, and Soleure. The year 1415 was famous for the celebrated Council of Constance. About this time the Swiss Cantons carried their arms across the Alps into Italy; but the troops of Savoy, crossing the Simplon to Domo d'Ossola, drove the Swiss garrison away. The cantons of Unterwalden and Uri having next purchased the town and valley of Bellinzona, the Duke of Milan sent the celebrated condottieri Pergola, who, after an obstinate fight at Arbedo, in June 1422, obliged the Swiss to recross the St Gothard. In 1444, Charlès VII. of France sent the Dauphin Louis, at the head of the Armagnacs, composed of soldiers of fortune of all nations, against Basle. The two armies met outside that town, when, after a most desperate fight, in which out of one Swiss division of 1200 men only ten remained alive, the dauphin, struck with surprise at the conduct of the Swiss, concluded a truce and sought their alliance. The house of Austria had, however, gradually lost nearly all their possessions in Helvetia, when, in 1467, Duke Sigismund sold his last remaining property, Wintherthir, to the Swiss, and the patrimonial estates of that house, even the castle of Hapsburg itself, passed into the hands of the stranger.

With the exception of the disputes which took place between the people of the canton Appenzell, and of the Valais and Rhætian Alps, with their lords, and of the civil war which arose between Zürich and Schwytz relative to the right to some lands, no other event of great importance occurred in the history of Switzerland till the year 1474, when Louis XI. of France induced the Swiss to make a diversion in his favour, by falling on the territory of Charles the Rash, Duke of Burgundy, who had advanced to the very walls of Paris, and threatened Louis with the loss of his throne. This unprovoked attack induced the duke to offer terms of peace to the King of France and the Emperor of Germany, with whom he was at the same time at war; and these monarchs accepted his offer, leaving their late allies to meet his whole vengeance as they best might. Peace was no sooner concluded, than Charles

History.

Twice defeat the Duke of Burgundy.

determined to inflict condign punishment on the Swiss for their unjustifiable aggression, and in the spring of 1476 he crossed the Jura with an army of 60,000 men. He encountered the army of the confederates near the town of Grandson, and after a desperate conflict on the 3d of March, was totally defeated with the loss of a thousand men. His camp, with an immense booty, fell into the hands of the Swiss. A few months after, on the 22d of June, he was defeated, with prodigious slaughter, in a second action, near the little town of Morat; and on the 5th of January 1477, when the duke was slain in the battle of Nancy, the states of Upper Burgundy agreed to pay the confederates the sum of 150,000 florins to make peace with them.

These repeated victories procured for the Swiss the reputation of being the best soldiers in Europe; and a considerable number of them were hired to fight the battles of foreigners. The sudden wealth acquired by plunder and pensions excited its possessors to profusion and extravagance; their morals became corrupted, and the simple republican honesty almost disappeared. A spirit of cupidity and pride displayed itself among the rulers, and dissipation and love of plunder among the people; and the Swiss became notorious throughout Europe as the hirelings of any potentate who had battles to fight and gold to squander. Domestic troubles and feuds generally prevailed; the peace and security of the country were disturbed to such a degree by an armed and desperate banditti of disbanded soldiers and idle vagabonds, that in 1480, during the short space of three months, nearly 1500 assassins and robbers were condemned to death.

The confederation strengthened, A.D. 1481.

The confederates had been faithfully supported in their wars by the towns of Fribourg and Soleure, and in 1481 these requested to be admitted into the confederation. Their request was warmly supported by the town cantons; but the mountaineers of the forest cantons objected to it, and the dispute ran so high that, at a general congress of all the confederates, the deputies were at the point of coming to blows, and the confederation was threatened with dissolution. This catastrophe was happily averted by the eloquent remonstrances of a pious hermit, called Nicholas Lóvenbrugger. His simple but pathetic appeal had the effect of removing their differences, and Soleure and Fribourg were received into the Swiss confederation.

Upon the death of Louis XI. of France, Charles VIII. renewed the alliance with the Swiss cantons, and received permission to recruit soldiers among them in exchange for subsidies. The friendship of the confederation was now sought by many sovereigns, among whom the Pope, the Duke of Milan, the house of Austria, and even Mathias of Hungary were prominent. During the Italian wars for the possession of the Milanese and of Naples, Swiss volunteers were extensively used. So great became the importance of the confederation, that their offer of mediation between Charles VIII. and Maximilian of Austria was accepted, when, by the treaty of Senlis in 1493, the county of Upper Burgundy was ceded to Maximilian. Ludovico Sforza, having usurped the Duchy of Milan, the Swiss were offered the districts of Bellinzona, Locarno, and Lugano by Charles VIII. to obtain their assistance in the conquest of the Milanese. The cantons, with the exception of Berne, having accepted the offer, 20,000 Swiss troops joined the French army in Italy.

Independence of Switzerland acknowledged by the emperor, A.D. 1499.

In the year 1497, the Grisons entered into a treaty offensive and defensive with the confederate cantons. This alliance gave great offence to the Emperor Maximilian, who immediately collected his troops, and marched both against the Grisons and their Swiss allies. Battle after battle took place, in all of which, more particularly at Bregentz, Frastenz, Malserheyde, and Dornach, the Austrians were defeated; and the Emperor, having lost 20,000 of his troops in eight months, and finding further exertions useless, concluded a peace with the Swiss at Basle in September 1499, by which he acknowledged their unconditional independence as a nation. This war, called the Suabian war, was the last the Swiss had to sustain for their independence. For three centuries after this date no farther attempts were made against the liberties of the Swiss cantons, which assumed their station as an independent power in Europe. The towns of Basle and Schaffhausen were received into the confederation in 1501, and Appenzell was added in 1513, and completed the number of *thirteen cantons* which have constituted the Helvetic body till within our own times—namely, Zurich, Schwytz, Uri, Unterwalden, the three Waldstätten or forest cantons, Lucerne, Glaris, Zug, Berne, Fribourg, Soleure, Basle, Schaffhausen, and Appenzell. Besides these there were various confederates and associates who were in alliance with the cantons, and entitled to assistance in case of foreign attack. These were the Abbot of St Gall, the city of the same name, the Pays de Vaud, the towns of Mulhausen and Bienne, the Grisons and the Valais, the republic of Geneva, and the county of Neuchâtel.

Thirteen cantons.

In 1513 the Swiss defended Sforza, whom they had the year before installed as Duke of Milan, against France at the battle of Novara, and another Swiss army invaded Burgundy. After the death of Louis XII. of France, Francis I. invaded Italy, and at the battle of Marignano, called the *battle of giants*, defeated the Swiss, who retired across the Alps into their own country, and concluded peace the next year with France. In the subsequent wars of Francis I. in Italy, Swiss troops fought in his ranks, and at the disastrous battle of Pavia, in 1525, the Swiss lost no less than 7000 men.

Reformation.

Switzerland had scarcely obtained rest from her political wars when religious disputes arose among the cantons, and converted into fierce enemies those who had lately fought side by side in defence of their liberties. The unscrupulous sale of indulgences by the agents of Pope Leo X. in Germany, Switzerland, and the other countries, led to a searching inquiry into the whole of the papal system, and caused vast multitudes to renounce altogether the authority of the Church of Rome. In no country did the doctrines of the Reformation create a greater excitement, or meet with more zealous supporters, than in Switzerland. The inhabitants of Zürich, Berne, Schaffhausen, Basle, St Gall, and the Grisons, as well as of many parts in the neighbourhood of Geneva and Neuchâtel, eagerly adopted the opinions of Calvin and Zwingli; while the people of the Waldstätten, and of Soleure and Fribourg, being more secluded and ignorant, and more under the control of the priests, continued staunch in their support of the papal authority. Fierce animosities speedily arose between the reformed and the papal cantons, and various sanguinary wars were carried on for many years. During these internal broils, the territory of the confederation was violated, and their rights infringed without remonstrance; and such was the divided state of the cantons, that Austria, their ancient enemy, might perhaps have subdued them but for the jealousy of the other great powers. To prevent this danger, they, in concluding the treaty of Westphalia in 1648, formally recognised the independence of the Swiss confederation. But though Switzerland was thus secured against the invasion of any of the greater powers, it continued to be torn by internal dissensions. The arbitrary manner in which the large towns levied taxes upon the people of the country, and of the smaller towns and villages, caused great dissatisfaction, especially in the territories of Berne and Lucerne, and at length the peasantry rose up in rebellion against their rulers; and it was not until after considerable bloodshed that the revolt was quelled, and several of the chiefs who were taken alive were tried, condemned, and

Insurrection of the peasants.

History.

Civil war, A.D. 1703.

executed. Scarcely had this insurrection terminated when religious quarrels again broke out between the Protestants and the Romanists. Till near the close of the seventeenth century, Switzerland was distracted by the dissensions arising from this cause; and in 1703, the whole of the Protestant and of the Catholic cantons were openly arrayed against each other, and a civil war of several years' duration ensued. The immediate cause of the war was a quarrel between the people of Toggenburg and their superior the Abbot of St Gall, who had endeavoured in a fraudulent manner to deprive them of their privileges. Zürich and Berne took part with the people, while the Catholic cantons espoused the cause of the Abbot. Several battles were fought, and at length, in 1712, an army of Catholics, 12,000 in number, encountered 8000 Bernois at Vilmergen. The conflict lasted six hours, and in the end the Catholics were completely routed, leaving 2000 of their number dead upon the field. A peace was soon after concluded at Aarau, on terms advantageous to the victors.

French invasion.

From this period till towards the close of the eighteenth century, the state of Switzerland underwent no material alteration; and their internal discords paved the way for external aggression, and rendered them an easy prey to the grasping ambition of the French republic. In 1797, the French government, which had previously interfered in the affairs of Switzerland, manifested a determination to take possession of that country, and evidently sought for a pretence to come to an open rupture. The Swiss government placed their only hope in a passive neutrality, which in the end proved their ruin. For the sake of peace, they submitted with the utmost servility to the imperious and insulting demands of the Directory; but their humiliation did not save them from destruction. The emissaries of France laboured but too successfully to incite dissensions among the people, and the French rulers made these dissensions a pretext for their interference with the constitution of the country. In this way the bailiwicks of Valtelina, Chiavenna, and Bormio, which had been for centuries dependent on the Grisons, but whom the Grisons had obstinately refused to admit to a community of civil and political rights, were incorporated with the Cisalpine republic. Insurrections broke out in several of the cantons, and were rendered triumphant by the assistance of the French arms. Geneva and the Pays de Vaud placed themselves under French protection, and at length the French armies under Brune and Schauenburg, having defeated the Bernese army under D'Erlach in 1798, united Geneva to the French republic, and established the "*Helvetic Republic.*" The inhabitants of Berne, Soleure, Freibourg, and especially of the Waldstätten, made a brave but ineffectual stand in defence of their rights and liberties. The most horrible excesses were committed by the French soldiers; the towns were successively rifled of their public property, and great part of the country was laid waste, and many of the inhabitants reduced to utter destitution. A new constitution was framed by the French directory, which provided that Switzerland should form a single republic, one and indivisible, under a central government to be established at Aarau. The country was divided into twenty-two cantons, and the supreme authority was committed to two councils and an executive directory, in whom was vested the appointment of prefects and other authorities for the various cantons, which were thus transformed into departments, with the loss of their independence as separate states. After this new constitution was established, a treaty was made with France, by one of the articles of which the Swiss republic was bound to furnish to its new ally a force of 16,000 men. Great miseries were suffered by the people, from the excesses of every kind committed by the French troops, and their heavy requisitions and exactions. The small canton of Unterwalden refused to swear fidelity to the new constitution of the Helvetic republic; but after a desperate struggle it was subdued; the inhabitants were massacred without distinction of sex or age; and that district, once peaceful and happy, was left a scene of horrible desolation. During the campaign of 1799, Switzerland was the theatre of the struggle between the armies of Austria, Russia, and France; the Austrians under Hotze; the Russians under Suwarrov and Korsakov; and the French under Massena, Molitor, Soult, and Lecourbe. The mountain cantons were in consequence utterly ruined, a considerable part of the country rendered uncultivated, and the population reduced to little short of actual starvation. The Helvetic directory was suppressed in 1800, and an executive commission substituted in its room; and about seven months after, this commission dissolved the councils and convoked a new legislature. A general diet was called in September 1801, for the purpose of re-organizing the constitution of the country. Meanwhile the treaty which was signed at Luneville between France and Austria guaranteed the independence of the Helvetic republic, and the French troops were consequently ordered to evacuate Switzerland. Their departure was the signal for a general revolt. All the old factions were awakened afresh. The Pays de Vaud formed itself into a single republic; Uri, Schwytz, and Unterwalden took up arms against the Helvetian government; and the towns of Zürich, Basle, and Schaffhausen renounced their allegiance. A civil war appeared inevitable, when Napoleon Bonaparte offered himself as arbitrator between the contending parties, and ordered Marshal Ney to advance with a body of troops to the frontiers of Switzerland to enforce compliance with his mandates. The existing government was dissolved, a provisional government established, and deputies from all the cantons were ordered to assemble at Paris to deliberate upon a constitution for their country. Several months were spent in debates; and Napoleon, after he had heard and reflected on their representations, promulgated an act of mediation, which was drawn up with a view of reconciling opposite factions, and of fairly meeting various interests. It restored the old federative system, but introduced very considerable improvements. The act of mediation was promulgated 19th February 1803; and the Helvetic general government having been dissolved, and the new constitution put in force, the French troops finally evacuated the country.

Swiss republic.

The French

Independence of the republic.

Act of mediation, A.D. 1803.

From that time till 1814 Switzerland enjoyed internal peace; and during the gigantic wars which at that momentous period raged throughout Europe, this country rested in security amid the din of battles and the crash of falling empires, and made rapid progress in the arts of industry and in the career of intellectual and social improvement. On the downfall of Napoleon, the act of mediation was dissolved; but the integrity of the country was guaranteed by the Congress of Vienna in 1815. The territories formerly dependent on the Bishop of Basle, which had been annexed to France, together with Valais, Neuchâtel, and Geneva, were ceded to it as new cantons, and a constitution, based on the act of mediation, was framed for the whole cantons, now amounting to twenty-two. On the 7th of August 1815 the federal compact was finally signed by all the deputies in the diet assembled at Zürich. The deputies then repaired in procession to the cathedral, where they bound themselves by a solemn oath, and in the name of their constituents, to the faithful observance of its enactments.

New constitution, A.D. 1815

During the fifteen years which elapsed from 1815 to 1830, Switzerland enjoyed profound tranquillity. The general condition of the country was prosperous, and education was improved in several districts; but the civil and criminal laws remained in a defective state; the press was under a strict censorship, and various anomalies existed in the institutions of many of the cantons. Petitions were from time to time presented for the revision of the constitution of

Statistics. 1814, but were everywhere rejected by the councils. The first alteration of this state of things took place in the canton of Ticino in May and June 1830, and the example was speedily followed by all the other representative cantons of Switzerland. A new constitution established equality of political rights among all the citizens of the state; the direct system of electing all the members of the legislature, the elections to take place every four years; separation of the three powers, legislative, executive, and judicial; publicity of debates; liberty of the press, subject to fixed laws against libels; inviolability of person and property and the right of petition. No tax to be imposed unless sanctioned by a majority of two-thirds in the great council. The constitution not to be modified until twelve years shall have elapsed from its enactment; and then any alterations proposed in it must be submitted to the approval of the primary assemblies of the people. These alterations in their constitution were peaceably adopted by the most of the cantons; but in some of them popular tumults arose, which were speedily suppressed by the firmness and prudence of the Diet.

In 1834, the tranquillity of Switzerland was endangered by a considerable body of Polish, German, and Italian refugees, who had taken up their residence in Switzerland. In the month of January, some hundreds of these refugees made a sudden attack on the dominions of the king of Sardinia, in expectation of combined attacks and insurrections in other parts of the Sardinian monarchy. The Sardinian government made strong remonstrances to the confederation concerning this violation of the neutrality of the Swiss territory; and the courts of Austria, Prussia, and other German states, whose territories border on Switzerland, joined in these remonstrances. After some negotiations, the matter was brought to an amicable termination by the Swiss governments promising in future to send away from their territory all those who should attempt to disturb the tranquillity of other states.

The new law establishing a system of education for the clergy in 1839 was opposed at first by the Protestants, and the government at Zürich was dissolved. Aargau, in 1844, demanded the expulsion of the Jesuits; and in 1848, in order to effect this, bodies of armed men, called the Free Corps, were organised in several cantons. The Free Corps under Colonel Ochsenbein having invaded Lucerne were defeated, and in 1846 a separate league, termed the Sonderbund, was formed by the seven Catholic cantons for a defence against the Free Corps. In 1847 the Diet passed a resolution declaring the illegality of the Sonderbund and the expulsion of the Jesuits. The Federal army, under General Dufour, having, in November of that year, defeated the forces of the Sonderbund at Fribourg and at Lucerne, the Catholic cantons submitted, the Jesuits were expelled, and monasteries suppressed. On the 12th of September 1848, the new constitution was promulgated. With the exception of the attempt of a small aristocratic party to separate Neuchâtel from Switzerland and to incorporate it with Prussia—an attempt which at once called forth the strong opposition of the united cantons, and which led to the entire separation of Neuchâtel from Prussia and its incorporation into Switzerland—the cantons have since maintained their internal tranquillity and external independence. During the late contest in Italy, between Austria on the one hand and France and Sardinia on the other, Switzerland maintained the strictest neutrality. (For farther notice see GOVERNMENT, &c.)

Physical features. The physical features of Switzerland are remarkable, and for beauty and grandeur are unsurpassed by those of any other country in Europe, being a singular assemblage of lofty mountains, glaciers, valleys, ravines, rivers, and lakes. Two groups of mountains are spread over its surface, the Jura on the W. and N.W., and the Alps on the S.E. and centre. The Jura range is composed of six parallel ridges, lying in a S.W. and N.E. direction, with few interruptions and no spurs. This range extends from the neighbourhood of Geneva along the boundary between France and the Pays de Vaud, and then enters the canton of Neuchâtel, which it almost entirely covers, as well as the N.W. part of Berne, the greater part of Soleure and Basle, and north-western Aargau. The hill of Bœzberg is generally considered as the north-eastern extremity of the Jurassic chain, although some geographers have adopted the names of the Jura of Franconia and Swabia, for the chain which receives in Germany the very undeserved title of Rauhe Alp. The theoretic extension thus given to the Jura as far as the neighbourhood of Ratisbon, is justified by the analogy of direction, geology and fossil remains; but the same may be said for the southern prolongation of the chain to the south-west of Geneva, on both sides of the Rhone as far as Seyssel in France, and the Mont du Chat and Montagne de l'Epine, south-west of Chambery, thus increasing its extent to more than 350 miles, instead of 250 as formerly calculated. Geologically speaking, the Jura is composed of a nucleus of the bluish-grey limestone called liasic, covered with an upper stratum of oolitic limestone of a yellowish hue. Fossil remains are abundant in the latter, and have lately been found in great quantities in the Mormont, where the South-Western Railway has been the cause of a deep cutting at La Sarraz, in the canton of Vaud.

Jura.

The Jura scarcely attains one-third of the height of the Alps, yet, in proportion to its elevation, it is colder. The highest summits occur in the ridge near to Geneva and Lausanne, between the Fort de l'Ecluse and Orbe, partly in French territory. Although most frequently mentioned, through the observations of De Luc and De Saussure, the Dôle, 5453 feet, is not the highest; Mount Tendre, the Colombier, and the Reculet surpass it; and the Crêt de la Neige has been found by the French engineers to be 11 feet higher than the Reculet, 5642 feet. They do not, however, rise into peaks, being but little superior to the general level of the chain, and entirely destitute of the imposing features of the Alps. Passages across the Jura are little inferior in height to the general line of the crests; but in a few cases, such as the gorges by which the Rhone at Bellegarde, the Rhine, and the Doubs at Morteau, emerge from their upper to their lower valleys, the chain is cut through to its very foot, and sometimes presents stupendous chasms. The Perte du Rhône, and the Malpertuis near Billiat, 5 miles lower down, are the most renowned, the whole body of the river being confined, in this portion of its course, between two immense walls, of 600 feet in height, into a channel estimated at from 15 to 50 feet in width.

Alps. From the radiating direction of the ridges, most of them centring in the neighbourhood of the St Gothard, the Alps better deserve the name of a system than of a chain. The main ridge, called the Pennine Alps, forms the boundary between Canton Valais and Italy, and separates the basin of the Upper Rhone on the north from that of the Po on the south. To the south of Mont Blanc, the Alps consist of a number of partly detached groups without well-defined axes. Eastward they are divided into two great ranges, which enclose the valley of the Upper Rhone, and meet at Mount St Gothard, whence four ranges diverge: the Bernese Alps to the west; the Alps of Glaris and the northern Grisons to the north-east; the south-east branch, which forms the southern boundary of the Grisons on the side of Italy; and the south-west branch, connecting the St Gothard with the Pennine Alps. Between these ranges are four large valleys,—those of the Rhone, the Reuss, the Upper Rhine, and the Ticino. There is a remarkable difference in the shape of the Alps, as they cover the central and western parts of Switzerland, and in the Alps of Tyrol

Statistics. and the Grisons, or Rhætian Alps. In the latter, though the summits are inferior in altitude to those of Savoy, Oberland, and Valais, their mass is larger in comparison with the width of the valleys, and is generally raised so high as to have a greater part of its surface covered with snows and glaciers, or unfit for production. In Rhætia the valleys are mere deep alleys, which is the cause of the scanty population. The mean breadth of the highest portion of the Alps does not exceed 100 miles, but it widens considerably as you proceed eastward. Many of the valleys of the Grisons, Engardine, &c., are, however, wide and open, and the character of the country seems to vary accordingly as the geological conformation is crystalline, slaty, or calcareous. The

Glaciers. number of Swiss glaciers are reckoned at 605, of which nine-tenths, or about 540, are in the following cantons: 255 in the Grisons, 155 in Berne, and 130 in Valais. The supply of water they produce is discharged into the basins of the following rivers: 170 glaciers into the Rhine, 15 to the Linth, 25 to the Reuss, 160 to the Aar, 135 to the Rhone, 35 to the Po, and 65 to the Inn.

Natural divisions. M. Franscini, in his *Statistique de la Suisse*, divides Switzerland into five regions, viz., alpine region, of about 6950 square miles in extent, and containing 388,493 inhabitants; the eastern region, of about 1930 square miles, and 564,124 inhabitants; the northern, of about 2130 square miles, and 803,395 inhabitants; the western or Jurassian, of about 2990 square miles, and 517,804 inhabitants; and the Italian or southern, of about 1230 square miles, and 123,924 inhabitants. It may also be divided thus: 1. The alpine; 2. the Jurassic; 3. the southern part of the space lying between these two ranges, in the form of a plain with isolated hills; and, 4. the northern portion, traversed by ridges of moderate elevation.

Tableland. The tableland of Switzerland, lying to the north of the alpine region and east of the Jura, is the finest and most productive of the whole. It slopes from south to north, from the foot of the Alps to the Rhine and the Lake of Constance, and includes the cantons of Vaud and Fribourg, the greater part of Berne, Lucerne, and Aargau, the whole of Zürich, Zug, Thurgau, and part of St Gall. The elevation of this tableland varies from 1200 to 1800 feet above the sea. Its surface is furrowed by numerous valleys, which generally run from south-east to north-west. Each of these valleys is divided by its river, and various ranges of wooded hills follow the course of the streams.

Rivers. Four-fifths of Switzerland belongs to the basin of the

Rhine. Rhine. This river has its rise in the Alps of the Grisons, receives the waters of some of the glaciers of that lofty region, and is at its source, Hinterrhein, at the foot of the glacier, 7268 feet above the level of the sea. Thence it pursues a northerly direction to the lake of Constance, receiving on its left the Tamina from the canton of St Gall, and on its right the Ill from the Austrian territory. It issues from the north-west portion of Lake Constance, at the town of Stein, where it is 1300 feet above the sea; it then flows in a tortuous but generally westerly direction to Basle, passing by Schaffhausen, Waldshut, and Seckingen, receiving the waters of the Thur, the Aar, and the Birs, forming for a direct distance of about seventy miles the northern boundary of Switzerland. At Basle, where it is 821 feet above the sea, it turns abruptly to the north and leaves the Swiss territory. The Falls of the Rhine are celebrated for their grandeur.

Aar. The Aar flows through the lakes of Brientz and Thun, into the Rhine, having previously formed a cataract at Handeck; and receives the waters of the Limmat, Saane, Thiel or Ziel, Emmen, and Reuss. At Aarberg the Aar is 1469, and at its junction with the Rhine 1033 feet above the level of the sea.

Linth. The Linth, a rapid stream, rises in the Alps of Glaris, it then flows through the lake of Wallenstadt, and is called the Limmat: after marking the limits between Schwytz and St Gall, it forms the lake of Zürich, and, flowing through part of the cantons of Zürich and Aargau, enters the Aar below the confluence of the Reuss. Statistics.

The Thur has its sources at Wildhaus, in the mountains Thur. of High Toggenburg, in the canton of St Gall, and enters the Rhine below Rheinau. Its level at its source is 3358, at Bischoffzell 1500, and at its confluence with the Rhine, 1141 feet above the level of the sea.

The Birs has its rise in the Jura, to the east of the pass Birs. of Pierre Pertuis, flows through the cantons of Berne and Basle, and enters the Rhine just above the town of Basle.

The Thiel or Zihl also has its source in the Jura, under Thiel. the name of Orbe, and is at the Lac de Joux 3312 feet above the sea; flows through the Lac des Brenets, where it disappears, and after a great subterranean descent, makes its re-appearance at the spot called "Source of the Orbe," where it is 1459 feet above the sea; it then flows through the lakes of Neuchâtel and Bienne, and soon after, leaving the latter, enters the Aar at an altitude of 1416 feet above the sea.

The Saane has its source in the Bernese Alps, and after Saane. a rapid course of about 70 miles, in which it passes Saanen, Freibourg, and Laupen, enters the Aar a few miles below the latter town.

The Rhone is formed from a glacier below the Pass of Rhone. the Furca, in the north-eastern extremity of the Valais, at a height of 5500 feet above the sea. Descending rapidly to Oberwald, it proceeds in a south-west direction past Brieg and Sion to Martigny, when it turns abruptly to the north-west, and continues in that direction to its entrance into Lake Leman. It issues from this lake at Geneva, below which it receives the Arve from the valley of Chamouni, and quits the Swiss territory near Chanci, the last village of the canton of Geneva.

The Arve does not strictly belong to Switzerland, the Arve. greater part of its course being through Savoy, but it is the most considerable alpine tributary to the Rhone, into which it flows about 1 mile below Geneva. It is at the source, near the village Du Tour, 4277 feet above the sea, has a course of 65 miles, and at its mouth is 1222 feet above the sea-level: it discharges into the Rhone, on the average, 4300 cubic feet of water per second.

The Inn rises in some small lakes near the Maloya Inn. Pass, is fed by the glaciers on the north side of the Bernina range, and, after flowing through the Grisons in a general N.E. direction, leaves the Swiss territory at Finstermünz.

The Ticino issues from Mount Gries, and traverses the Lago Maggiore in Italy.

The Swiss rivers are subject to rises during the summer Ticino. season of sometimes as much as 16 feet. Their lowest waters last generally from the beginning of November to the end of March, their highest state is in the month of June; and from the middle of July to the end of October they preserve their average volume. The Falls of the Rhine are 78 feet in height, those of the Doubs 88 feet, and the underground fall of the Thiel or Orbe, from the valley of Joux to its re-appearance near Vallorbes, 741 feet.

The lake of Geneva or Leman, the great reservoir of the Lakes. Rhone, spreads in the form of a crescent, its northern bank L. Geneva. being about 56 miles in length, and the southern bank about 46. Its breadth near the centre is about 9 miles, but it becomes much narrower towards Geneva. The surface of the lake is 1230 feet above the level of the sea, its greatest depth is about 1100 feet, and its area 340 square miles. It receives several streams, the principal being the Dranse, from the Alps of Savoy, and the Vevayse and the Venoge, from the Swiss side. The lake of Geneva is known to have been frozen over only twice—in A.D. 762 and 805. It is subject to remarkable risings, called *seiches*, of from 4 to 5 feet, lasting about 25 minutes. Several steamers

Statistics.

ply between Geneva, Morges, Ouchy for Lausanne, Vevey, and Villeneuve.

L. Constance.

The lake of Constance, or Boden See, is about 42 miles long and 9 miles wide. It surface is 1300 feet above the level of the sea, its area is about 290 square miles, and its greatest depth is 1800 feet. Numerous steamers navigate this lake.

L. Four Cantons.

The lake of the Four Cantons, or Vier Waldstätter See, is 26 miles in length. The southern part, called the lake of Uri, is a sheet of deep water, 8 miles long, and between 1 and 2 broad, running from south to north between two almost perpendicular ranges of mountains; a narrow channel unites it with the middle basin, which is about 9 miles in length and about 2 wide. Another strait leads from the middle into the western basin, called the lake of Lucerne, the widest and finest of the three. The surface of the lake is 1428 feet above the sea, and its greatest depth is 1000 feet. The country around the Waldstatter See is the cradle of Swiss independence, and many of the localities possess great historical interest from the exploits of its heroes. Steamboats ply between Lucerne and Küssnacht, and Lucerne and Fluellen, the port of Altorr.

L. of Zurich.

The lake of Zürich, formed by the Limmat, is 24 miles long, and from 1 to 2 miles wide. Its greatest depth is 600 feet, and its surface is 1341 feet above the level of the sea. Steamboats run on this lake between Zürich, Horgen, Richterschwyl, Rapperschwyl, and Schmerikon.

L. of Neuchâtel.

The lake of Neuchâtel is about 30 miles in length, and 5 miles broad throughout one-half of its length. It is 1426 feet above the sea, and has a depth of 350 feet. Steamers ply on this lake, and through the Thiel river on that of Bienne, connecting the railways of Yverdon and Nidau.

L. of Bienne.

The lake of Bienne is about 10 miles long and 2 wide; the level of its surface is 8 feet below that of Neuchâtel, and its greatest depth is 217 feet.

L. of Wallenstadt, &c.

Besides these there are several other lakes of considerable extent, such as the lake of Wallenstadt, or Wallensee, an expansion of the Seer, and lately artificially connected with the Linth, 11 miles in length, and 1394 feet above the level of the sea; and the lakes of Brientz and Thun, both formed by the Aar; the latter, 13 miles long, has a depth of 800 feet, and is 1823 feet above the sea. Steamboats ply on this lake, which is much visited by tourists from Berne. The fish these lakes contain are trout, pike, salmon, tench, carp, perch, and a very delicate fish called umber. The collective extent of the twenty-two largest lakes is about 1035 square miles, of which 260 have to be subtracted as being out of the Swiss territory. The remainder, about 775 square miles, is about one-twentieth of the whole country. The variation of level in the lake of Geneva is 6 feet, and in the lake of Neuchâtel 7 feet 5 inches; the lowest state in the latter is in August, while in the former it is in spring.

Metals.

Switzerland receives a considerable supply of metals from abroad, a great portion of which, however, is again exported in a manufactured state. Iron is produced to the amount of about 10,000 tons annually, of which 5000 tons of excellent character is produced by the Bernese Jura, 1900 tons by Soleure, 1100 by Schaffhausen, and 450 tons from Ardon in the Valais. Salt is produced to the amount of 13,000 tons; of which the works at Schweitzerhall, near Basle, yield 11,000 tons, and the remainder by those at Bex; the salt works at Rheinfelden and Kaiser Augst in Aargau have been abandoned. About 250 tons of copper is produced annually, and 500 tons of lead. There are some mines of anthracite coal of a poor quality, at Outre-Rhône, Salvant, Iserable, in Valais, and a few other places. Among the other mineral productions of Switzerland are marble, alabaster, gypsum, slate, granite, and other kinds of building stone; sulphur near Lake Thun; asphalte in the Valais; and particles of gold are found in the sands of some of the rivers, but not in sufficient quantities to pay for the search.

Springs.

The number of mineral springs in Switzerland is very great; there are as many as twenty first-rate watering-places, and a great number of inferior ones. The most frequented are those of Pfeffers and Leuk. The temperature of the springs at the former is 36°·6′ centigrade, or 98 Fahr., and at the latter 50°·6′ centigrade, or 123 Fahr. Those of Baden, Schinznack, St Moritz, Heirnichsbad, Rosenlaui, and Stachelberg, are also well known, and much visited.

Climate.

The observations of Kaemtz on the Rigi, Schöner on the St Gothard, Bravais on the Faulhorn, and Plantamour on the Great St Bernard, show the average diminution of temperature to be of 1° of the centigrade thermometer for about 570 feet of ascension. The temperature of a place does not, however, altogether depend on its elevation, but also upon the proximity of large glaciers, the reflection of heat from adjoining slopes, and in the mobility of the atmosphere. The slopes are heated by ascending currents of warm air from the valleys; the neighbourhood of glaciers has always, and that of lakes very often, a cooling influence, and are subject during the warmest hours of a summer day to a motion of cool air originating in the same cause as that which produces the land and sea breezes on the shores of the ocean. At a height of about 8000 feet the average temperature is not above freezing point. The average temperature of Berne is 45° Fahr., that of Basle 46°, and that of Geneva 46½°.

Animals.

Among the wild animals of Switzerland are the bear, wolf, wild boar, ibex, deer, and game of all kinds; the marmot, ermines, &c. Large birds of prey are common in the mountains, but the chamois is becoming scarce, and bears and wolves are found in some districts only.

Switzerland is distinguished for the extent and excellence of its pastures, and the number of cattle they support, though in opposition to received opinion, the Swiss import more cattle than they export; the numbers of late years having been in the average 72,000 and 50,000; they are, however, imported when young and sold when fat, in addition to which there is greater profit derived from cheese and hides than from selling the cattle themselves, as their keep is not expensive. Early in the spring, on the disappearance of the snow, they are sent into the lower pastures; in the beginning of June they are moved into the middle pastures, and a portion of them ascend into the highest pastures during July and August. The number of cattle in Switzerland is estimated at 875,000; the number of horses at 105,000; that of sheep 405,000; that of goats 376,000; and that of pigs 279,000; the cattle and goats are on the increase, but the horses and pigs are on the decrease.

Agriculture.

In Switzerland agriculture is carried on to the greatest perfection that the climate and soil of such a country will allow. By means of trenches and sluices water is conveyed from the mountains to any required point: extreme care is taken to economise and render available the manure obtained from their herds; and great judgment is shown in the culture of the different kinds of soil. Even apparently sterile and unavailable slopes are made use of, mould being carried up from below and spread upon them in the form of terraces. The use of animal labour in agricultural operations is not extensive, chiefly owing to the rugged surface of the country; and nearly everything is done by hand. The grain crops are inferior in quantity, but the pasturage is extremely good, and its bright verdure such as to render it a distinguishing feature of the country. The vine is cultivated in several localities, and some of the wines produced are of a very good quality. The cultivation of tobacco is undergoing great development, especially in the northern part of Vaud, which yields a cheap though rather indifferent produce. The domestic economy of a Swiss country household is very simple; from their land and cattle they can supply nearly the whole of their wants,

Statistics. and the profits of their dairy afford them the small sums of money they require. The quantity of timber at present exported exceeds L.86,000 in value, but this must ultimately have a very bad effect on the country, as it is so far beyond the rate of growth.

Commerce. Previous to 1852 commerce throughout Switzerland was limited by a number of internal duties, which were exacted at many of the frontiers of particular cantons. From that time, however, a general line of custom-house offices has been drawn round its frontiers, and one general tariff of duties established by the central government, which, though moderate, is very complicated, and shows that the Swiss legislators have derived but little profit from the example given to Europe by England and Sir Robert Peel. Nobody would believe that singing birds have the honour of figuring in the Swiss tariff. Geneva, where free trade had always been practical, suffered very much by the change, but other cantons gained in proportion as they were more or less fettered previously. The national import duties are divided by the federal government, and each canton in proportion to the number of inhabitants. Each canton is at liberty to levy excise duties. The federal revenue and expenditure of Switzerland for each of the years 1855, '56, and '57, is as follows:—

Import duties.

	1855.	1856.	1857.
Revenue,.........	L.642,600	650,000	627,440
Expenditure,....	619,000	643,320	608,240

Transit trade. Since the abolition of internal customs, the transit trade has increased from 391,000 quintals in 1852 to 597,000 in 1856, out of an import trade which amounted in bulk to 1,890,400 quintals in 1840, 2,652,200 in 1849, and 10,297,055 upon an average from 1852 to 1857—a rate of increase greatly beyond that of the population. The progression is the same with regard to value; the imports and exports together amounted in 1842 to L.18,553,643, in 1852 to L.28,452,219, and, on the average, from 1852 to 1855, to L.40,606,177. The last sum gives a proportion of L.16 to each individual; while in Belgium it is L.12; in France, L.4; in the Zollverein, 66s.; in Sardinia, 50s.; and in Austria, 34s. Of the total sum of L.40,666,177, L.14,000,000 should, however, be deducted as only transit trade, reducing the actual amount due to each individual Swiss to L.10, 10s. France and Lombardy receive but little Swiss produce for their home consumption, while Switzerland receives from the former wines, spirits, and corn, and from the latter silk to a large amount.

Railways. The railway system of Switzerland, considering the physical difficulties presented by the country, is very extensive, most of the large towns of the north and central portions being connected by this means. The electric telegraph is also much used, there being a total length of over two thousand miles laid down.

Manufactures. The watches, for the manufacture of which Switzerland is famous, are mostly made at Geneva, Neuchâtel, Val St Imier, the valley of Joux, and the Val de St Croix, in the Jura of Vaud. This branch of industry, together with that of jewellery, employs about 23,000 people, and the number of watches made annually is about 190,000. The value of those exported in 1853 was L.117,000, and L.255,000 in 1857; but though the quantity produced is thus greatly on the increase, the quality is said not to be so good as formerly, owing, it is believed, to the growing immorality of the workmen in the large towns.

The silk manufactures employ a great number of people in the canton of St Gall, and the manufacture of ribbons is carried on at Basle. In addition to the large quantity of silk imported for these branches of industry, a considerable quantity is produced in Switzerland itself. About five-sixths of the raw material imported comes from Lombardy, and about two-thirds of the manufactured fabrics exported passes through France, and the remainder through the Zollverein. The cotton manufactures are very animated, and it is estimated that they employ more than 660,000 spindles. In Zurich there are 330,000 spindles and 76 mills at work; in Argovia, 137,000; in St Gall, 85,000; in Glaris, 62,000; and in Thurgovia, 22,500.

The manufacture of cutlery and cheap mathematical instruments, a great number of which come to the London market, is carried on to a great extent at Aarau and Zurich.

Population. Switzerland forms the centre where three great continental races meet; the Teutonic Swiss occupy the northern cantons, the French the western, and the Italians the canton of Ticino and the southern valleys of the Grisons; while those speaking the language called *Romansch* a dialect somewhat similar to Latin, occupy half the Grisons. Of the whole population 1,680,000, or about two-thirds, speak German; 540,000, French; 130,000, Italian; and 42,000 the Romanic dialects in the Grisons. Notwithstanding these peculiarities of language, and the variety of physical features, they have lived so long together in a state of confederation as to have assumed quite a national character, and may be looked upon as one people. The French language has long been on the increase.

Births and deaths. The annual average of the births in Switzerland during the three years 1850, '51, and '52, was 70,000, being in proportion to the population as 1 to 34. The proportion of the males to the females with regard to the number of births is as 15 to 14, while to the total population it is as 40 to 41; so that, though there are more males born, they are on the average shorter lived than the females. The porportion of illegitimate to legitimate births is as 1 to 18. The annual average of marriages during the same period was 16,270, being in proportion to the population as 1 to 147. The average annual number of deaths during these three years was 55,500, being in proportion to the population as 1 to 43.

Before 1798 Switzerland consisted of a confederation of states of three very different kinds:—1. Thirteen cantons; 2. the subjects or vassals of these cantons; and 3. the allies of these cantons. The federal bond uniting the various cantons was very loose, and there was no permanent sovereign body, or central government, equally acknowledged by all. No important questions could be decided in the general diets, unless it had been previously debated and decided on in the councils of each of the cantons. The subjects of the Swiss were either subjects of certain particular cantons, or common bailiwicks subject to all the cantons. The whole population of the thirteen cantons at the close of last century was about 1,000,000; that of their subjects was about 250,000; and that of their associates and confederates, and the subjects of these confederates, amounted to nearly half a million more. Altogether, the territory belonging to the Helvetic Federal Body contained a population of about 1,700,000.

Government. By the present constitution, promulgated in 1848, the general affairs of the Confederation are intrusted to a National Council, the members of which are elected for three years, and in the proportion of one to 20,000 inhabitants; and the council of the states, composed of forty-four deputies, two for each canton. Formerly these used to assemble at Berne, Zürich, and Lucerne alternately, but Berne is now fixed upon as the regular place of meeting. A president of the Federal Council and six members, to form an executive government, are chosen by the national council and the council of the states together every three years. The two councils also elect the Tribunal Fédéral, consisting of eleven judges, for three years; and conflicts between the cantons, and between them and the federal council, are decided by this high court. Each canton has sovereign authority in its own affairs, with the exception of certain rights which are vested in the federal power, such

Swords || Sybaris.

as the declaration of war, the conclusion of peace, custom-house duties, post-office, telegraphs, &c. The form of government is *republican*, and is vested in assemblies elected by the people, all the male population, above a certain age, having a vote, without respect of property qualification. The cantons are subdivided into 177 districts and 3059 communes. The general desire seems to be towards a greater amount of centralization than formerly, but it is still thwarted by the private interests and jealousies of separate cantons. They have, however, recently adopted a national coinage and system of measures; the coinage being the same as that of France.

Army. There is no *standing* army in Switzerland, but every able-bodied man, up to a certain age, is called out for a short period in every year and drilled. The number of the *élite*, or those who are supposed always to be in readiness for service if required, is 77,000; the reserve, 43,000; and the landwehr, 57,000; making thus a total of 177,000 men in the event of an emergency. In the winter of 1856, when threatened by Prussia, they placed on foot, within a few months, an army of 200,000 men, well provided with artillery, and proposed to encounter one of the first powers in Europe. The Swiss are very skilful marksmen, devoting a great deal of time to rifle practice, and holding annual matches near one or other of the great towns, at which all the best shots compete for a prize. (N. S.)

Sydenham.

SWORDS, a market-town of Ireland, on the right bank of a river of the same name, in the county and 8 miles north by east of Dublin. It is for the most part very meanly built; and has a Gothic church, a Roman Catholic chapel, a small court-house, and an endowed school. There is neither trade nor manufactures, and the place is in a very decaying condition. Here stands one of the remarkable round towers of Ireland, about 80 feet high. Pop. 1294.

SYBARIS, a celebrated ancient city of Magna Græcia, near the west shore of the Gulf of Tarentum, between the mouths of the rivers Sybaris and Crathis. It seems to have been the earliest Greek colony in this part of Italy; for it is said to have been founded in 720 B.C., by colonists from Helice in Achaia. Situated as it was in a fertile plain, the new settlement rapidly rose to a high degree of prosperity, and became a large and populous city. Contrary to the custom of most of the Greek states, settlers from other countries were freely admitted at Sybaris; and this was very probably one cause of its size and prosperity. Its wealth and luxury were proverbial, and have probably been much exaggerated by ancient writers. But there is no good reason to doubt that Sybaris had attained, in the sixth century B.C., a greater amount of power and riches than had been reached by any Greek state before. Its territories extended to the opposite shore of the peninsula, where it founded the colonies of Laus, Scidrus, and Posidonia; and, according to Strabo, it was mistress of twenty-five dependent cities, most of them probably towns in the interior. Numerous details are given by ancient writers about the magnificence and luxury of the Sybarites; but besides the intrinsic absurdity of many of these tales, it is a suspicious circumstance that these accounts are given with so much minuteness, while we are told so little of the history of the city, with the exception of these events that led immediately to its fall. One of these wonderful stories relates how Sminclyrides, a citizen of Sybaris, went to court Agarista, daughter of Clisthenes, tyrant of Sicyon, followed by a train of more than 1000 of his own personal attendants, including cooks, fishermen, &c. Unfortunately, with all this equipage, he did not find favour with the young lady or her father, although he surpassed and astonished all Greece with his magnificence and luxury. There is probably very little truth in these accounts of Sybaris; and as little in the assertion of Strabo, that it could bring into the field an army of 300,000 of its own citizens.

It seems to have arrived at its greatest prosperity soon after 580 B.C.; but towards the middle of that century political dissensions rose to a violent degree. The government had been for a long time oligarchical, probably in the hands of the wealthier classes; but a democratic party, under a leader called Telys, at length succeeded in gaining the upper hand, and compelled a number of the opposite party to go into exile. The aristocratic city of Crotona afforded a refuge to the fugitives; but Telys and his supporters demanded to have them given up. This demand having been refused, led to a declaration of war against Crotona on the part of the Sybarites. The two armies met near the river Trais, where the Sybarites, though more than three times the number of their enemies, were totally defeated with great loss. The Crotonian army pursued the fugitives to the very gates of Sybaris, which they took without further resistance. Determined to carry out their vengeance to the very last, they laid the city in ruins, and turned the course of the Crathis into it, so that it should never more be inhabited. This happened in 510 B.C. Those who survived its ruin took refuge in the colonies of Laus and Scidrus; and when they attempted, in 452, to rebuild the city, they were driven away by the Crotoniats, a little more than five years after. On this they applied for assistance to the Spartans, but without success; afterwards, however, they obtained the aid of the Athenians, who resolved not only to restore these settlers, but to send colonists of their own along with them. The result of this was the foundation of Thurii, near the site of the ancient city; but Sybaris itself never was restored. No traces have yet been discovered of its remains.

SYDENHAM, a hamlet and chapelry in the parish of Lewisham, Kent, 4 miles from Deptford, and 8 miles S.S.E. from London, lies partly in a deep and pleasant valley, and partly on a considerable hill, environed by much agreeable scenery, which, spite of railroads, still retains somewhat of its rural character. Houses, however, are rapidly springing up on every side, and Sydenham will soon form a portion of suburban London. There are here (1.) a station on the London and South Coast Railway, bringing the metropolis within twenty minutes' ride; and (2.) at Lower Sydenham, a station on the London and Southborough Road branch of the Mid Kent Line. — Situation and statistics.

The population of Sydenham, in 1841, was 2915; in 1851 it had increased to 4501. In the former year there were 516 inhabited houses, 40 uninhabited, and 20 building; in the latter, the inhabited houses numbered 801; the uninhabited, 47; houses building, 28. In 1640 a mineral-spring, afterwards known as the Sydenham Wells, was discovered in this vicinity. Its properties were mildly cathartic, and resembled those of the Epsom waters; but it has long ceased to be recommended by the faculty, or made use of by invalids. The poet Campbell was a resident at Sydenham from 1804 to 1821. His house was situated on Peak Hill, looking towards Forest Hill. He left Sydenham for lodgings at 62 Margaret Street, Cavendish Square, on assuming the editorship of the *New Monthly Magazine*. The living of Sydenham is a perpetual curacy in the patronage of the Earl of Dartmouth, valued at L.248 yearly. The church, a neat and graceful edifice, is dedicated to St Bartholomew.

Crystal Palace. The Crystal Palace is situated within the Sydenham district, and a branch from the London and Brighton Railway diverges at

Sydenham. the Sydenham station to a terminus within the palace grounds. Its site forms a portion of an estate of 290 acres, known as *Penge Place* (purchased by the Crystal Palace Company in 1852), and from its great elevation commands a fine view of the cloudy roofs of the great metropolis, and extensive prospects in Kent and Surrey. The building itself is a great improvement upon the structure of glass and iron which enshrined, in 1851, the industrial exhibition of all nations in Hyde Park, and must be regarded as a satisfactory monument of the engineering skill and mechanical enterprise of the England of the nineteenth century. The Hyde Park building was marked by too great a monotony, and its elevation was disproportionate to its length; but in the Sydenham palace an agreeable effect is produced by the three transepts, by the lofty arch of the centre, and the recesses in the garden front. The dimensions are given by the authorities as—length, 1608 feet; greatest width, 384 feet; general width, 312 feet; area, including wings, 603,072 feet; height of nave, from ground floor, 110 feet 3 inches; height of central transept from ground-floor, 174 feet 3 inches; height of central transept from basement, 197 feet 10 inches; area occupied by the galleries, 261,568 feet. The girders which support the galleries and roof work are of cast-iron, and 24 feet long. The first gallery is reached by a flight of stairs, 23 feet high; the upper gallery, by spiral staircases, about 40 feet in height. If all the columns made use of in this superb structure were laid out in a straight line, they would extend $16\frac{1}{2}$ miles. The iron employed amounts to 9641 tons, 17 cwt., and 28 lb.; the superficial quantity of glass used is 25 acres, and weighs 500 tons. The colonnade leading from the palace to the railway station is 720 feet long, 17 feet wide, and 18 feet high, consuming, so to speak, 60 tons of iron, and 30,000 superficial feet of glass.

The palace is heated by hot water, on a system designed by its principal architect, Sir Joseph Paxton, who had formerly submitted it to the test of experience at Chatsworth. On this point it will be sufficient to state, that the hot water pipes employed, if placed in a straight line, would reach 60 miles; and that the boiler-houses erected in the basement story contain 22 boilers, each holding 11,000 gallons of water.

The interior. The interior of the palace presents many objects of attraction, blending together, perhaps too confusedly, the beauties of art and the wonders of mechanical industry. How far the palace may advantageously be made use of as a grand educational agency, working at a definite object, it is not now our province to inquire; but in spite of many errors of judgment, and, as it seems to us, of taste, there can be no doubt that it exercises a considerable and a beneficial influence upon the minds of its visitors, and that its general tendency is to enlarge their comprehension, refine their ideas, and quicken their perceptions. The most attractive features are, probably, the *Courts;* those portions of the building which are devoted to the illustration of architecture, domestic and ecclesiastical, in its various stages of progress. In these the curious visitor may observe a reproduction of the houses of the Greeks, Romans, and Pompeians; and a visible embodiment of the distinctive features of the Byzantine art; English, German, and French mediævalism; the Renaissance style, the Elizabethan, and the Italian. The Alhambra, the glories of old Thebes and Memphis, and the wonders of Nineveh are also illustrated—in miniature, it is true, but with considerable effect and commendable accuracy. The arrangement of these details were confided to such authorities as Messrs Digby Wyatt, Owen Jones, Penrose, Layard, Bonomi, J. B. Waring, and George Scharf, jun., names which may reasonably be accepted as a guarantee for historical fidelity and general excellence.

Sculpture. Not the least praiseworthy feature of the internal arrangement is the exhibition of fine sculptures from the antique, and copious illustrations of the genius of modern art. The master-pieces of the artists of the old classic world; of the greatest geniuses of France, Germany, and England, are here brought before the eye of the spectator in such juxtaposition that he may, if he will, contrast with ease their relative excellences, the elegance of Canova with the severe grandeur of Thorwaldsen, and the ideal beauty of Baily with the classicism of Gibson. From Paris and Munich, from Florence and Venice, from Rome and Milan, experienced emissaries have procured casts of world-famous statues, and accurate copies of notable frescos, monuments, screens, ornamental arches, or richly-decorated doorways, which, if we accept the well-known axiom of Keats, that "a thing of beauty is a joy for ever," must amply repay the visitor to the Crystal Palace for any fatigue his perambulations of its magnificent corridors may entail.

The gardens. The palace and its grounds occupy an area of about 200 acres, and it may be noted, says the official *Handbook*, that, in the formation of the gardens, the same uniformity of parts is adhered to as in the building itself; that is to say, the width of the walks, the width and length of the basins of the fountains, the length of the terraces, the breadth of the steps, are all multiples and submultiples of the one primary number of eight. Thus, an harmonious combination is effected, which the spectator admires and acknowledges, though ignorant of its cause.

The length of the upper terrace is 1576 feet; its width, 48 feet. The central flight of steps, and the grand central walk, are each 96 feet wide. The lower terrace is 1664 feet in length, and 512 feet in width. The total length of the garden front of this terrace is 1896 feet; of the central walk already alluded to, 2660 feet. The gardens exemplify the more attractive features both of the Italian and English styles, and from their gradual slope are susceptible of infinite effects of light and shade, while commanding, from almost every point, the richest prospects imaginable of the surrounding country.

The water-works. The water-works claim from us a word of passing notice. There are two series of fountains—the upper and the lower; the upper consisting of nine basins, of which the central is of superior dimensions; the lower, of the iron water-temples, from which twelve cascades pour down a volume of water, extending a distance of 600 feet; and the two great fountains, into whose basins this volume rushes in a sort of cataract, 120 feet in breadth, and 30 feet in fall. The smaller fountains in the upper series fling their columns of spray to a height of 90 feet, the central fountain attains an altitude of 150 feet: the iron water-temples are 60 feet in height. The basins of the great fountains, the largest in the world, are 704 feet long, with a diameter of 418 feet. A great central column mounts in each to the astonishing altitude of 280 feet, each column composed of 50 2-inch jets. The whole system of fountains provides for the action of 11,788 jets, making use of 120,000 gallons of water per minute. To Sir Joseph Paxton is due the credit of their construction.

Admission to the palace is gained by yearly tickets, at one guinea each; and day-tickets, one shilling each, on every day but Saturday, when their price is two shillings and sixpence.

[Lysons' *Environs of London;* Hasted's *Kent;* Cyrus Redding's *Life of Campbell;* Howitt's *Homes and Haunts of English Poets; Official Handbooks;* and *Annual Reports of the Crystal Palace Company.*] (W. H. D. A.)

SYDENHAM, THOMAS—the greatest name in English practical medicine—was born in 1624 at Winford Eagle, Dorsetshire, where his father, William Sydenham, had a fine estate. He was a commoner of Magdalen Hall, Oxford, 1642, but was obliged to leave that city when it became a royal garrison, not having taken up arms for the king, as the students of those days generally did. In 1649, after the garrison delivered up Oxford to the Parliamentary forces, he returned to Magdalen Hall, and was created Bachelor of Physic on the Pembrokean creation, when Lord Pembroke became chancellor of the university, and honorary degrees were conferred. This was in April 1648. He had not previously taken any degree in arts. He then, on submitting to the authority of the visitors appointed by the Parliament, was made by them (at the intercession of a relative) Fellow of All Souls, in the room of one of the many ejected Royalists. He continued for some years earnestly prosecuting his profession, and left Oxford without taking any other degree. He was also, according to his own account, in a letter to Dr Gould, fellow-commoner of Wadham College in the year Oxford surrendered. It is not easy to understand why he went to Wadham, as he was not a fellow but a fellow-commoner—equivalent to a gentleman commoner in Cambridge—unless it was that, on returning to Magdalen Hall, he found himself, as a Parliamentarian, more at home in Wadham—where the then head was John Wilkins, Cromwell's brother-in-law—a man of genius and of a keen scientific spirit, and afterwards and still famous as Bishop of Chester—one of the founders of the Royal Society, which first met at Oxford; and author, among other works, of a discourse on a *Universal Language* and of an *Inquiry as to the best Way of Travelling to the Moon;* a man of rare parts and worth, and of a liberality in religion and science then still rarer, being according to Anthony Wood, "an excellent mathematician and experimentist, and one as well seen in the new philosophy as any of his time;" such a man would be sure to cordialise with Sydenham, who was of the Baconian or genuine Empiric school; and who, in the "new philosophy," saw the day spring of all true scientific progress. It is not clear when Sydenham settled in Lon-

don, or more properly speaking in Westminster, it certainly was before 1661. In 1663 he was admitted a licentiate of the College of Physicians of London, he never was a fellow; his degree of doctor of medicine was taken at Cambridge in 1676, long after he was in full practice, his college being Pembroke; his diploma is signed by Isaac Barrow. His reason probably for taking a Cambridge degree may have been that his eldest son was a pensioner at that college.

Sydenham's elder brother, William, was a distinguished soldier and politician during the Commonwealth. This, along with his own likings, and his love of the new philosophy, prevented him, during the reigns of the second Charles and James, from enjoying court favour. It has often been doubted whether Sydenham actually served in the army of the Parliament; but from an anecdote known generally as Dr Lettsom's, but which appears first in a curious old controversial book by Dr Andrew Brown, the *Vindicatory Schedule*, published two years after Sydenham's death, it is made quite certain that he did.

Before settling in London he seems, on the authority of Desault, to have visited Montpelier, and to have attended the lectures of the famous Barbeyrac. After this he devoted himself to his profession, and became the greatest physician of his time, in spite of the court, and of the College of Physicians; by one of whose fellows—Lister—he was called "a miserable quack." He suffered for many of the later years of his life from the gout, his description of which has become classical, and died in his house, Pall-Mall—or as he spells it, Pell-Mell—in 1689. He lies buried in St James, Westminster, with the following noble because true inscription:—"*Prope hunc locum sepultus est Thomas Sydenham, medicus in omne ævum nobilis, natus erat, A.D.* 1624; *vixit annos* 65." His works, which became rapidly popular during his lifetime, and to an extraordinary extent soon after his death—there were upwards of twenty-five editions in less than a hundred years—consist chiefly of occasional pieces, extorted from him by his friends, and often in the form of letters, none of them are formal treatises, and all are plainly the result of his own immediate reflection and experience. One is greatly struck at the place he occupies in the writings of all the great medical authors at the end of the seventeenth and beginning of the eighteenth centuries. Morton, Willis, Boërhaave, Gaubius, Bordeu, &c., always speak of him as second in sagacity to "the divine Hippocrates" alone. Boërhaave never mentioned him in his class without lifting his hat, and called him *Angliæ lumen, artis Phœbum, veram Hippocratici viri speciem.* His simple, manly views of the nature and means of medicine as an art seem to have come upon the profession like revelations; it was as if the men in Plato's cavern, who had been all their lives with their backs to the light, studying their own shadows, had suddenly turned round and gazed on the broad face of the outer world, lying in sunshine before them.

All Sydenham's works are in Latin, and though from his education and tastes, and the habits of his time, and also from the composition of the *Processus Integri*—brief notes left by him for his sons' use, and published after his death—there is little doubt he could have written them in that tongue, there seems every likelihood that he was assisted in this by his friends Drs Mapletoft and Havers. There are three English translations—one by Dr Pechey, another by Dr Swan, to which is prefixed a life by Samuel Johnson, among his earliest performances, and published by Cave, and the last, the Sydenham Society's edition, by Dr Latham.

This, we believe, is nearly all of a personal kind we know, or are likely to know of this great and good man—his private tastes and worth we can only infer from his associates. He who had the right and the honour to call John Locke *conjunctissimus*, and who lived on cordial terms with Boyle and all the best men of his time, was not likely to be otherwise than a man of moral excellence as well as intellectual greatness; and from his own unstudied writings we cannot but be sure that he was a most affectionate father, a warm and faithful friend, and a lover of truth and liberty for their own sakes—a man of keen, generous, habitual humanity and tenderness to suffering, and a man profoundly and pervadingly religious. Not that he is ever a moraliser, or given to be didactic, or given to public religiosity; his clear, manly, modest nature would despise this as much as it did any other quackery or nonsense; but his sense of God—of our constant relation to him as our Maker and Judge—of the law of duty—is felt throughout everything he writes, and at times breaks out into the noblest acknowledgments. We do not know how to exemplify his characteristic spirit and manner, better than in the first sentence of his preface to his first work, or "*Opusculum*" as it was called—"*Observationes Medicæ circa Morborum Acutorum Historiam et Curationem.*"

"He who sets himself to the work of curing men would do well to ponder again and again these four things. 1*st*, That he must himself some day render an account to the supreme Judge of the lives of the sick committed to his care. 2*d*, That whatsoever of art or of science he has by the divine blessing attained to, is to be directed in the main to the glory of God in the highest, and to the welfare of the human race; for it were an unworthy thing that their celestial gifts should be made to serve avarice or ambition. Moreover, 3*d*, that he has taken upon himself the charge of no ignoble or contemptible creature; for that we may estimate the worth of the human race, the only begotten Son of God became man, and thus enriched by his own dignity, His nature we assumed. Finally, that he is himself not exempted from the common lot, but is subject to the same laws of mortality and is obnoxious and open to the same calamities and sorrows as are others; so that, being himself a fellow-sufferer, he may the more diligently, and with a more tender affection succour those who are sick."

Here is the key-note of the character and life of this admirable man. We know of no more impressive assertion of the dignity, privilege, and peril of being a healer of men, and we question if there ever was a case in which a man was more truly as good as his word. The religious nature of Sydenham comes more formally and explicitly out in a theological fragment, printed for the first time by Dr Latham; it is taken from a manuscript in the public library of the university of Cambridge. Of this remarkable fragment it has been said by one well qualified to judge, "There is much in it of the spirit both of Locke and Butler—of Locke in the spirit of observation and geniality; of Butler in the clear utterances as to the supremacy of reason, and the necessity of living according to our own true nature."

But we must advert to the more specific qualities of these practical tracts. Besides their broad, accurate, vivid delineations of disease—portraits drawn to the life and by a great master—and their wise, simple, rational rules for treatment, active and negative, general and specific,—there are two great principles continually referred to as supreme in the art of medicine. The first is, that nature cures diseases; that there is a recuperative and curative power, the *vis medicatrix*, in every living organism, implanted in it by the Almighty, and that it is by careful, reverential scrutiny of this law of restoration, that all our attempts at cure are to be guided; that we are its ministers and interpreters, and neither more nor less; and the second, that symptoms are the language of a suffering and disordered and endangered body, which it is the duty of the physician to listen to, and as far as he can to explain and satisfy, and that like all other languages it must be studied. This is what he calls the Natural History of Diseases. With these two central convictions, it is amazing how much error, rubbish, and mischief he exposes and ends. In these respects, the impression in reading him is a very striking one. Here is a man writing nearly two hundred years ago, and yet we have the truth as to hygienic physiology—the duty of living according to the

constitution given us by God, and obeying the laws of health, watching, following, assisting the efforts of nature, all which we now believe and glory in, as a sort of modern gospel of the body,—taught with the same downrightness, authority, earnestness, and unencumbered good sense, as in the pages of Andrew Combe, or Sir John Forbes, or Sir James Clark. It is difficult for us, living as we do in the broad light of our day, to understand all that is implied in an English physician writing and practising in 1680 as Sydenham did; it amounted to a new revelation—to a *restauratio magna* of the entire study and art of treating diseases—and was among the first and the best fruits of the then dawning philosophy of Lord Bacon. What Locke did for the science of mind, for the conduct of the understanding, and for the art of making men reason justly,—what Harvey and Newton did for the sciences of organic and inorganic matter,—Sydenham did for the art of healing and of keeping men whole: he made it in the main observational; he founded it upon what he himself calls "downright matter of fact," and did this not by unfolding a system of doctrines or raising up a scaffolding of theory, but by pointing to a road, by exhibiting a method—and moreover teaching this by example not less than by precept, walking in the road, not acting merely as a finger-post, and showing himself to be throughout a true artsman and master of his tools. The value he puts upon sheer, steady, honest observation, as the one initial act and process of all true science of nature, is most remarkable; and he gives himself, in his descriptions of disease in general, and of particular cases, proofs quite exquisite, of his own powers of persevering, minute, truthful scrutiny. Like most complete men, Sydenham was a humorist. The well-known story of his saying to Sir Richard Blackmore, when he asked him what books he should study medicine in, "Read *Don Quixote*, Sir," is a proof of his sense as well as of his fun; he doubtless meant that medicine, the art of curing diseases, was not to be learned from books. He has acknowledged his obligations to John Locke in a well-known passage quoted by Dugald Stewart:—

"*Nôsti prœterea*," writing to Dr Mapletoft, "*quam huic meæ methodo suffragantem habeam, qui eam intimius per omnia perspexerat, utrique nostrum conjunctissimum Dominum Johannem Lock; quo quidem viro, sive ingenio judicioque acri et subacto, sive etiam antiquis (hoc est optimis) moribus, vix superiorem quenquam inter eos qui nunc sunt homines repertum iri confido, paucissimos certe pares.*"

And Locke, in the preface to the immortal Essay, speaks of Sydenham as "one of the master builders at this time in the commonwealth of learning," in company with "Boyle, Huygens, and the incomparable Mr Newton."

The subjects of his tracts are, as has been said, all practical, and comprehend almost the entire round of the art of medicine; but the best known are those upon acute diseases, —upon fevers, and the "constitutions of years," as in connection with epidemics,—the smallpox,—the gout,—and hysteria. In all these the powers of insight and of description are quite unmatched, making any attempt at improvement in the natural history of disease hopeless enough.

We conclude with one or two selections from his writings, which, to be fully appreciated, must, as has been already said, be read with some understanding of the times he lived in; what a mass of errors and prejudices his art was sunk in; how rampant the hypothesis mania was, and how utterly the practice of his art was overrun with the vilest and silliest nostrums. We must have this in our mind, or we shall fail in estimating the full amount of exact, strong, independent thought, of true courage and uprightness, and of all that deserves to be called magnanimity and virtue, which was involved in his thinking, writing, and practising as he did.

"The improvement of physic, in my opinion, depends, 1*st*, Upon collecting as genuine and natural a description or history of diseases as can be procured; and 2*d*, Upon laying down a fixed and complete method of cure. With regard to the history of diseases, whoever considers the undertaking deliberately will perceive that a few such particulars must be attended to: 1*st*, All diseases should be described as objects of natural history, with the same exactness as is done by botanists, for there are many diseases that come under the same genus and bear the same name, that being specifically different, require a different treatment. The word *carduus* or thistle, is applied to several herbs, and yet a botanist would be inaccurate and imperfect who would content himself with a generic description. Furthermore, when this distribution of distempers into *genera* has been attempted, it has been to fit into some hypothesis, and hence this distribution is made to suit the bent of the author rather than the real nature of the disorder. How much this has obstructed the improvement of physic any man may know. In writing, therefore, such a natural history of diseases, every merely philosophical hypothesis should be set aside, and the manifest and natural phenomena, however minute, should be noted with the utmost exactness. The usefulness of this procedure cannot be easily overrated, as compared with the subtle inquiries and trifling notions of modern writers; for can there be a shorter, or indeed any other way, of coming at the morbific causes, or of discovering the curative indications, than by a certain perception of the peculiar symptoms? By these steps and helps it was that the father of physic, the great Hippocrates came to excel; *his theory* (θεωρία) *being no more than an exact description or view of Nature.* He found that Nature alone often terminates diseases, and works a cure with a few simple medicines, and often enough with no medicines at all. If only one person in every age had accurately described, and consistently cured, but a single disease, and made known his secret, physic would not be where it is now; but we have long since forsook the ancient method of cure, *founded upon the knowledge of conjunct causes*, insomuch that the art, as at this day practised, is rather the art of talking about diseases than of curing them. I make this digression in order to assert, that the discovering and assigning of remote causes, which now-a-days so much engrosses the minds and feeds the vanity of curious inquirers, is an impossible attempt, and that only immediate and conjunct causes fall within the compass of our knowledge."

Or as he elsewhere pithily states it:—

"*Cognitio nostra, in rerum cortice, omnis ferme versatur, ac ad* τὸ ὅτι *sive quod res hoc modo se habeat, fere tantum assurgit;* τὸ διότι, *sive rerum causas, nulla tenus attingit.*"

He was the first to point out what he called the varying "constitutions" of different years in relation to their respective epidemics, and the importance of watching the type of each new epidemic before settling the means of cure. In none of his works is his philosophic spirit, and the subtlety and clearness of his understanding, shown more signally than in his successive histories of the epidemics of his time. Nothing equal to them has ever appeared since; and the full importance of the principles he was the first to lay down, is only now beginning to be acknowledged. His confession as to his entirely failing to discover what made one epidemic so to differ from another, has been amply confirmed by all succeeding observers. He says:—

"I have carefully examined the different constitutions of different years as to the manifest qualities of the air, yet I must own I have hitherto made no progress, having found that years, perfectly agreeing as to their temperature and other sensible properties, have produced very different tribes of diseases, and *vice versâ.* The matter seems to stand thus: there are certain constitutions of years that owe their origin neither to heat, cold, dryness, nor moisture, but *upon a certain secret and inexplicable alteration in the bowels of the earth,* whence the air becomes impregnated with such kinds of *effluvia* as subject the human body to distempers of a certain specific type."

As to the early treatment of a new epidemic, he says:—

"My chief care, in the midst of so much darkness and ignorance, is *to wait a little,* and proceed very slowly, especially in the use of powerful remedies, in the meantime observing its nature and procedure, and by what means the patient was relieved or injured;"

and he concludes by regretting the imperfection of his observations, and hoping that they will assist in beginning a work that, in his judgment, may greatly tend to the advantage of mankind. Had his successors followed in his track with equal sagacity, honesty, and circumspection, our

 knowledge of these destructive and mysterious incursions of disease, would, in all likelihood, have been greatly larger and more practical than it is now.

Sydenham is well known to have effected a revolution in the management of the smallpox, and to have introduced a method of treatment upon which no material improvement has since been made. We owe the cool regimen to him. Speaking of the propriety of attending to the wishes of the sufferer, he says, with equal humanity and good sense:—

"A person in a burning fever desires to drink freely of some small liquor; but the rules of art, built upon some hypothesis, having a different design in view, thwart the desire, and instead thereof, order a cordial. In the meantime, the patient, not being suffered to drink what he wishes, nauseates all kinds of food, but art commands him to eat. Another, after a long illness, begs hard, it may be, for something odd, or questionable; here, again, impertinent art thwarts him and threatens him with death. How much more excellent the aphorism of Hippocrates—'Such food as is most grateful, though not so wholesome, is to be preferred to that which is better, but distasteful.' Nor will this appear strange, if it be considered that the all-wise Creator has formed the whole with such exquisite order, that, as all the evils of nature eminently conspire to complete the harmony of the whole work, so every being is endowed with *a Divine direction or instinct*, which is interwoven with its proper essence, and hence the safety of mankind was provided for, who, notwithstanding all our doctoring, had been otherwise in a sad enough plight."

Again:—

"He would be no honest and successful pilot who were to apply himself with less industry to avoid rocks and sands, and bring his vessel safely home, than to search into the causes of the ebbing and flowing of the sea, which though very well for a philosopher, is foreign to him whose business it is to secure the ship. So neither will a physician, whose province it is to cure diseases, be able to do so, though he be a person of great genius, who bestows less time on the hidden and intricate method of nature, and adapting his means thereto, than on curious and subtle speculations."

The following is frank enough:—

"Indeed, if I may speak my mind freely, I have been long of opinion that I act the part of an honest man and a good physician as often as I refrain entirely from medicines, when, upon visiting the patient, I find him no worse to-day than he was yesterday; whereas, if I attempt to cure the patient by a method of which I am uncertain, *he will be endangered both by the experiment I am going to make on him and by the disease itself; nor will he so easily escape two dangers as one.*

"That practice, and that alone, will bring relief to the sufferer, which elicits the curative indications from the phenomena of the diseases themselves, and confirms them by experience, by which means the great Hippocrates made himself immortal. And had the art of medicine been delivered by any one in this wise, though the cure of a disease or two might come to be known to the common people, yet the art in its full extent would then have required men more prudent and skilful than it does now, nor would it lose any of its credit; for as there is in the operations of nature (on the observations of which a true medical praxis is founded) more of nicety and subtlety than can be found in any art supported on the most specious hypotheses, so the science of Medicine which Nature teaches will exceed an ordinary capacity in a much greater degree than that which mere philosophy teaches."

There is much profound truth in this. Observation, in its strict sense, is not every man's gift, and but few men's actual habit of mind. Newton used to say, that if in any one way he differed from other men, it was in his power of continued attention—of faithful, unbroken observation; his ladder had all its steps entire, and he went up with a composed, orderly foot. It requires more strength and fineness of mind, more of what deserves to be called genius, to make a series of trustworthy observations in Medicine, or any other art, than to spin any amount of nice hypotheses, or build any number of "*castella in aere*," as Sydenham calls them.

It would not be easy to over-estimate the permanent impression for good, which the writings, the character, and the practice of Sydenham have made on the art of healing in England, and on the continent generally. In the writings of Boërhaave, Stahl, Gaubius, Pinel, Bordeu, Haller, and many others, he is spoken of as the father of rational medicine; as the first man who applied to his profession the Baconian principle of interpreting and serving nature, and who never forgot the master's rule, "*Non fingendum aut excogitandum, sed inveniendum, quid natura aut faciat aut ferat.*" He was what Plato would have called an "*artsman*," as distinguished from a teacher of abstract science. But he was by no means deficient either in the capacity or the relish for speculative truth. Like all men of a large sagacious nature, he could not have been what he was, or done what he did, without possessing and often exercising the true philosophizing faculty. He was a man of the same quality of mind in this respect with Watt, Franklin, and John Hunter, in whom speculation was not the less genuine that it was with them a means rather than an end. (J. B—N.)

SYDENHAM, *Floyer*, a translator of Plato, was born in 1710, and graduated in arts at Wadham College, Oxford, in 1734. Between 1759 and 1780 he published translations of the Io, Greater and Lesser Hippias, Banquet, Rivals, Meno, First and Second Alcibiades and Philebus, in 3 vols. 4to. This translation was on the whole a very creditable one; in the more abstruse parts of Plato, the translator often missed the sense, but in the less abstract portions the version is excellent. It was completed in 1804 by Thomas Taylor. The subscribers to a work like this were few, and the learned and laborious, the "candid and gentle" author died in his old age in prison, where he had been incarcerated for a debt contracted for the barest necessaries of life with an eating-house which he frequented. He died April 1st 1787. His other works were —*A Dissertation on the Doctrine of Heraclitus, so far as it is mentioned or alluded to by Plato*, 1775; *Onomasticon Theologicum*, 1784. Out of the facts connected with this melancholy end of Sydenham, the literary fund is said to have taken its rise.

SYDNEY, the capital city of the colony of New South Wales, situated on the southern side of the harbour of Port Jackson, about 7 miles from the entrance to the port; S. Lat. 33. 52., E. Long. 151. 12. It was founded on the 26th January 1788, and named from Viscount Sydney, at that time secretary for the colonies.

Sydney is distinguished as the earliest of the Australian settlements, and was commenced as a convict establishment under the transportation system of the Imperial Government. The resource at command for that system in North America having been gradually cut off, first by a growing preference with the colonists for negro labour, and at last by the separation of the United States, the British authorities turned attention elsewhere, and the reports of Captain Cook directed them to New South Wales. "The first fleet," as it has been called, consisting of 11 vessels, left for the antipodes on 13th May 1787, and arrived at Botany Bay, the intended destination, on the 18th January. But this place proving quite unsuitable, the whole expedition was promptly removed to Port Jackson, a few miles to the northward. This port, one of the finest harbours in the world, was previously thought to be only a boat harbour, and was called after one of Cook's seamen, who had first discovered it. The party, consisting of 1030 persons, including 565 male and 192 female convicts, with 200 soldiers, and some women and children, was landed at Sydney Cove, one of the many beautiful inlets of the harbour, and there they founded the present city of Sydney, with Captain Arthur Phillip, R.N., at their head, as the first governor of the new penal colony.

For a time at first the town was irregularly constructed, and comprised very picturesque and humble edifices, some of which have lingered into present times. The present plan was laid out in 1809. The city is surrounded on three sides by water: to the north, the main harbour called the Stream; to the east, Woolloomoloo Bay; and to the west,

Darling Harbour. It is built partly on high ground, and partly along a hollow, traversed by the principal thoroughfare, George Street. The basis is sandstone, which affords a valuable building material, that is plentifully made use of both in building and paving the town. The soil is light and sterile—a characteristic feature that prevails far beyond the limits of Sydney. On the other hand, the water or harbour scenery is most diversified and beautiful, with numerous inlets, and rocky promontories covered with the natural evergreen vegetation, and thickly interspersed with houses and gardens belonging to the expanding suburbs of the capital.

The harbour is quite landlocked; and large ships may approach close to or even touch the rocky shores on which the town is built. These natural advantages, have given undisputed pre-eminence to Sydney as the great commercial emporium of the colony; and nature has been powerfully seconded by the system of extensive wharf accommodation along Sydney Cove and Darling Harbour. A dry dock, capable of accommodating the largest merchantman, has also been constructed at Waterview Bay, one mile distant from Sydney; and there are, besides, two patent slips at Darling Harbour, the larger of which can take up vessels of from 1500 to 2000 tons. The town and shipping are protected by five forts or batteries on various commanding situations, including the principal ones of Fort Maquarri, Dawes' Battery, and the more recent and imposing erections at Kiribilli Point on the north shore, and Fort Denison on what was originally called Pinchgut Island. There is a large and admirably constructed dry-dock in private hands, on Water View Bay, and another constructed by the government on Cockatoo Island, capable of accommodating the largest class of ocean steamers. There is also a very fine patent slip at Balmain in the hands of a company. The customs-tariff is in general liberally framed, and upon principles of free trade. The duties are levied upon a few principal articles of import, chiefly spirits, wines, and tobacco. The duty on the latter, however, operates protectively upon an inferior colonial production. There is an export duty on gold of 2s. 6d. per oz., as in the adjacent colony of Victoria, the governments of both places having found difficulty in securing by other means a payment for the use of the auriferous soil. The scale of commerce and shipping is large, and has been greatly augmented since the gold discoveries in 1851. The colonial imports in 1850 were L.1,333,413; the exports, L.1,357,784. In 1858 they were—imports, L.6,058,366; exports, L.4,186,277. The apparent discrepancy in the exports arises from the large transit of live stock across the border to Victoria, no account of which can be taken. These figures are for the whole colony of New South Wales, including the Moreton Bay District, which has just been created a separate colony; but nearly the entire of this large commerce is connected with the central harbour of Sydney. The chief articles of export are wool and gold, the latter in annual value above L.1,000,000, having considerably increased since 1858, and the former about one-third to one-fourth more. The shipping inwards for 1858 was 348,984 tons, and outwards 366,825 tons. The colonial revenue for 1858 was L.1,456,451, exclusive of loans for railways, &c., and for 1859 it was L.1,540,550. The public debt on 31st December 1858 was L.2,797,090. The great railway schemes which are being carried out by the colonial government, will soon much increase this amount. Three great railway lines have been projected from Sydney, to the north, to the west, and to the south-west. These have all been commenced, and of the last, proceeding *via* Paramatta towards Goulburn, and intended eventually to reach the Victoria frontier, 34 miles are already finished and in operation. There is telegraphic communication throughout great part of the colony, and particularly to the south-west, where, at Albury on the frontier, 360 miles from Sydney, the telegraph lines from Victoria are united, and thus connect Sydney with that colony, and with South Australia and Tasmania. Already the grand project of telegraphic connection with Europe has been seriously entertained at Sydney, and seems likely to be soon carried out, now that there is almost a continuous line from England *via* Kurachee and Ceylon to the eastern part of Java.

The population of Sydney by the last census in 1856 was 53,118, consisting of 26,220 males, and 26,898 females, while that of the entire colony was, on the same occasion, 268,737. Ten years previously that of the city was 37,203. In 1858, the population of the two electoral districts in which Sydney is divided, was estimated at 53,358, exclusive of the populous and now connected suburbs. Sydney and these numerous offshoots of Paddington, the Glebe, Newtown, St Leonards, &c., may now contain about 75,000 souls. So considerable a place, with a proportionably large export and import commerce, presents a very active scene of life and business. Omnibuses constantly traverse town and suburbs, and many vehicles are despatched from Sydney in all interior directions for the passenger and postal service, while the towns on the sea-coast are connected by steam communication, extending south to Melbourne and Hobart-Town, and north to Moreton Bay, and the newly discovered gold region behind Port Curtis and Rockhampton. The oft interrupted steam postal communication with Britain seems at length permanently settled. The present line is *via* Suez and Melbourne, occupying about 50 days to Sydney, when the short and fast route through France is availed of. This postal service has hitherto been monthly, but it is expected presently to be fortnightly, by arrangement with the contracting steam company (the Peninsular and Oriental), and it is partly with this object in view, partly to avail of the recent telegraphic extensions to Ceylon, that an alteration has just been effected (March 1860), by which Galle has been made the place of call instead of Mauritius. Sydney, however, as standing at the extreme of this postal line, the last place of arrival and the first of departure, and exposed to frequent disappointment in receipt of mails, has of late been dissatisfied with this route, and in conjunction with the New Zealand settlements, which are still more unfavourably situated, has been endeavouring to establish a second and alternate line *via* Panama.

In 1843, Sydney, in common with Melbourne and some other Australian towns, was formed into a municipality under a mayor and corporation. The proceedings of this body having rendered it unpopular, it was abolished some years ago; but the institution has since been restored, and has made itself useful in effecting improvements in sanitary and other departments. The corporation revenues for 1858 amounted to L.55,451, including a government grant of L.10,000, but exclusive of loans; the expenditure was L.66,862. In religious affairs, Sydney is the residence of an Anglican bishop, and a Roman Catholic archbishop. The Australian museum, commenced in 1838 and incorporated in 1853, comprises a good illustration of Australian natural history. The University was founded in 1850, and the same year established by act of council. Its degrees now take rank with those of similar institutions in Britain. In 1858 there were 33 matriculated students. The city has long been lighted with gas. It is now well supplied with water, and a great system of drainage is in progress. The main thoroughfares of Pitt Street and George Street have a carriage-way of 60 feet in breadth; and there are now many handsome shops, churches, and public and private edifices. There are 8 banks, most of which have large capitals, and many branch establishments; and the town is varied on its outskirts by several parks, by a botanic garden, and by the domain surrounding a handsome and spacious Government House.

Shortly after the gold discoveries, the establishment in Sydney of a branch of the royal mint was petitioned

for, and with success. This institution came into operation in May 1855. The coinage is limited to gold, the sovereigns and half-sovereigns to be of equal weight and purity to those of imperial coinage. There has not yet, however, been conceded to it the privilege of an imperial coinage—a circumstance that materially diminishes the advantage of the local mint, and is of constant inconvenience in the commercial relations between Australia and Britain. Meanwhile the adjacent colonies have accepted the coin as legal tender, although not without demur and delay, particularly in the case of Victoria, which objected alike to the invidious non-imperial distinction, and to the fact of the mint having been hastily placed at Sydney, while nearly all the gold was at Melbourne. For a time at first, therefore, the Sydney mint threatened to prove a serious loss to the colony. The works cost L.50,000, and the annual maintenance L.12,000, while the income fell short of the latter sum. There is now, however, an excess of income, but the colony is prohibited by imperial regulation from making the institution a source of profit. The area of the legal tender has been extended to several colonies, Mauritius, Ceylon, and Hong-Kong, which are still imperially administered. Those colonies having free governments to decide in the matter for themselves. The business of the Sydney mint is again threatened by a recent demand of the legislature at Melbourne for a mint there also; and if, as seems reasonable, the imperial privilege will soon be conceded to Australian coin (the branch mint operations being all under imperial appointees, and subjected to regular imperial test), there is a yet further diminution in extent of operations in prospect, because great part of the business hitherto can be regarded as merely the substituting of colonial for imperial coin, in consequence of the latter having more value outside Australia than the former, and being in consequence always preferably taken for export.

The 26th of January is now a distinguished anniversary, which has of late been somewhat regularly celebrated, and with due eclât, in London, where, from the facilities of intercommunication and affection for the parent country, very many colonists can now always be mustered. It is, however, no longer the celebration of a penal settlement, but of a flourishing colony, which has long been entirely self-supporting, and is now possessed of a free constitutional government. The battle of the transition from "convictism" is not altogether a pleasing retrospect. The cessation of transportation to New South Wales, and the removal of the stigma of its being a penal settlement, were but reluctantly conceded by the imperial and colonial authorities, and even by an influential party of colonists under the past regime, who, as employers of labour, found more profit and less annoyance from the assigned convict than from the free immigrants. The league against the transportation system, inaugurated in 1851 at Melbourne, and established also at Sydney, was eventually victorious, and but for the partial revival of the system at Western Australia, these colonies might now have been entirely freed, at all events, from any further criminal admixture, and have been in a fair and rapid way for recovering from the social damage already sustained. As it is, however, the progress has been very marked in the relative diminution of crime, and, to the residents themselves, it is even more evident in the general social aspect. A prosperous colony of the British people, in a temperate latitude, should be a scene comparatively destitute of heinous crime. These colonies, with the widely spread and lingering elements of their original character, cannot assume this position; but the following comparative return of the convictions at the Supreme Court of Sydney gives a good assurance of progressive improvement, even allowing for the effects of irregularity and extravagance that characterized the earlier years of the gold discovery, 1851 to 1853. In 1853, the convictions were 604; in 1854, 637; in 1855, 526; in 1856, 461; in 1857, 395; in 1858, 415.

Sydney is the seat of the Governor-General of the Australian settlements. The supremacy, however, which the Governor of New South Wales legally enjoys with reference to the other colonies has long been, in consonance with understanding, a dead letter, and exists only for certain possible emergencies. The colonial legislature assembles in a handsome edifice of the capital, and consists of a council, at present of crown nomination, and consisting of forty members, besides the president, and an assembly of seventy-six members, including the speaker, elected by the colonists. The former body, the Upper Chamber, or House of Lords, as it were, will, with the view of giving it more independence, probably soon be made elective as well as the other, in obedience to prevailing public opinion, and in harmony with example in the other colonies. The political tendencies, and the religious as well, since self-government has permitted their free devolpment, are all towards a democratic equality; universal suffrage, the ballot, no property qualification, are principles either already adopted or on the eve of being so. The good wages and independent position of all classes, and the absence of local traditional inequalities, render these results natural, suitable, apparently, and probably irresistible. It is pleasant to add, that neither this conceded freedom of political action, nor the tendency to this extreme democratic departure from the home model, have affected the loyal sentiments of the colony. The new constitution was proclaimed in November 1855; but the colony ever since, although actively contentious enough as regards its own political parties, has displayed only an increased deference and loyalty to the parent government, the natural result, indeed, of its having secured at length that free political condition which it had long desired and contended for.

SYENE, now ASWAN. See EGYPT.

SYLBURG, or SYLBURGIUS, *Friedrich*, a very distinguished Greek scholar of the sixteenth century, was born at Wetter near Marburg, in 1536, and hence the frequent addition to his name of Veterensis. He received his education at the University of Jena, where he studied Greek with great ardour, under the renowned Rhodomannus. After leaving college he spent some years in teaching, but disliking the profession he exchanged the ferula for the pen. Sylburg formed a connection with Wechel the printer, in Frankfort-on-the-Main, for whom he engaged to edit works in the Greek language. In 1591 he exchanged his position for one in Heidelberg with the printer Jerome Commelin. In both these situations Sylburg, by his profound knowledge, his great diligence, and his extraordinary industry, became one of the most illustrious names of his century. His society was courted by such great men as Casaubon and De Thou, and he gained from the Landgrave of Hesse an annual pension from the funds of the University of Marburg. Sylburg died at Heidelberg on the 16th of February 1596. He has left a reputation behind him hardly inferior to that of the illustrious family of Stephens. His life and labours will be found recorded in the *Vita Frederici Sylburgii* of J. G. Jung, Berleburg, 1745.

SYLLOGISM. See LOGIC.

SYLVESTER, JOSHUA, an English poet of some celebrity in his day, was born in 1563. He was a species of merchant, or "merchant adventurer" as he styles himself, and being of a roving disposition kept very generally poor. He was engaged chiefly in translating works from the French, and he rendered Du Bartas' poem of the *Divine Weeks and Works* into sweet, fantastical, and rather insipid verse in 1605, which had a great run. This poetical Puritan addressed a lively piece, with an edifying title, on the iniquities of tobacco, to King James VI. in 1615. The

title of the book ran thus: *Tobacco battered, and the Pipes shattered (about their ears that idly idolize so base and barbarous a weed, or at leastwise over-love so loathsome a vanitie), by a Volley of Holy Shot thundered from Mount Helicon.* Sylvester seems to have had considerable powers of versification, but was destitute both of taste and judgment. After firing this "holy shot" from his exalted position, he seems to have betaken himself to a less elevated region, for he died at Middleburg in Holland, in 1618.

SYMMACHUS, QUINTUS AURELIUS, a Latin writer of high reputation during his own time, was born at Rome, being the son of Lucius Avianus Symmachus, who became prefect of the city in the year 364 A.D. The son was carefully initiated in the learning of the age, and soon distinguished himself by his talents and eloquence. He became pro-consul of Africa in 370, and prefect of the city in 384. He likewise appears to have filled the office of *pontifex.* While he held that of prefect, he addressed to Valentinian II., Theodosius, and Arcadius, an elaborate epistle, urging the restoration of the pagan rites and observances. This application produced no effect, but his zeal for the ancient superstition was still unabated; and in 388 or 389, when congratulating Theodosius, he again, in the name of the senate, entreated him to restore the altar of Victory to the senate-house. But the Emperor, who had a more personal reason for being dissatisfied with his conduct, on account of his favourable sentiments towards the usurper Maximus, sent him into exile at a great distance from Rome. His disgrace does not however appear to have been lasting; for he was nominated consul in the year 391. He survived Theodosius, and was employed by his sons Arcadius and Honorius.

Symmachus is chiefly known to posterity as the author of ten books of Epistles, which reflect some light on the history of that era. He seems to have chosen Pliny as his model; but he belongs to a very inferior age of Latinity, and has a due share of the quaintness and affectation by which it is generally characterized. His *relatio* in favour of paganism (lib. x. epist. lxi.) produced a refutation from Ambrose, bishop of Milan, who on that subject addressed two epistles to Valentinian. He was likewise assailed by Prudentius, who composed a poem in two books, *Contra Symmachum Præfectum Urbis.*

The *Epistolæ* of Symmachus are said to have been printed before the close of the fifteenth century, and other very early editions are mentioned. Only 317 Epistles appear in the edition printed by J. Schott, Argent., 1510, 4to. The subsequent impressions include 965, divided into 10 books. The next edition was printed by Froben, Basil, 1549, 8vo. An edition, illustrated with notes, was afterwards prepared by Juretus, Paris, 1580, 1604, 4to. To the annotations of this editor, Lectius added his own, Genev., 1587, 1599, 8vo. The text of Lectius is preferable to that of Juretus. Another edition, accompanied with notes, was published by Scioppius, Mogunt., 1608, 4to. These notes he was accused of having pilfered from the papers of Giphanius.[1] The next editions of Symmachus were those of Pareus, Neapoli Nemetum, 1617, 1628, Francof., 1642, 8vo. He added a *Lexicon Symmachianum* and *Electa Symmachiana.* We have only to mention another edition, Lugd. Bat., 1653, 12mo. Of the orations of Symmachus some fragments were discovered in the Ambrosian Library at Milan by the indefatigable Angelo Mai, and by him have been communicated to the public, Mediolani, 1815, 8vo.

SYMONDS. See SHIP-BUILDING.

SYMPHONY (Ital. *Sinfonia*). Anciently this word had various musical meanings. It now usually signifies a piece of instrumental music for an orchestra, consisting of several movements, and generally performed in a concert-room. The overture differs from the symphony chiefly in the smaller number of its movements, seldom containing more than a short, slow, introductory movement, and an allegro, and being used at the beginning of an opera or a ballet. The word symphony is also used to signify an instrumental passage which usually introduces a piece of vocal music, or is brought in at its close, or occurs during some pause of the voice. Hadyn, Mozart, and Beethoven have produced the finest models of the orchestral symphony in point of originality, beauty, ingenious construction, and skilful instrumentation. For clearness of design and breadth of effect, Haydn's symphonies still remain unrivalled.

SYNÆRESIS (συναίρεσις, *a drawing together*), is a figure by which two syllables are united in one, as *vemens* for *vehemens.*

SYNAGOGUE, a Jewish place of worship. Authors are not agreed about the time when the Jews first began to have synagogues. Some suppose them as old as the ceremonial law, and others fix their beginning to the times after the Babylonish captivity. Jerusalem is said to have contained 480 synagogues. The chief things belonging to a synagogue were—1, the ark or chest, made after the model of the ark of the covenant, containing the Pentateuch; 2, the pulpit and desk in the middle of the synagogue, in which he that was to read or expound the law stood; 3, the seats or pews for the people; 4, the lamps to give light at evening service, and the feast of dedication; 5, rooms or apartments for the utensils and alms-chest. The synagogue was governed by a council or assembly, over whom was a president, called the Ruler of the Synagogue. These are sometimes called Chiefs of the Jews, the Rulers, the Priests or Elders, the Governors, the Overseers, the Fathers of the Synagogue. Service was performed three times a day, namely, in the morning, in the afternoon, and at night. At the time of morning sacrifice, evening sacrifice, and after the evening sacrifice on Monday, Thursday, and Saturday, there was a more forcible obligation upon the people to attend than upon the other days.

SYNALŒPHA (συναλοιφή, *a melting together*), is a contraction of syllables, performed principally by suppressing some vowel or diphthong at the end of a word, on account of another vowel or diphthong at the beginning of the next. As, *ill' ego*, for *ille ego*, &c.

Conticuer' omnes intentiqu' ora tenebant.—VIRGIL.

SYNTAX, the proper construction of the words of a language into sentences and phrases. (See GRAMMAR.)

SYNTHESIS (συντίθημι, I put together), is a species of reasoning, opposed to analysis, which is the logical or formally deductive method, in which the reasoner, from certain assumed data, concludes either formally or materially a proposition of higher generality than any of those with which he set out. It is frequently called the method of composition or combination, in contrast to analysis, which is called the method of resolution. (See LOGIC.)

SYRA (anc. *Syros*), an island of the Grecian Archipelago, belonging to Greece, and one of the Cyclades, eleven miles S. of Andro; about N. Lat. 37. 29.; E. Lon. 24. 55. It is about ten miles in length by seven in breadth, and irregular in its outline, with steep and rugged coasts. The interior is hilly and is chiefly composed of mica slate, and there is abundance of iron and an inferior kind of marble. The soil is in general not very fertile, and there is a deficiency of water; but the island produces wheat, barley, cotton, wine, figs, and silk. Pop. 42,000. The capital is Hermopolis, also called New Syros, at the head of a bay on the east coast, near the site of the ancient city, all traces of which have disappeared. It is the residence of Russian, French, Austrian, and other consul; and con-

[1] *Fabricii Bibliotheca Latina*, tom. iii., p. 208, edit. Ernesti.

tains a handsome new church, a gymnasium, quarantine establishment, &c. Shipbuilding is actively carried on; and there is an extensive trade. About 1500 vessels annually enter and clear from the harbour. This port is the centre of the steam navigation of the Archipelago. Pop. 14,000.

SYRACUSE (anc. *Syracusæ*), a Greek city in Sicily, memorable in ancient history. It was, with the exception of Naxos, the earliest of all the Greek colonies in the island, having been founded by a band of Corinthians under Archias, in the year 734 B.C. The original settlers established themselves on the small island of Ortygia, at the mouth of the capacious bay which afterwards formed the great harbour of Syracuse; and for a long time the city did not extend beyond its narrow limits. The name was most probably derived from the neighbouring marsh or lake of Syraco. The new city rose steadily if not rapidly in power and prosperity; and founded several colonies of its own, among which were Acræ, Casmenæ, and Camarina. But we know little of its history previous to the fifth century, B.C. In the beginning of that century the government was oligarchical, in the hands of a class called the *Gamori*, probably the descendants of the original settlers. Meanwhile a democratic party by degrees grew up, who, in 486, effected a revolution, and expelled the *Gamori* from the city. The latter, however, applied for aid to Gelon, tyrant of Gela, who immediately put himself at their head and took possession of Syracuse. Perceiving the superior advantages of this city over Gela, he resolved to make it his capital; and in order to increase its size and importance, he demolished the neighbouring city of Camarina, and transplanted the inhabitants to Syracuse. Soon afterwards, entering into a war with the Megareans, he defeated them, took and razed their city, and in like manner transplanted the people. Syracuse thus became powerful, and full of inhabitants; and the friendship of Gelon was courted by Athens and Lacedæmon at the time of the Persian invasion. But in the meantime the Carthaginians had entered into a treaty with the Persians; by which it was agreed, that the former should attack the Greeks in Sicily and Italy, in order to divert them from assisting their countrymen at home. Sicily was accordingly invaded by the Carthaginians with a vast army; but they were utterly overthrown by Gelon, as is related under the article CARTHAGE. After this victory, the people out of gratitude obliged him to assume the title of king, which till that time he had refused.

Gelon died in the year 478 B.C., and was succeeded by his brother Hiero, whose character is differently drawn by different historians. He is highly celebrated in the odes of Pindar; and it is certain that his court was the resort of men of letters, whom he treated in the most courteous manner and with the greatest liberality. In 467 B.C. Hiero was succeeded by Thrasybulus; who proving a tyrant, was in ten months dethroned, and a popular government restored, which continued for the space of about sixty years.

After the establishment of free government, Syracuse, along with the other Greek cities in Sicily, made rapid progress in wealth and power; and it was probably about this time that it reached its highest pitch of prosperity. But during this period also it incurred the greatest danger it had yet experienced, in a contest with Athens at the very height of her power. The memorable siege of Syracuse, which in the end proved fatal to Athens, began in the spring of 414 B.C. The Athenians under Nicias landed to the north of the town, and established their naval station at a place called Thapsus. The city had by this time far extended beyond its original limits; the plateau of Achradina to the north of the harbour was densely peopled, but was commanded by the heights of Epipolæ to the west. The latter were at once seized by the besiegers as an important position, and secured by the erection of a fort on a hill called Labdalum. They then proceeded to construct a line of trenches across the plateau in order to shut in the city; and the rapid progress of this work so alarmed the Syracusans, that they made several attempts to stop it by counterworks. These were, however, all destroyed by the Athenians; and their fleet having sailed into the great harbour, they were able to carry the circumvallation down to the shore, leaving only a small part of it towards the north of the plateau in an unfinished state. Hitherto the Athenians had been successful in all their operations, and in all the contests that had taken place in the course of them; but the arrival of Gylippus from Sparta with reinforcements for the Syracusans turned the tide of affairs. He forced his way through the Athenian lines where they were incomplete, and entered the city. Then, directing all his efforts to prevent the completion of the circumvallation, he first surprised the Athenian fort of Labdalum, and afterwards proceeded to intersect their lines by a cross wall running out from that of the city. This he succeeded in carrying out quite beyond the line of circumvallation, so as to render it impossible to enclose the city. Nicias, after an unsuccessful attempt to capture this outwork, wrote to Athens for assistance, and meanwhile strengthened his position on the harbour by fortifying the headland of Plemmyrium which commanded its entrance. But the Syracusans, making a simultaneous attack by sea and land, captured this fort, and subsequently defeated the Athenian ships in the harbour. A strong fleet arriving from Athens under Demosthenes and Eurymedon revived for a time the hopes of the besiegers. They attacked once more the Syracusan outworks on the heights, but were repulsed with great loss. It was now evident that all hope of capturing the city was gone; and the Athenians would have been wise had they immediately raised the siege. But the counsel of Nicias for delay prevailed against that of Demosthenes, and they speedily found their position changed from that of besiegers to being themselves besieged. Their fleet was blockaded in the harbour, and finally destroyed; and the army attempting to retreat by land, after suffering great losses, was forced to lay down their arms. This siege was scarcely ended when a new and formidable invasion by the Carthaginians took place; but the event of that expedition was as unfortunate to its authors as the former had been. (See CARTHAGE.) In the meantime, a considerable revolution had happened in Syracuse. Dionysius, a man of great valour and address, by various insidious stratagems, succeeded in gaining unlimited power, and assumed the title of king of Syracuse in the year 404 B.C. The Syracusans did not tamely submit to their new master; but Dionysius managed matters so well, that their frequent revolts answered no other purpose than more certainly to entail slavery on themselves; and he was allowed to possess the throne without much opposition till his death, which happened in the year 367 B.C. The wars which this monarch carried on with the Carthaginians, and their unsuccessful attack on Syracuse in 397 B.C., are narrated in the article CARTHAGE.

On the death of Dionysius, he was succeeded by his son, likewise called Dionysius. He no sooner ascended the throne, than Dion, his uncle, succeeded in gaining an ascendency over his mind by the help of the philosopher Plato, under whose care he placed the young king. But the courtiers, dreading the effects of the philosopher's instructions, prevailed on the king to banish Dion, and to keep Plato himself in a kind of imprisonment in the citadel. At last, however, he set him at liberty; and Plato then returned to his own country.

In 356 B.C., Dion resolved at once to avenge himself on the tyrant for the wrongs he had suffered at his hands, and to deliver his country from the oppression under which it groaned. He raised a body of troops, landed in Sicily, and

Syracuse. taking advantage of the tyrant's absence, proceeded to Syracuse. On his march he prevailed on the inhabitants of Agrigentum, Gela, Camarina, and other cities, to join him. As soon as he entered the territories of Syracuse, multitudes flocked to him; and as nobody appeared to oppose him, he boldly entered the capital, where he soon found himself at the head of 50,000 men. Dionysius returning to the city, after some attempts at resistance, betook himself to flight. But in 350 B.C. he again made himself master of Syracuse; and being exasperated by his past misfortunes, became more tyrannical than ever. The Syracusans first had recourse to Icetas, tyrant of Leontini; but as the Carthaginians in alliance with this monarch took this opportunity to assail them with a powerful fleet and army, they were obliged to apply to the Corinthians. By them Timoleon, a celebrated commander, was sent to the assistance of the Syracusans, whom he found in a very distressed situation; Icetas being master of the city, the Carthaginians of the harbour, and Dionysius of the citadel. As all parties were equally the enemies of Dionysius, he found it impossible to resist, and therefore surrendered himself to Timoleon in 343 B.C.

After the departure of the tyrant, Timoleon succeeded in expelling both Icetas and the Carthaginians from Syracuse, and obtaining possession of the whole city. By sound of trumpet, he invited the inhabitants to come and assist in demolishing the citadel and other castles, which he called the *nests of tyrants;* after which he caused edifices for the administration of justice to be erected in the place where the citadel had stood. He found the city in a most miserable condition; for many having perished in the wars and seditions, and others having fled to avoid the oppression of tyrants, Syracuse, once so wealthy and populous, was now become almost a desert. Timoleon supplied the city with inhabitants from Corinth and other cities of Greece, and at the same time great multitudes from Italy and the other parts of Sicily resorted thither.

For twenty years the Syracusans enjoyed the fruits of Timoleon's victories; but new disturbances arising, in a short time another tyrant started up, who exceeded all that had gone before him in cruelty and other vices. This was the celebrated Agathocles, of whose exploits against the Carthaginians a full account is given under the article CARTHAGE. He was poisoned by one Mœnon in the year 289 B.C., after having reigned twenty-eight and lived ninety-five years. A succession of tyrants followed, till at last the city being held by two rivals, Tœnion and Sosistratus, who made war within the very walls, Pyrrhus king of Epirus, was invited into Sicily, in order to put an end to these distractions, and to deliver the island from the Carthaginians. He willingly complied with the invitation, and was everywhere received with loud acclamations, as the deliverer, not only of Syracuse, but of all Sicily. As he had a fine army of 30,000 foot and 5000 horse, with a fleet of 200 sail, he drove the Cathaginians from place to place, till he left them only the two strong posts of Eryx and Lilybœum. So sanguine were his anticipations, that he caused his son to assume the title of king of Sicily; but in the mean time, having displeased the Sicilians by his arbitrary behaviour, they deserted from him in such numbers that he was glad to set out for Italy in 275 B.C. After his departure, Hiero, a descendant of Gelon, the first king of Syracuse, first as general and afterwards as king, succeeded, during a long period of peace, in raising Syracuse to a high degree of wealth and prosperity. He preserved internal tranquillity, promoted agriculture and commerce, and adorned the city with many splendid buildings. The most important war carried on by Hiero was with the Mamertines of Messana, whom he reduced to such straits that they were obliged to call in the Romans to their assistance. The consequences of this have been fully related under the articles ROME and CARTHAGE. Hiero, who had allied himself with the Carthaginians, being himself defeated by the Romans, and finding his allies unable to protect him against the power of that republic, concluded an alliance with them, and continued faithful to them even in the time of the second Punic war, when they were in the greatest distress. In his reign flourished the celebrated mathematician Archimedes, whose genius he employed in fortifying the city of Syracuse, by innumerable machines, in such a manner as rendered it almost impregnable by any method of attack known at that time.

Hiero died about 211 B.C. and was succeeded by his grandson Hieronymus; but he imprudently forsook the counsels of his grandfather, and entered into an alliance with the Carthaginians. He was soon afterwards murdered, in consequence of his tyranny and cruelty; and the greatest disorders took place in the city, which Hannibal, though then in Italy, found means to foment, in hopes of keeping the Syracusans in his interest. This indeed he effected; but as his own affairs in Italy began to decline, he could not prevent Marcellus from landing in Sicily with a formidable army, which the Sicilians had no means of resisting. Syracuse was invested in 214 B.C.; but the machines invented by Archimedes baffled all attempts to take it by assault. The immense preparations which the consul had made for taking the city by storm, could not have failed to accomplish his purpose, had not the place been defended by the genius of Archimedes.

The consul, finding himself defeated in every attempt, turned the siege into a blockade, and at last made himself master of Syracuse in 212 B.C. He took the opportunity of a festival, when the soldiers and citizens had drunk plentifully, to make a detachment scale the walls of the quarter called Tyche, in that part of it which was nearest to Epipolæ, and which was ill guarded. He speedily possessed himself of Epipolæ; and the inhabitants of Neapolis as well as of Tyche then sent deputies to offer their submission. Marcellus granted life and liberty to all of free condition, but gave up those quarters of the city to be plundered. The other quarters still held out, and an attempt was made by the Carthaginians to relieve the place, but this proving unsuccessful, they left the citizens to their own resources. The Romans, having obtained by treachery a landing in the island of Ortygia, succeeded in carrying by assault a part of Achradina, and on this the remainder of the city was given up to them. In the confusion of the assault Archimedes was killed.

The city of Syracuse continued subject to the western empire till its fall, when the island of Sicily, being ravaged by barbarian tribes, the capital also underwent various revolutions, till, at last, in the ninth century, it was so destroyed by the Saracens that very few traces of its ancient grandeur are now to be seen. The ancient city, in its most extended condition, was of a triangular form, and consisted of five parts. These were Ortygia, or the Island, which was the oldest part, Achradina, Tyche, Neapolis, and Epipolæ. The circuit, according to Strabo, amounted to 180 stadia, or 22 English miles and 4 furlongs. For an account of the modern Syracuse see SICILIES, *Two*. Its population is 18,000.

SYRIA.

Syria.

SYRIA is a country of high historic and sacred interest. Take it in its full extent, including Palestine, and no country in the world can be compared with it. Even that northern section to which this article is confined has claims on our attention possessed by few lands. Syria was the cradle of commerce. What England is now, Phœnicia, a province of Syria, was thirty centuries ago—"the mistress of the seas." Tyre was the London of antiquity. The merchants of every nation met and traded in her rich marts. Syria was also the cradle of manufacture. Tyrian purple was the garb and symbol of royalty in every land; and Homer tells us that before his day a Sidonian robe was considered a gift of sufficient splendour to propitiate the angry patron-goddess of Troy (*Il.* vi. 288). Damascus, the capital of Syria, is confessedly the oldest city in the world; and while its ancient rivals have been laid in the dust, it still possesses all the freshness and beauty of youth. Antioch, another capital of Syria, was the third city of the Roman empire, and was famous even in the Augustan age for its splendour, its wealth, and the luxurious refinement of its inhabitants; and there, eighteen centuries ago, the name we bear and in which we glory—the name Christian, was invented. The mountains of Syria possess an interest far surpassing those of Greece or Italy. The names of Hermon and Lebanon are household words; and they are bound by sacred ties to all our hearts hold dear.

Notwithstanding all this, the geography of Syria has yet to be written. No regular survey of it has ever been made; the sites of some of its great cities remain unexplored and almost unknown; the picturesque beauty of its wildest glens and mountains has never been fully described; and the abundant resources of its soil and its mines have never been fairly estimated. In the writings of Maundrell, Shaw, Burckhardt, Chesney, Robinson, and Porter, we have all hitherto published, as the result of personal research, regarding the modern geography of Syria.

The name.

The original name of the country, now usually called *Syria* by western geographers, was Aram. This, in fact, is the only name given to it in the Old Testament, but the Hebrew *Aram* (אֲרָם) is generally rendered in the English version *Syria*, probably after the Septuagint Συρία (2 Sam. x. 6; 1 Kings x. 29; xv. 18, &c.) Aram was a son of Shem; and his descendants having peopled a large district, embracing Mesopotamia and north-eastern Syria, gave to this country the name of their progenitor (Gen. x. 22; xxv. 20); just as the family of Asshur, the elder brother of Aram, called their country *Assyria*. The Semitic name Aram is not confined to the sacred writings. It is used by Homer (*Il.* ii. 783); and Strabo states, that those who are commonly named Syrians call themselves *Aramæans* (Αραμμάιους; *Geog.* i.; xiii. 4; xvi. 4; see Reland, *Pal.* p. 46). It is a singular fact, that the name Syria, though known to, has never been adopted by, native writers. The only name generally known among the inhabitants, and used by their authors, is Esh-Sham.

Origin of the name *Syria*.

Some think the name Syria is derived from Tyre, in its Semitic form *Sur*. There can be no doubt that the city of Tyre was from the very earliest period well known to the Greeks; and being the place with which they were best acquainted, and had most intercourse, they naturally gave its name to the country; just as they called the southern part of the country Palestine, from the small maritime province of Philistia (Bochart. *Geog. Sac.* iv. 34). Others suppose that the word Syria is an abbreviation of *Assyria*. Herodotus says, Assyria is the Barbarian and Syria the Greek name (vii. 63). So also Justin represents the Assyrians and Syrians as the same (i. 1); and Strabo several times alludes to this, showing that such was the general opinion of learned men in his day (Bochart. *Geog. Sac.* ii. 3). In fact, by most of the classic writers, the two names were used promiscuously. Upon examining the subject closely, however, it would seem that this confounding of two countries arose from the similarity of the names, and from want of clear and systematic knowledge not only of etymology, but of geography. Assyria unquestionably derived its appellation from the patriarch Asshur, and embraced the country round Nineveh (as Pliny states, lib. ii.), which was afterwards called Adiabane (Bochart. *Geog. Sac.* ii. 3). *Syria*, on the other hand, was the Greek form of *Sur*, and appears to have been applied somewhat vaguely to the whole of Aram, Phœnicia, and Palestine. Some may have prefixed the article, and thus made it *Al*-Syria or *As*-Syria.

Extent and boundaries.

The old country of Aram, the Syria of the Bible, embraced Mesopotamia, and that section of Syria only which lies north of Mount Hermon, and east of the great mountain-range which runs along the coast of the Mediterranean. Mesopotamia was called *Aram-Naharaim*, "Aram of the two rivers" (Gen. xxiv. 10); while the division of Aram west of the Euphrates appears to have been first called by the general name *Aram-Dammesek*, "Aram of Damascus," but was afterwards subdivided, as we shall see (2 Sam. viii. 6). Herodotus, the first writer who uses the name Syria, makes the country extend as far eastward as the ancient Aram, while he stretches it northward over a large section of Asia-Minor, westward to the Mediterranean, and southward to the borders of Egypt (i. 72; ii. 104, 116; Reland, *Pal.* pp. 43, 44). Pliny writes somewhat indefinitely. He says, the part of Syria bordering on Arabia was called Palestine, Judea, Coele, and Phœnice; that in the interior, Damascena; that south of the latter, Babylonia; the part lying between the Euphrates and Tigris, Mesopotamia; beyond (north of) the Taurus range, Sophene; on this side of it, Commagene; and the part adjoining Cilicia, Antiocheia. He thus extends it even farther than Herodotus; but in another place he says, its length from Cilicia to Arabia is 470 miles, and its breadth from Seleucia to Zeugma on the Euphrates, 175; while he affirms that some geographers distinguish Syria both from Phœnicia and Judea (*Hist. Nat.* v. 13). According to Xenophon (*Anab.* i. 4), Syria was separated from Cilicia by a pass called the "Syrian Gates;" but he includes in it Mesopotamia. Strabo's description is more definite (xvi. 2). Syria, he writes, was bounded on the north by Cilicia and Mount Amanus; on the east by the Euphrates and the Arabian Scenitæ, who live on its western bank; on the south by Arabia-Felix and Egypt; and on the west by the Mediterranean. Some of the old geographers speak of Phœnicia as a distinct province (Herodot. iii. 5; Ptolemy, &c.); while others, as Strabo and Pliny, include it in Syria. Jewish writers generally distinguish between Syria and Palestine (Reland. *Pal.* p. 10). Ptolemy confines Syria to what may be regarded as its proper limits (*Hist. Nat.* v.) He says it was bounded on the south by Judea, on the west by the Mediterranean, on the north by Cilicia and Cappadocia, and on the east by the Euphrates as far as Thapsacus, and by the Arabian desert. This is the region which forms the subject of the present article.

The boundaries of Syria may be more definitely stated, as follows:—On the north, a line drawn from the head of the Gulf of Issus eastward to the Euphrates; on the east, the River Euphrates as far as the ruins of Thapsacus, now

Syria.

El-Hummâm, and then a line drawn past Palmyra, and across the plain to the Haurân Mountains; on the south, a line extending from the Haurân Mountains, by the waters of Merom, to the ruins of Tyre; on the west, the "Great Sea." The province thus extends from 33. 15. to 36. 50. north latitude; and from 35. 10. to about 37. 40. east longitude.

Physical geography.

The surface formation or physical structure of Syria is peculiar. The country is divided into a series of longitudinal belts, extending from north to south. There is first a narrow belt of plain along the sea-coast; next to this is a belt of mountains; next follows a long valley; then another but less regular mountain-range; and lastly, a great belt of table-land. These we shall take in order.

1. *The maritime plain.*—This plain commences on the south, at the Promontorium Album, a bold promontory of white limestone which projects into the Mediterranean. From hence to the banks of the river Auwaly (the ancient Bostrenus), a distance of 28 miles, the average breadth of the plain is about a mile. Opposite the sites of Tyre and Sidon the mountains retreat slightly, and the coast also juts out into the sea; the breadth is there increased to some two miles; while in other places the rocky hills almost dip into the Mediterranean. The surface of the plain is undulating, and the soil fertile, composed chiefly of disintegrated limestone, washed down from the heights of Lebanon. The greater part of it is now waste and desolate, but the few spots still cultivated show what it might be. The gardens and orchards of Sidon are almost unrivalled, producing melons, bananas, mulberries, figs, grapes, apricots, and oranges, in addition to the more common fruits and vegetables. Here and there we still meet with a few scattered palm-trees. This little plain constituted the nucleus of Phœnicia. Its coast-line is singularly bare and uniform. Opposite the promontory of Tyre there was formerly an island; it is now a peninsula, having been united to the mainland by Alexander's Mole; on it stood the new city of Tyre. (See Tyre.)

Between the River Auwaly and Beyrout the plain is intersected by several rocky spurs from Lebanon. The promontory of Beyrout is low and sandy. From the base of the mountains to the apex it measures about 3 miles. Vast groves of olives, gardens of mulberries, and orchards of fruit-trees grow upon it; but the drifting sand threatens them all with destruction. The bay of St George, on its northern side, affords, perhaps, the safest anchorage along the whole coast. It derives its name from its being the scene of the fabled contest between England's patron saint and the Dragon.

North of this bay the plain is again broken for a distance of nearly 20 miles by the rugged roots of Lebanon. On approaching Tripolis, it opens out into broad and beautiful fields and orchards. The gardens of Tripolis are more extensive and scarcely less productive than those of Sidon. Northward the plain still expands to a breadth of some 6 miles, sweeping round the gentle curve of a spacious bay, which extends to the rocky islet on which the ruins of Aradus lie, 25 miles from Tripolis. The soil is here exceedingly fertile, though the greater part of it is waste. From Aradus to the base of Mount Casius the plain continues unbroken, varying from 2 to 5 miles in width. Mount Casius interrupts it, rising abruptly from the sea. On its northern side lies the rich alluvial plain of Seleucia, at the mouth of the Orontes, now in part covered with orchards of mulberries and cultivated fields. Then, again, the bold headland called Ras-el-Khanzîr juts into the Mediterranean, separating the plain of Seleucia from that of Issus. The latter is very narrow, low, and marshy. At its northern end is a low promontory over which the road is carried; on the top of the pass are the remains of an ancient arch, and not far distant may be seen traces of a massive wall. This is doubtless the site of the "Syrian Gates" referred to by Xenophon in his description of the march of Cyrus, and is, consequently, the northern limit of our province.

2. *The Mountain Range.*—This range shuts in the maritime plain on the east, and is divided naturally, as well as historically and nominally, into three sections. The southern section is called

Lebanon. The great chain of Lebanon commences on the north bank of the River Litâny, from whose gloomy defile it rises boldly and abruptly. It runs in a north-eastern direction for about 90 miles, and terminates at the pass called in Scripture the "Entrance of Hamath." The breadth of the ridge varies from 15 to 20 miles, and its average elevation is about 7000 feet. Two peaks, Jebel-Sunnîn and Jebel-Mukhmel, rise considerably higher; and on their summits the snow remains in streaks during the whole summer. The latter is the loftiest mountain in Syria, rising about 10,000 feet above the sea. The main body of the ridge is limestone, but along the lower western slopes are thick strata of chalk, and fossils of various kinds everywhere abound. The summits are rounded, bare, and of a greyish-white colour. On the eastern side the descent is rugged and abrupt into the valley of Bukâa, the ancient Coele-Syria; while on the western it is more gentle, and we here see what industry can do even amid the wildest forms of nature, when it has a Syrian soil to work upon and a Syrian climate to aid it. No idea could be formed of the resources or cultivation of Lebanon by looking up from the maritime plains. As the whole range from base almost to summit is cultivated in terraces, nothing meets the eye when turned upwards but rude walls of rough stones, and loffy cliffs of gray rock. But when, on gaining some commanding peak, the eye is turned downward, one can scarcely repress the thought that the wand of an enchanter has been waved over the scene. Stair-like terraces of bright green corn and luxuriant vines, intermixed with long ranges of mulberries, olives, and fig-trees, have taken the place of naked rocks. Those more rugged parts along the lower declivities where cultivation is impossible, are scantily clothed with the oak and the pine. And high up on the side of the loftiest peak, far apart from other trees, still stand in stately, solitary grandeur the little grove of cedars—the last remnant of a sacred forest.

Nusairîyeh Mountains. The pass at the northern end of Lebanon, through which the road leads from the coast to the plain of Hamath, is about 5 miles wide. Beyond it rise the Nusairîyeh Mountains, which run in an unbroken chain northward to the Orontes, constituting the second section of the general chain. They are much lower than Lebanon, not averaging more than 4000 feet. Limestone is the prevailing rock; and thin oak-forests cover nearly the whole ridge. Where the chain meets the Orontes at Antioch, it sweeps round to the west, and terminates abruptly in a singular conical peak, which rises up bare and steep to a height of 5700 feet; this is the Casius of which Pliny tells such wonderful stories. The Nusairîyeh range is the Bargylus Mons of old geographers.

Jawar Dagh. On the north bank of the Orontes the mountains again rise abruptly in huge masses of naked rock. A spur shoots out from them westward, shutting in the plain of Seleucia and terminating in the bold promontory of Ras-el-Khanzîr. This part was formerly called Mons Pieria, from whence the city of Seleucia took its name Pieria. The chain which continues northward is the Amanus of Roman geographers, and is now called in Turkish Jawar Dagh. It has an elevation of about 6000 feet, and its scenery is both wild and picturesque, the lower slopes being furrowed with deep glens and clothed with forests of evergreen oak.

3. *The Great Central Valley.*—This valley runs along

the eastern base of the mountain-chain, and forms the most striking feature in the physical geography of the country. It is the continuation of a wonderful crevasse, which, further south along the course of the Jordan, has for a hundred miles and more a depression varying from 1 foot to 1312 feet below the level of the sea. Between the parallel ridges of Lebanon and Anti-Lebanon this valley extends from S.W. to N.E. about 70 miles in length, and is from 3 to 7 miles in breadth. It is almost perfectly flat; and the soil is in general rich, loamy, and abundantly watered. It is the Coele-Syria of the ancients; and its modern name is *El-Bukâa*, "the Plain." It has an elevation of some 3000 feet above the sea. At its northern end it joins the plain of Hamath, which extends far eastward; but there is still enough of depression along the course of the river Orontes to indicate the proper line of the valley. At Hamath it has again a ridge of hills on its eastern side; and here its course is due north, and it gradually contracts until, sweeping round westward at Antioch, it cuts through the mountain-chain in a sublime gorge, opening a way for the Orontes to the Mediterranean.

4. *The Anti-Lebanon Range.*—Along the east side of the valley of Coele-Syria lies another mountain-range, the Anti-Libanus of old geographers, now called Jebel Esh-Shurky. It rises up on the plain of Jaulân, a few miles east of the waters of Merom, and runs due north for 20 miles, gradually increasing in elevation, and covered with oak-forests. It then joins Mount Hermon, which is the culminating point of the whole range. It is a massive, white, naked, truncated cone, attaining an elevation of nearly 10,000 feet; and is, like the peaks of Lebanon, tipped with perpetual snow. From Hermon, as a centre, several ridges radiate, spreading out like an opening fan from N.E. to E. The ridge on the extreme left is the loftiest, varying from 4000 to 7000 feet in height; it sinks down into the plain of Hamath after a course of about 80 miles. That on the extreme right is much lower; it bounds the plain of Damascus, and extends away beyond Palmyra. All the ridges are bare, and hopelessly barren; though here and there one meets with scanty forests of oak and juniper. The main ridge is limestone, like Lebanon, abounding with fossils; but the lower ridges toward the plain of Damascus are chalky, and in places white as snow. They form a fit home for wild beasts—bears, leopards, wolves, swine, and especially jackals. Between the expanding ridges are several terrace-like plateaus, bleak and arid, though not all barren; and they are intersected by two wild and rich glens—*Abana*, which creates by its abundant waters the noble plain of Damascus, and *Helbon*, famed as of yore for its vintage (Ezek. xxvii. 18). The fullest account of this remote region will be found in Porter's *Damascus.*

Plain of Hamath. At the northern end of the main, or western, ridge of Anti-Lebanon lies the fertile plain of Hamath, extending from the banks of the Orontes to the desert of Palmyra. About 50 miles north of Anti-Lebanon another chain rises up in the same line, not far from the ruins of Apamea. It is made up of several clumps of hills, almost detached; and it runs northwards as far as the parallel of Aleppo. These hills are limestone, in places well wooded, and are intersected by little fertile plains and valleys. They are interesting to the traveller and antiquarian as containing some of the most remarkable ruins in Syria. The southern section is called Jebel-Rîha, the central Jebel-el-Ala, and the northern Jebel-Simân, from its having been the residence of St Simon Stylite.

5. *The Eastern Plateau.*—This plateau continues almost unbroken from the southern limits of the country to the banks of the Euphrates. Its southern section constituted the ancient kingdom of Bashan, and is one of the most fertile tracts in Western Asia. Its surface is flat, with a deep, rich, black soil, and is dotted here and there with little conical and cup-shaped mounds of basalt, evidently extinct craters. It has an average elevation of nearly 2500 feet above the sea. In the very centre of this plain is one of the most remarkable regions in the world, in a physical point of view. It is now named the *Lejah*, or "Retreat," but the Hebrews called it *Argob*, and the Greeks *Trachonitis*, both words being descriptive of its wild, stony character. It is oval in shape, about 25 miles long by 13 wide. Its borders are as clearly defined as a rocky coast-line. The general surface is elevated from 20 to 30 feet above the surrounding plain. It is wholly composed of basalt rock, which appears to have issued from innumerable pores in the earth, and to have flowed out on every side until the plain was almost covered. Before cooling it seems to have been tossed like a tempestuous sea. The crater-like cavities from which the liquid mass exuded are still visible. Deep fissures and yawning chasms intersect the whole like a network; while here and there are huge mounds of shattered rock. The rock is black, filled with air-bubbles, and hard as flint. The aspect of the whole is savage and desolate in the extreme. The very trees that grow among the rocks have a blasted look; yet, strange to say, this forbidding region is thickly studded with deserted towns and villages.

Mountains of Bashan. Away on the eastern border of the plain is an isolated range of volcanic hills, the highest peak of which, called Kuleib, has an elevation of about 5000 feet. Their sides are partially covered with remains of ancient oak-forests, and dotted with the ruins of primeval cities. These are the "Mountains of Bashan" mentioned in the Bible, called Alsadamus Mons by Ptolemy, and Jebel-Haurân by the Arabs. Another isolated and much lower ridge separates the territory of Bashan from Damascus.

The Plain of Damascus, now called *El-Ghûtah*, is celebrated throughout the world for its richness and beauty. It is perfectly flat; and its fertility and surpassing loveliness are wholly owing to the waters of the Abana and Pharpar, which are diffused by innumerable canals and ducts over its surface. On the north of the Ghûtah the low bare ridge which runs eastward from Hermon intersects the great plateau; but beyond this range it again extends arid, bleak, and desolate—fit abode for timid gazelle and wild Bedawy—far away to the banks of the Euphrates. On its western side, in the midst of low, white, chalk-hills, stands Aleppo. Between Aleppo and the Euphrates is a large salt marsh.

The Orontes, now called El'Asy, is the largest river in Syria. Its highest source is in the valley of Coele-Syria, beside the ruins of Lybo, at the base of Anti-Lebanon; but its principal source is 10 miles farther down, at the eastern base of Lebanon. It flows northward towards Hums, the ancient Emesa, where a strong embankment, built many centuries ago, dams up the river, and forms a large lake, called Kades. From hence it flows on in the same general direction through the centre of the valley to the parallel of Antioch, where it turns abruptly westward, and passes through a sublime gorge to the Mediterranean. Before passing Antioch it is doubled in size by a tributary from a lake called Bahr-el-Abiad, lying a few miles northward. Rivers.

The Leontes, now called El-Litâny, is the second river in magnitude. It rises in the plain of Coelé-Syria, near Bâalbek, and receives numerous small tributaries from Lebanon and Anti-Lebanon. At the southern end of the plain it enters a narrow deep ravine, in many places only a few feet wide, and at one spot spanned by a natural bridge. After intersecting the mountain-ridge, it falls into the Mediterranean near Tyre.

The Abana, the Chrysorrhoas of the Greeks and Barada of the Arabs, is a wild mountain-torrent, rising in the very centre of Anti-Lebanon, cutting in succession through three of its parallel ridges, and at length bursting forth from its

rocky barrier, bearing gold in its bosom and scattering emeralds far and wide over the matchless plain of Damascus. About 15 miles east of the city, the river, greatly reduced in size, divides into two branches, each of which feeds a little lake.

The other rivers of Syria are the Pharpar, now called Nahr-el-Awaj, which rises high up on the side of Hermon, flows across the plain of Damascus, and falls into a lake, or rather marsh. The *Lycus flumen*, or Nahr-el-Kelb (the Latin "wolf" having degenerated into the Arab "dog"). Its source is on Jebel-Sunnîn, and it falls into the Mediterranean some eight miles north of Beyrout. At its mouth is the remarkable pass where Egyptian, Assyrian, and Roman conquerors have in succession inscribed records of their deeds. The Adonis springs from a cave beneath a stupendous cliff beside the ruins of Apheca, and through a yawning chasm,

> "Runs purple to the sea, supposed with blood
> Of Thammuz yearly wounded."

The Eleutherus, now Nahr-el-Kebîr, sweeps round the northern end of Lebanon, through the "Entrance of Hamath," and falls into the Mediterranean some 15 miles north of Tripolis.

Historical and political geography.

No country in the world of the same extent has passed through so many political changes and vicissitudes as Syria. Its first colonists were the descendants of Aram, who gave the name of their progenitor to the whole eastern section of the country. This section was soon subdivided into no less than six districts. (1.) Its northern part, between the city of Hamath and the Euphrates, was called Aram-Zobah (1 Sam. xiv. 47; 2 Sam. x. 6, comp. viii. 3). Palmyra appears to have been in this province (2 Chr. viii. 3, 4). South of the former lay *Aram-Dammesek*, so named from Damascus its capital (2 Sam. viii. 5). (3.) A small territory round the base of Hermon was attached to the city of Beth-Maachah, and hence called *Aram-Maachah* (1 Kings xv. 20; Deut. iii. 14; 1 Chr. xix. 6). (4.) Apparently adjoining the latter was another small territory, called *Aram-Beth-Rehob* (comp. Judges xviii. 28; 2 Sam. x. 6). (5.) Josephus states that Uz, the son of Aram, founded the principality of *Trachonitis* (*Antiq.* i. 7), which the Hebrews called *Argob*. It contained many great and strong cities founded by a race of giants (Deut. iii. 13, 14), the remains of which still exist (Porter's *Damascus*, vol. ii.) (6.) Between Trachonitis and Damascus lay a small but very ancient province, colonized by *Jetur*, a son of Ishmael (Gen. xxv. 15), and by the Greeks named *Iturea*.

Mount Lebanon appears from the earliest ages to have been inhabited by several small independent tribes, who were more or less closely connected with their neighbours on the coast, the Phœnicians. The *Arkites* (Gen. x. 17) dwelt in Lebanon, and the ruins of their old capital Arca may still be seen a few miles from Tripolis. The *Giblites* were also "mountaineers" of Lebanon, and they gave their name to a city and province which to this day we can recognize in the Arabic form, *Jebeil*.

Phœnicia was a province so distinct and so remarkable that it will be treated separately in the sequel.

Under the Seleucidæ the various principalities of Syria were for a time united in one kingdom; but during the harassing civil wars of this dynasty a new division took place, and the old city of Damascus was made the capital of a southern kingdom, including Palestine.

The political divisions of Syria in classic ages, as given by Greek and Roman geographers, are far from being definite. Strabo mentions five provinces:—1. *Commagene*, a fertile and comparatively level region, lying along the right bank of the Euphrates; bounded on the N. by Mount Taurus, and on the W. by the range of Amanus. Samosata was its metropolis, and was situated on the Euphrates, which was here spanned by a bridge (Strabo, *Geog.* xvi.) 2. *Seleucis* lay on the S. and S.W. of the former, and embraced the territories annexed to the cities of Seleucia-Pieria, Antioch, Apamea, and Laodicea-ad-Mare. 3. *Coele-Syria.* This province was originally confined, as the name implies, to the great valley between Lebanon and Anti-Lebanon; but in Strabo's time it was already extended almost indefinitely southward and eastward. It included the territory of Chalcis, a city at the western base of Anti-Lebanon, 20 miles south of Heliopolis; the province of Abila, or Abilene, a mountainous region between Hermon and the valley of the Abana (Luke iii. 1); Damascus, with its noble plain; Iturea; Gaulanitis, lying along the east bank of the upper Jordan; Auranitis, the beautiful plateau east of the latter; Trachonitis, already described; and Batanæa, which embraced the mountains called Jebel-Haurân. 4. *Phœnicia* (see below). 5. *Judœa* (see article PALESTINE).

Pliny's divisions are still more numerous than Strabo's; and Ptolemy makes no less than fifteen provinces. In fact, it appears from a careful perusal of ancient authors, that every city as it rose to importance gave its name to a little state round it; but whenever it was eclipsed by a neighbouring rival, its principality was swallowed up. This gave rise to great confusion in the political geography of the country; but the fact sufficiently accounts for that indefiniteness so marked in the works of Strabo, Pliny, and Ptolemy. Ptolemy mentions three small districts not named by Strabo:—1. *The Coast*, from the Syrian Gates to the border of Phœnicia. This included the narrow plain of Issus, and the plain at the mouth of the Orontes, which Strabo calls Pieria. 2. *Palmyrene*, embracing the desert plains, and naked mountains round Palmyra, and extending eastward to the Euphrates. 3. *Laodicea Scabiosa* embraced the southern section of the plain of Hums, and a part of the adjoining ridge of Anti-Lebanon. The site of the old city from which it took its name was identified a few years ago by the writer of this article. The ruins lie upon the bank of the Orontes, 15 miles above Emesa (Hums), and are now called Tell Mindau.

Under the Romans Syria became a province of the empire, and was generally governed by a proconsul. Some portions of it, however, were for a time suffered to remain under the rule of petty princes, who were dependent on the imperial government, and whose dominions were gradually incorporated. There were also a number of cities to which freedom was given; these had their own laws, and administered their own revenues. Both principalities and free cities were financially subject to the Roman government—they were, in fact, employed as instruments for the collection of the imperial revenues. Antioch was the usual residence of the governor, and was the acknowledged capital of the province. The province increased so rapidly in extent and wealth that, in the reign of Hadrian, it was found necessary to divide it into three parts, namely—1. *Syria Major*, with Antioch at first, and afterwards Laodicea as its capital; 2. *Syria Phœnice*, or *Syrophenice* (Mark vii. 26), embracing the territories of Tyre, Damascus, and Palmyra; 3. *Syria Palæstina.* Towards the close of the fourth century another subdivision of Syria took place, which formed the basis of the ecclesiastical government. The sections were as follows:—1. *Syria prima*, with Antioch for its capital, and the greater part of Northern Syria within its borders. 2. *Syria Secunda;* capital city, Apamea. It embraced the rich plain of Hamath, with several large and prosperous towns. 3. *Phœnicia Prima*, including the greater part of the ancient province of Phœnicia, and extending as far inland as Cæsarea Philippi. Its metropolis was Tyre. 4. *Phœnicia Secunda*, also called Phœnicia-ad-Libanum. Damascus was its capital; and Abila, Heliopolis, Laodicea-ad-Libanum, and Palmyra, were subject to its governor. The other sections were *Palæstina Prima*, *Secunda*, and *Tertia.*

Phœnicia.

In the beginning of the seventh century the wild followers of Mohammed captured Syria, and then Damascus became for a time not only the capital of all Syria, but also of an empire that extended from the Indian Ocean to the shores of the Atlantic. The changes and vicissitudes through which Syria passed from that period to the present day belong more to history than geography.

The whole country of Syria and Palestine is at present divided into three pashalics—Damascus, Aleppo, and Sidon. The *Pashalic of Damascus* includes the districts lying east of the Jordan, the Bukâa, and the Orontes as far north as Hamath. Damascus is the residence of the commander-in-chief of all the Sultan's forces in Syria. The *Pashalic of Sidon* includes all Palestine west of the Jordan, all Lebanon, and the coast as far north as Tripolis. Beyrout is the capital, and is at present the most flourishing town in Syria. A governor, with the title of pasha, resides at Jerusalem; but he is subject to the Pasha of Sidon. The *Pashalic of Aleppo* embraces all northern Syria, with a section of Asia-Minor, extending to Aintab and Marash. The following table gives a comprehensive view of the statistics of these pashalics so far as they are known. It must be remembered that the Turks are far behind in statistics:—

	Damascus.	Aleppo.	Sidon.	Total.
Muslems.........	412,000	460,000	424,000	1,296,000
Christians.......	79,100	81,000	281,000	441,100
Jews..............	5,300	10,000	9,000	24,300
Druzes	18,000	Not known	60,000	78,000
Metâwileh	18,900	...	7,000	25,900
Nusairîyeh......	14,500	41,000	Not known	55,500
Total.........	547,800	592,000	781,000	1,920,800

PHŒNICIA.

The best geographers have included Phœnicia in Syria, and, therefore, its physical geography, statistics, and more recent history, have been connected in this article with those of the latter country; but the political state and history of Phœnicia, during the period of its independence, are so distinct and so interesting that the writer has thought it best to give a condensed view of them in this place in a separate form.

Name.

The Semitic and ancient name of Phœnicia was *Chna*, or *Canaan* (כְּנַעַן, Greek, Χνᾶ). This is the only name used by the Phœnicians themselves, and also by the Hebrews (Gen. x. 17–19; Reland, *Pal.* p. 7). It signifies "low region," probably as opposed to the plateau of Aram; and is, therefore, descriptive of the country. (The root is כָּנַע, "to be low.") The word Phœnicia is supposed by some to be derived from the name of a man, said to be a brother of Cadmus; by others from φοίνιξ, "a palm; by others from the purple dye, φοινός; and by others from the Red Sea, whence, according to Herodotus (vii. 89), the Phœnicians came.

Extent and boundaries.

Ancient geographers give widely different accounts of the extent of Phœnicia. Some say it included the whole maritime plain from the Gulf of Issus to Egypt; while others confine it between the rivers Eleutherus and Crocodilon. Some make it run as far eastward as Damascus; while others shut it in by the ridge of Lebanon. This is not much to be wondered at. The Phœnicians would not confine themselves within definite bounds. They went wherever they found an opening for trade, and they contrived to make that spot their home. It is probable that the nucleus of the nation was very small, including only the narrow strip of plain along the western base of Lebanon, between the Promontorium Album and the River Bostrenus. Soon, however, they extended northwards and southwards, building cities wherever they found a little bay or cape to shelter their ships. Sidon and Tyre were the parent cities—the cradles of the world's commerce. The island of Aradus was early occupied; then followed Accho and Dor on the south, Tripolis and Gabala on the north. All these, and many more, were colonized before the time of Herodotus (iii. 5; iv. 38, &c.) About the period of the Roman conquest of Syria (B.C. 64), the limits of Phœnicia were pretty accurately defined. Pliny says it reached from Aradus to the Crocodile river, which falls into the sea a few miles south of Dor, a distance of 140 miles; its breadth did not average more than 2 or 3 miles. Its situation was admirably adapted for the development of its commerce. On the east, the ridge of Lebanon secured it from attack. The great strongholds, Tyre and Sidon, were so placed naturally as to bid defiance to any ordinary foe. The only approaches to them lay along the coast, and these were defended by the difficult passes at the River Lycus and the Promontorium Album. The coast beyond these points was more open. On the west, the Phœnicians had an uninterrupted seaboard, with a number of little rock-girt ports, insignificant indeed as respects modern navigation, but sufficient for the wants of those primitive ages. The plain, though narrow, is rich, and abundantly watered by streams from Lebanon. The mountain-sides above yielded oil, and wine, and "summer fruits," for which they are still famous; besides an unlimited supply of pine, cedar, and oak, for ship-building. The gardens and fields below produced those palm-groves which probably gave the country its name. The palm has almost disappeared, only a few solitary trees appearing here and there; but orchards of oranges and lemons have taken their place round Sidon, Beyrout, and Tripolis. The glory of Phœnicia has passed. A mournful and solitary silence now reigns along the greater part of a coast which once resounded with the din of an enterprising commercial people.

History of Phœnicia.

The early part of Phœnicia's history is, in a great measure, legendary. In the Bible Sidon is said to be a son of Canaan; and the Arvadites and Arkites, two other Phœnician tribes, were of the same family (Gen. x. 17, 18). In the Scriptures, as well as on their own coins and inscriptions, the Phœnicians are always called Canaanites (Judges i. 31; Reland, *Pal.* p. 7). It would seem, however, from the nature of the language, which closely resembles the Hebrew (Gesen. *Monum. Phœn.*), that they were either amalgamated with some Semitic tribe, or had such intimate relations with their neighbours of Aram, as led them to adopt their language. Herodotus says they immigrated from the Red Sea, and Strabo that they came from two islands in the Persian Gulf. There can be no doubt that the whole descendants of Ham migrated from the plains of Assyria; and the route followed by the Canaanites may have been along the shores of the Persian Gulf, up the Red Sea, and, as Justin states (xviii. 3), to the Assyrian Lake, or Dead Sea, and thence finally to the coast at Sidon. But however this may be, it is certain that they were settled on the little plain at the base of Lebanon, at least as early as the time of Abraham (comp. Gen. x. 19; xv. 21), or nearly 2000 years B.C. Herodotus, who made a journey to Tyre for the express purpose of verifying a date, states that the great temple of Hercules in that city had already existed twenty-three centuries. This would throw back the founding of the temple, and of course the city, to about B.C. 2800, or some 450 years before the Flood, according to the common chronology. No scholar, however, who examines in an impartial spirit the confused annals and long-drawn chronological records of Phœnicia or Egypt, will venture to adopt them in preference to that of the Bible.

Sidon was the first capital of Phœnicia. It was emphatically the "Great Zidon" when the Israelites invaded Canaan (B.C. 1450; Josh. xi. 8). It is several times men-

Phœnicia. tioned by Homer, and before his day its manufactures had obtained a world-wide celebrity. In the earliest periods of Grecian history Sidonian ships were well known on the coasts, and Sidonian merchants in the marts of that country, and also of Asia-Minor. Isaiah wrote, more than twenty-five centuries ago, "Tyre is of ancient days . . . . the crowning city, whose merchants are princes" (xxiii. 7–12); and yet he calls her a "daughter of Zidon." The glory of the daughter then excelled that of the mother, and hence we can account for the fact that some later classic authors call Tyre ματέρα Φοινίκων. In fact, from the earliest period of which we have any trustworthy and full history, Tyre was the chief city of the Phœnicians. Here Hiram reigned who aided Solomon in building the Temple and in navigating his fleets. From his days to the time of Pygmalion we have a dry, uninteresting list of the rulers of Tyre. (See Kenrick's *Phœnicia;* Mover's *Die Phönitzier;* Bochart's *Geog. Sac.*) During the reign of Pygmalion the great colony of Carthage was founded by his sister Dido, so well known to the readers of Virgil. Some time after this the friendly relations which had subsisted for several centuries between the Phœnicians and Israelites were broken; and the cruelties perpetrated by the former were the causes of the prophetic curses pronounced upon them by Joel and Ezekiel (Joel iii.; Ezek. xxvi.), and subsequently so fearfully executed. The whole of Phœnicia was overrun by the Assyrian monarch Shalmanezer (Joseph. *Antiq.*, ix. 14), and afterwards by Nebuchadnezzar, when Sidon was captured, and Tyre stood a siege of thirteen years (*Antiq.* x. 11). In the days of Darius both Phœnicia and Palestine were considered provinces of the Assyrian empire, though still enjoying a kind of independence. The Phœnicians had now attained to great eminence, not only as a commercial, but also as a warlike people. Their fleets were constantly employed in the wars between the Persians and Greeks under Darius and Xerxes (Herodot. vii. and viii.) About B.C. 352, the Phœnicians attempted to regain their independence, and resist the power of Persia; but though they made a noble effort to defend Sidon against the hated foe, they were basely betrayed, and then visited by a terrible punishment. Forty thousand of the inhabitants of Sidon are said to have burned their houses over their heads rather than submit to the cruel conquerors.

After the victory of Issus, Alexander the Great marched upon Phœnicia; and, after an obstinate siege, captured the island-city of Tyre. Phœnicia now lost its nationality, and with this much of its enterprising spirit. Situated on the confines of the dominions of the Seleucidæ and the Ptolemies, it was often the theatre of devastating wars. When the Roman empire extended to Western Asia, Phœnicia was annexed to the province of Syria. Tyre, Sidon, and Aradus still continued to prosper; and Beritus rose to fame, not merely as a commercial city, but as a seat of learning. From this period, however, the history of Phœnicia merges into that of Syria.

Literature and art. It was not for their navigation merely, and their commercial enterprise, that the Phœnicians were celebrated. They were generally regarded, in ancient times, as the inventors of those phonetic characters which, to some extent, form the basis of all literature. The earliest specimens of Greek inscriptions bear considerable resemblance in the forms of their letters to the Phœnician; and they are found in some places colonized by the Phœnicians. Their skill in working gold and silver was also widely known. The bowl presented by Menelaus to Telemachus, and the silver vase proposed by Achilles as the reward in the funeral games of Patrocles, were of Phœnician workmanship (Homer, *Od.* iv. 618; *Iliad*, xxiii. 743). The bronze castings and purple robes of Tyre were everywhere prized. Even in the Roman age that city enjoyed the exclusive privilege of manufacturing the royal purple. The dye was obtained from small shell-fish, of the genera *buccinum* and *murex*, found along the rocky coast. Each mollusk yields but a single drop of the fluid dye, which is extracted by a sharp-pointed instrument (Pliny, *Hist. Nat.*, ix.) Glass was also manufactured in Phœnicia at a very early period. It is said to have been accidentally discovered by some merchants, who arrived on the coast near Carmel with a cargo of natron; and having used some pieces of it to keep up their cooking vessel on the fire, it was melted by the heat, and, mingling with the sand, produced glass (Plin. xxxvi.)

Colonies. Colonies were planted by the Phœnicians in almost every maritime country of the known world; in this respect, also, they were the Anglo-Saxons of antiquity. Cyprus was probably their earliest colony beyond the Syrian coast, and traces of their monuments remain on the island to this day. Thence they extended along the shores of Asia-Minor to Rhodes and the isles of Greece. Several towns were founded on the coast of Crete; and they crossed the mouth of the Adriatic, and established themselves in Malta, Sicily, and at Carthage. Cadiz and Tarshish, on the shores of Spain, were early occupied; and it is probable that they reached England, and carried on mining operations in Cornwall. (See Kenrick's *Phœnicia;* Bochart, *Geog. Sac.*)

Religion. Of the religion of the Phœnicians we have no definite or clear account. The fullest is given in Eusebius's *Prepar. Evangel.* Baal and Ashtaroth—representatives of the sun and moon—were their chief deities. To these they dedicated high places and temples in every part of their dominions. The name Baal also was often adopted by kings and great men; it was prefixed to that of other deities, as Baal-Zebub, "God of flies;" Baal-Berith, "God of the covenant;" Baal-Markos, "God of sports;" and it was prefixed to that of places where temples or altars were set up; as Baal-Gad, Baal-Hermon. The worship of these favourite deities was not only carried by the Phœnicians to their various colonies, but was also introduced among neighbouring nations. Jezebel, the daughter of Eth*baal*, promoted it in Israel (1 Kings xvi. 31).

Climate of Syria. There is, perhaps, no country in the world, of the same extent, which possesses a greater variety of temperature and climate than Syria. Perpetual snow crowns the summit of Hermon, while tropical heat scorches the deep valley of the upper Jordan at its base. The high altitudes along the brow of Lebanon are as cool and invigorating during the summer months as the south of England; while the marshy tracts round the waters of Merom, along the banks of the Orontes, near Apamea, and at the western base of Mount Amanus, are almost as hot and debilitating as the plains of Southern India. The whole seaboard, owing to its exposure to the rays of an unclouded sun, and its being sheltered by the mountain-ranges behind, is very sultry, and in some places unhealthy. But there are a few spots, even on the coast, such as Beyrout and Sueidîyah, where the soil is dry and the air pure; and these form excellent winter residences for invalids. The temperature and climate in the various parts of the interior depend on the elevation and the character of the soil. Jerusalem is high and breezy; but the rays of the sun, reflected from the bare white rocks and white soil around, render the heat most oppressive during the day. In Palestine rain very rarely falls from the end of April till the beginning of October; and a little cloud in the sky, as large as a man's hand, would be a wonder. The whole country is thus parched; vegetation, except where streams of water flow, is extinguished; and the air, during the long summer day, becomes so hot, dry, and scorching, as to render travelling unpleasant, if not actually dangerous.

In Lebanon, on the other hand, though the sun may be powerful, the air is fresh and balmy; while the dense foliage of its sublime glens gives a pleasant shade, and its foaming

torrents diffuse an agreeable coolness, even during the mid-day heat. The stalwart frames of the inhabitants of Lebanon are the best certificates of its bracing climate. The way in which the people digest and thrive on rancid oil, raw vegetables, and other abominations, speaks volumes for the peptic character of the mountain-air. The air, except where artificial irrigation is carried to an undue extent, is extremely dry, and malaria is almost unknown.

In Palestine the autumnal rains commence about the latter end of October, or beginning of November; in Lebanon they are a month earlier. They are usually accompanied by thunder and lightning; they continue for two or three days, not constantly, but falling chiefly during the night. For the two succeeding months they fall heavily at intervals. January and February are the coldest months; but along the coast of Syria, and in Palestine, frost is very rarely seen, and the cold is not severe. Snow falls on the higher altitudes along the whole mountain-ridge, on the plains of Coele-Syria and Hamath, and the writer once saw it eight inches deep on the terraced roofs of Damascus. Yet, in the western declivities of Lebanon, the snow seldom whitens the ground at a lower elevation than 2000 feet. Rain falls at intervals during the month of March; in Palestine it is rare in April; and even in Lebanon and Northern Syria the few showers that occur are generally light.

In the valley of the Jordan the barley harvest begins as early as the middle of April, and the wheat a fortnight later. In the hill-country of Judæa reaping commences about the beginning of June, while in Lebanon the grain is seldom ripe before the middle of that month. A pretty accurate index is thus given to the relative temperature of the different districts. It is not easy to ascertain the exact ranges of the thermometer, as much depends on the position of the instrument; and there are neither observatories nor meteorological societies in the country. In Aleppo, according to Russell, the range of the thermometer is very great; sometimes descending below zero, and rising above 100° Fahr. During a residence of nearly ten years in Damascus, the writer never saw the thermometer below 23°, or above 95°.

Inhabitants of Syria.

The inhabitants of Syria and Palestine form a most interesting study. Their dress, their manners and customs, and their language, are all primitive. No European nation, with the exception perhaps of the Spaniards, bears the least resemblance to them. Like Spain, too, the best specimens of humanity are here found among the lower classes. The farther we go from the contaminated atmosphere of government offices, the more successful shall we be in our search after honesty, industry, and genuine patriarchal hospitality—the great, almost the only, unadulterated virtue of the Arab. The people are illiterate, and extremely ignorant of all western inventions; but there is a native dignity in their address and deportment which will both please and astonish those who have seen the awkward vulgarity of the lower classes in some more favoured lands. Whether we enter the tent of the Bedawy or the cottage of the peasant, we are received and welcomed with an ease and courtesy that would not disgrace a palace. The modes of salutation are very formal, some would call them verbose and even tedious. Still there is something pleasing in them after all. The gestures used are graceful, if a little complicated. The touching of the heart, the lips, and the forehead with the right hand, seems to say that each one thus saluted is cherished in the heart, praised with the lips, and esteemed by the intellect. An Arab when eating, whether in the house or by the wayside, however poor and scanty his fare, never fails to invite the visitor or passing wayfarer to join him. And this is not always an empty compliment. In making purchases from an Arab, one finds his politeness almost overpowering. When the price is asked, he replies, "Whatever you please, my lord." When pressed for a more definite answer, he says, "Take it without money." One cannot but remember under such circumstances Abraham's treaty with the sons of Heth for the cave of Machpelah. Our feelings of romance, however, are somewhat damped when we discover that the price ultimately demanded is four or five times the value of the article; and that every form of lying and misrepresentation will be tried to gain a few additional piastres. The only exception to the general politeness of the Arabs in their intercourse with strangers of another faith, is to be found in some bigoted Muslems of the old school, who have for long centuries been accustomed to use the words "infidel," "dog," "Christian," as synonyms.

The modern inhabitants of Syria and Palestine are a mixed race, made up of the descendants of the ancient Syrians who occupied the country in the early days of Christianity; and of the Arabians who came in with the armies of the khalifs and settled in the cities and villages. The number of the latter being comparatively small, the mixture of blood did not visibly change the type of the ancient people. This may be seen by comparing the Christians with the Muslems. The former are undoubtedly of pure Syrian descent, while the latter are more or less mixed, and yet there is no visible distinction between the two save what dress makes. Every observer, however, may at a glance distinguish the Jew, the Turk, or the Armenian, each of whom is of a different race. The whole inhabitants may be best considered under the heads of religious sects. Religion has made most of the real distinctions existing among them; though difference of climate, employment, and mode of life have also had their effects on dress and minor matters. The mountaineer, for example, has his bag-trousers of immense capacity, his stiff embroidered jacket, and his trim turban; while his wife struts about in all the state of her towering silver horn and flowing white veil. The Bedawy of the desert is *sans culottes*, and his raiment consists of a loose calico shirt, over which is occasionally thrown a coarse cloak, and on his head is a gaudy kerchief, bound with a twisted rope of camel's hair. The city gentleman is arrayed in flowing robes, yellow slippers, red over-shoes, and turban of spotless white or embroidered Indian muslin. The peasant of the plain of Damascus looks more active in his gay-coloured spencer and short Turkish trousers. The inhabitants of some of the villages of Palestine and plains of Hamah seem to carry most of their wardrobe on their heads; for the enormous turban is out of all proportion to the scanty shreds that cling round the body.

We may now glance at the several religious sects.

1. *The Muslems.* These are, and have been for many centuries, the lords of the soil, and they constitute the great majority of the community. They are proud, fanatical, and illiterate. They are taught by the faith they hold to look with contempt on all other classes, and to treat them not merely as inferiors, but as slaves. They are in general noble in bearing, polite in address, and profuse in hospitality; but they are regardless of truth, dishonest in dealing, and immoral in conduct. In all large towns the greater proportion, especially among the upper classes, are both physically and mentally feeble, owing to the effects of polygamy, early marriages, and degrading vices; but the peasantry are robust and vigorous, and much might be hoped for from them if they were brought under the influence of liberal institutions, and if they had examples around them of the industry and enterprise of Western Europe. In religion the Muslems of Syria are *Sonnites;* that is, in addition to the written word of the Koran, they recognise the authority of the *Sonna*, a collection of traditional sayings and anecdotes of the prophet, which is a kind of supplement to the Koran, directing the right observance of many things omitted in that book. They are in general very exact in the observance of the outward rites

of their religion; and in Islâm there is little else. Their great feast of *Ramadân* is kept by a vast majority with scrupulous care; but it must be admitted that long abstinence has not the effect of sweetening their temper or improving their morals.

Besides the *Sonnites* or orthodox Muslems, there are three other sects which we must class under the common name, Muslem.

The *Metâwileh* or followers of Aly, son-in-law of Mohammed. His predecessors on the throne, Abu-Bekr, Omar, and Othman, they do not acknowledge as true khalifs. Aly they maintain to be the lawful Imâm, and they hold that the supreme authority, both in things spiritual and temporal, belongs of right to his descendants alone. They reject the *Sonna*, and are allied in faith with the *Shiites* of Persia. They are almost as scrupulous about the "clean" and the "unclean" in their ceremonial observances, and in the ordinary affairs of life, as the Hindoos. They will neither eat nor drink with those of another faith, nor will they use the ordinary drinking or cooking vessels of others. The districts where they chiefly reside are Bâalbek; Belâd Beshârah, on the southern part of Lebanon; and round the village of Hurmul, near the fountain of the Orontes.

The *Nusairîyeh* or *Ansairîyeh*. It is not easy to tell whether this sect is to be classed among Muslems or not. Their religion still remains a secret, notwithstanding all attempts recently made to dive into its mysteries. They are represented by Asseman as holding a faith half Christian and half Mohammedan. They believe in the transmigration of souls, and observe in a singular, if not idolatrous, manner a few of the ceremonies common in the Eastern Church. They are a wild and somewhat savage race, given to plunder, and even bloodshed when their passions are roused or suspicions excited. They inhabit that range of mountains which bears their name, and which extends from the banks of the Orontes at Antioch to the entrance of Hamath.

The *Ismaelîyeh*, who inhabit a few villages on the eastern slopes of the Ansairîyeh Mountains, resemble the former in this, that their religion is a mystery. They were originally a subdivision of the Shiites, and are the feeble remnant of a people too well known in the time of the Crusades, under the name of *Assassins*. They have still their chief seat in the old castle of Masyâd, on the mountains west of Hamath.

2. *The Druzes*. The Druzes form one of the strongest, most united, and most remarkable sects in Syria. Their peculiar doctrines were first propagated in Egypt by the notorious Hâkim, the third of the Fatimite dynasty. This khalif, who gave himself out for a prophet, though he acted more like a madman, taught a system of half materialism, asserting that the Deity resided in Aly. In the year A.D. 1017, a Persian of the sect of Batanis, called Mohammed Ben-Ismail-ed-Derazy, settled in Egypt, and became a devoted follower of Hâkim. He not only asserted the absurd pretensions of the new Egyptian prophet, but he added to his doctrines that of the transmigration of souls, which he had brought with him from his native country; and he carried his fanaticism to such an extent that the people at last rose in a body and drove him out of Egypt. He took refuge in Wady-et-Teim, a narrow valley at the western base of Hermon; and being secretly supplied with money by the Egyptian monarch, propagated his dogmas, and became the founder of the Druzes. His system was enlarged, and in some degree modified by other disciples of Hâkim, especially a Persian called Hamza, whom the Druzes still venerate as the founder of their sect and the author of their law. Hamza tried to gain over the Christians by representing Hâkim as the Messiah whose advent they expected. Such was the origin of the Druze religion. Their tenets, and especially their mode of worship, are still kept strictly secret. A few of their books have found their way to the public libraries of Europe; and it was the good fortune of the writer recently to obtain in Syria copies of their seven standard works, which had been taken by a Christian from one of their khulweh's during the war of 1845. Some of these works are written in a mystic style, unintelligible to ordinary readers. Their Confession of Faith seems to consist of the following propositions:—

(1.) The Unity of God, and his manifestations of himself to man in the persons of seven individuals, the last of whom was Hâkim.

(2.) Five superior spiritual ministers always existing. These have also appeared in the persons of men at various periods. The chief of them were Hamza and Christ.

(3.) The transmigration of souls. The souls of men never pass into animals.

(4.) The belief in a period when their religion shall be triumphant,—Hâkim shall reign, and all others shall be subject to him for ever.

(5.) The seven points of Islâm are set aside, and the following substituted:—1. Veracity (to each other only). 2. Mutual protection and aid. 3. Renunciation of all other religions (implying persecution of all others when practicable). 4. Profession of the unity of Hâkim (as God). 5. Contentment with his works. 6. Submission to his will. 7. Separation from those in error and from demons.

The Druzes are divided into two classes, the "initiated" and the "uninitiated." With the former all the rites and ceremonies remain strictly secret. The holy books are kept under their care. They have some ceremonies, or are supposed to have some, which are less pure and spiritual than those set forth in their creed. They assemble in their chapels (*khulwehs*) every Thursday evening, refusing admission to all others. What they do then and there is unknown. A figure of a calf made of brass or other metal has been found in their places of worship, and is supposed by some to be an idol, but this they deny, and there can be no doubt that their books do not seem to teach or favour idolatry. Their places of worship are always in remote but conspicuous spots, as if to secure privacy and effectually guard against intrusion. On the whole, they seem to be more a political than a religious body. Their secret meetings are for collecting and communicating information, rather than for worship. The initiated are their chief advisers both in peace and war. The whole country in which they reside is divided into districts; each district has its council of initiated assembling weekly; a delegate from each council appears at the meetings of the councils of bordering districts to hear and to detail everything effecting the Druze interests. The rapidity and accuracy with which news is thus propagated is astonishing, and is of vast importance in time of war.

The Druzes are industrious and hospitable when at peace, but in war they are noted for their daring ferocity. They occupy the southern section of the ridge of Lebanon. They also abound in villages on the eastern and western declivities of Hermon and in Jebel-Haurân. There are a few in Damascus, and in one or two villages near it. Their numbers may be estimated at about 80,000.

3. The Christians are divided into several sects, as follows:—

The Greeks. They are called Greeks simply because they profess the Greek faith, and belong to the Greek or Oriental Church. They are Syrians both by birth and descent; and there is not a trace either in their spoken language, or in the language of their ritual, of any national affinity with the people of Greece. Their number has been estimated at about 115,000. The Greek Church in Syria is divided into the two patriarchites of Antioch and Jerusalem. They are nominally indeoendent, but virtually

Syria.

under the control of the Patriarch of Constantinople. The jurisdiction of the Patriarch of Antioch, who usually resides at Damascus, extends from Asia-Minor to Tyre, and includes (in Syria) the eight bishoprics of Beyrout, Tripolis, Akkar, Laodicea, Hamah, Hums, Saidnaya, and Tyre. The patriarchite of Jerusalem includes the whole of Palestine, and the country east of the Jordan. Its sees are Nazareth, Acre, Lydda, Gaza, Sebaste, Nabulus, Philadelphia, and Petra. The Greek Church enjoys the privilege of having its religious services conducted in the language of the people. It is unfortunate, however, that nearly all the higher clergy are foreigners. They all look to Russia as their natural protector; and Russian gold is profusely expended in the decoration of their churches and support of schools. The parish clergy *must* all be married men; and most of them are selected from among the lowest of the people, with no other fitness for the sacred office than that which the ceremony of ordination confers.

The Syrians or *Jacobites*, originally separated from the Eastern Church on account of the Monophysite heresy. Their head is the patriarch, who resides in Mesopotamia. Their number is very small. The village of Sudud, south-east of Hums, on the borders of the desert, is their head-quarters. They are regarded by all the other sects as heretics; and because they are few and poor they are generally despised.

The Maronites. This sect originated during the Monothelitic controversy of the seventh century. A monk called *John Maron* was the apostle of this heresy among them, and they consequently received his name. In the year 1180 they renounced Monothelitism, and submitted to the authority of the Pope, since which time they have been characterised by an almost unparalleled devotedness to the see of Rome. In order to increase Romish influence among them, a college was founded in that city by Gregory XIII. for the education of a select number of their youth. The two celebrated Oriental scholars and writers, J. S. and J. A. Assemanns, were Maronites, trained in this college. It is remarkable, however, that a church so devoted to the papacy should deviate so far from the Latin ritual. Their ecclesiastical language is Syriac; they have their own distinct church establishment; and every candidate for the priesthood is permitted to marry before ordination.

The Maronites are found in small communities in all the large towns from Aleppo to Nazareth; but they are at home in Lebanon. This mountain-range they inhabit more or less throughout its whole extent; but their great stronghold is the district of Kesrawan, east of Beyrout. Their patriarch, who is their spiritual chief, is selected by the bishops, though he receives the robe of investiture from Rome. The Maronites have a strange taste for the cloister. The number of their convents is greater in proportion than that of any other sect in Christendom. Their whole community does not exceed 220,000 souls; and yet they have in Lebanon alone 82 convents, containing above 2000 monks and nuns. The Maronites are brave and industrious; and their native mountains, though steep and rugged, are the garden of Syria.

The Papal Schismatic Churches have sprung from the missionary efforts of Romish priests and Jesuits during the last two centuries. As the object was to gain partisans, more pains were taken to obtain nominal submission to the authority of the Pope than any real change of doctrine or ritual. They still retain their Arabic service, their oriental calendar, their communion in both kinds, and their married clergy. Their spiritual chief takes the pompous title of "Patriarch of Antioch and all the East." The community numbers about 40,000.

4. *The Jews.* A sketch of the inhabitants of Syria and Palestine would not be complete without a notice of the Jews. In one sense they are the most interesting people in the land. For eighteen centuries have they been driven forth from the country of their fathers, and yet they cling to its holy places still. They moisten the stones of Jerusalem with their tears; her very dust is dear to them, and their most earnest wish on earth is that their bodies should mingle with it. The tombs that whiten the side of Olivet tell a tale of mournful bereavement and undying affection unparalleled in the world's history. The Jews of Palestine are all foreigners. They live almost exclusively in the four holy cities, Jerusalem, Hebron, Tiberias, and Safet; and their whole number does not exceed 9000.

Altogether different from these are the Jews of Damascus and Aleppo. They are Arabs in habits and language, in so far at least as religion will permit. Some of them are men of great wealth and corresponding influence. For generations they have been the bankers of the local chiefs, and have often and fearfully realized all the strange fluctuations of Eastern life—now ruling a province, now gracing a pillory; at one time all-powerful favourites, at another disgraced and mutilated outcasts. Their number is about 15,000.

5. *The Turks.* The Turks are few in number, strangers in race and language, hated by every class, wanting in physical power, destitute of moral principle, and yet they are the despots of Syria. Those occupying the higher government situations are all Turks. They obtain their power by bribery, and they exercise it for extortion and oppression. Their character has been ably sketched by Hamilton:—"They are all ignorant and presumptuous, vain and bigoted, proud without any feeling of honour, and cringing without humility; they cannot resist the temptation of money, or the prospective benefit of a lie. In their government and administrative duties they are tyrannical and overbearing, in their religious doctrines dogmatical and intolerant, and in their fiscal measures mercenary and arbitrary. They are as ignorant of their own history as that of other nations; and this is the case even with the better educated, who are in most respects far inferior in character, probity, and honour to the peasants and the lower classes. As long as the Turk is poor, and removed from temptation, he is honest; but no sooner is he appointed to office, or obtains the management of public money, than his uneducated mind is unable to withstand the charm, and he becomes a peculator and a thief. He appropriates to himself whatever he can lay hands on, and oppresses those below him; while, for the sake of securing his ill-gotten plunder, he propitiates his superiors by bribery and adulation. This has undoubtedly led to the demoralizing practice of the Turkish government of selling all places to the highest bidder, allowing him in return to make the most he can out of the unprotected subjects by extortion and taxation." The Turkish rulers of Syria are here drawn to the life. The country has been ruled for centuries by foreign tyrants. who have no interest in either the soil or the people, save that of grasping their whole available wealth. The Turks have only been able to rule by the cruel policy of pitting against each other the various rival sects and parties. The results are patent—poverty, hatred, bigotry, and bloodshed. A few places along the coast have latterly began to show signs of new life, owing mainly to the enterprise of European merchants, and the protection afforded to property by the influence of European consuls. Beyrout shows what Syria might become under a liberal and paternal government. The eastern border affords a marked contrast to the western. Hundreds of towns and villages are there deserted, though not ruined, and every year adds to their number, while tens of thousands of acres of the richest soil are abandoned to the periodical raids of the Bedawin.

Ruins.

Syria, like Palestine, is emphatically a land of ruins. In some of her fairest provinces desolation reigns triumphant.

Syria.

Many of her noblest cities are now heaps of rubbish; others, though not ruined, are deserted. The silent streets and empty houses, and lonely, desolate palaces and temples of the latter, are even more painfully, more terribly impressive than the utter ruin of the former. The writer has seen in the province of Haurân alone nearly one hundred towns and large villages, most of which contain from fifty to five hundred houses each, perfect in every part as if only built yesterday, and yet there is not now, and history tells us there has not been for centuries, a single man to dwell in them. These houses are all of remote antiquity. Their walls, roofs, doors, and window-shutters are of stone, and so massive as almost to bid defiance to time. The names of a few of them are known in history—such as Phæno, Batanæa, Kenath, Salcah, Philippopolis, Beth-Gamul (Porter's *Damascus*, vol. ii.) In northern Syria there are also many deserted cities, some of which are in a wonderful state of preservation. In Jebel Simân, west of Aleppo; in Jebel-el-Ala, on the east bank of the Orontes; and again, around El-Bara, farther southward, these ancient deserted towns are found. (See Porter's *Handbook*, pp. 609, 617, sq.)

Some of the ruins of Syria, in their massive proportions and architectural splendour, rank among the finest in the world. Bâalbek may be said to stand unrivalled, its cyclopean foundations containing stones from 60 to 70 feet long, surmounted by temples finished in the highest style of Grecian art. Palmyra, though less colossal and less pure in style, is still more striking in the vast extent of its ruins. The long colonnades of Apamea, the great tunnels and docks of Seleucia, and the massive fortifications of Tyre and Aradus, cannot fail to excite wonder and admiration. There are, besides, in the ranges of Lebanon and Anti-Lebanon, upwards of fifty temples more or less dilapidated; and there are some huge castles, such as those of Banias, Esh-Shukîf, Hunîn, El-Husn, Aleppo, Damascus, Bozrah, and Salcah, which prove that the old Syrians were masters in the science of military architecture. Of the ancient great cities of Syria no less than nine are now completely desolate—namely, Apamea, Laodicea-ad-Libanum, Seleucia Pieria, Orthosia, Arca, Chalcis, Phaeno, Bozrah, and Salcah; eight have dwindled down to poor and miserable villages—namely, Heliopolis, Palmyra, Tyre, Aradus, Riblah, Gebal, Edrei, and Kenath; Antioch, the capital in the age of Roman splendour; Sydon, the ancient capital of Phœnicia; and Hamath, one of the primeval strongholds of the Canaanites, are now small decaying towns; while Damascus alone, the oldest city of Syria, of the world, still retains its ancient prosperity.

History.

The earliest notices of Syrian history are found in the Bible, which is at once the most ancient and the most authentic of all histories. In the 10th chapter of Genesis there is a brief record of the colonization of the nations of the world by the descendants of Noah. From this it appears that Syria, by the nature of its first settlement, was divided into two sections, which remained distinct for nearly 2000 years. The first section, embracing the whole eastern division of the country, was peopled by the family of Aram, Damascus being the metropolis, and probably the nucleus of the colony. The second, or western division, was colonized by the sons of Canaan—Sidon, Arka, and Arvad—who settled on the coast and in the ridge of Lebanon; and Hamath, who penetrated farther eastward than his brethren. The next event in the history of Syria was the advent of Abraham. A very early tradition represents him as settling for a time at Damascus; and it is corroborated by two facts,—his steward was a native of that city, and not far from Damascus there is still a sacred spot called by the name of the Patriarch. For a period of nearly nine centuries we have no records of Syrian history. In the time of King David (B.C. 1040), Syria is represented as consisting of a number of independent kingdoms, as Zobah, Damascus, Maachah, and Geshur. Against these the Jewish monarch waged war, and, being successful, placed garrisons in their principal cities. After the death of David, Syria regained its independence. Now, however, the kingdom of Damascus attained to such power as to be the recognized head of Syria. Under the warlike dynasty of the Hadads it became the most influential kingdom in Western Asia; and by frequent incursions into the territories of Israel and Judah, and by the pillage of many of its cities and villages, it terribly revenged the victories of David. The watchful care and prophetic power of Elisha saved Israel for a time from the fury of its foe, and brought upon the armies of Benhadad unexpected calamities. About B.C. 892 Damascus was honoured by a visit from the prophet. Benhadad was then sick, and his sufferings not only made him overlook his old enmity to Elisha, but constrained him to consult him as to his recovery. The man who was sent on this errand was Hazael, whose guilty designs the prophet detected and exposed. His reply and subsequent conduct were thoroughly characteristic of the wily and cruel eastern, "Is thy servant a dog that he should do this thing?" he exclaimed; and then turning away, he hastened to Damascus and murdered his master! Thus terminated the dynasty of Hadad, after a rule of more than 160 years. Hazael succeeded to the throne, and proved both a wise monarch and able general. Under him the armies of Syria were victorious to the borders of Egypt. His successors did not inherit his genius, and the power of Syria began to decline. About B.C. 750 Rezin, the last independent ruler of Syria, entered into an alliance with the king of Israel, and waged war against Judah. The latter, in its difficulties, sought aid from the powerful monarch of Assyria, Tiglath-Pileser, who was not slow to give it. He marched at once across the desert, overran Syria, took Damascus, and carried the inhabitants captive to the banks of the Kir. (2 Kings xvi.; Joseph. *Antiq.* ix. 12; Amos i. 4.)

Syria now became a mere dependency of a more powerful empire, and was ruled by foreign satraps. It remained a province of Assyria until, during the struggles of the eastern monarchs, it was seized by Pharaoh-Necho, king of Egypt. A few years afterwards it was captured by Nebuchadnezzar (B.C. 604), and for a period of three centuries continued subject to the Babylonian and Persian administrations.

Immediately after the great battle of Issus (B.C. 333), Syria passed into the hands of a different dynasty and a different race. Alexander the Great became its ruler. He assigned it to the general Laomedon, and Damascus became the seat of his short sway. After the death of Alexander, and the brief but fierce struggle of his lieutenants over the fragments of his gigantic empire, the fortunes of war threw Syria into the power of Seleucus Nicator, the founder of the dynasty of the *Seleucidæ*. This prince built Antioch, and made it the seat of his government. He and his successors on the throne may justly be termed a race of architects. They not only adorned their capital with structures which rivalled in splendour the noblest monuments of Greece; but they founded many other great cities in various parts of the country. Though almost constantly at war, their kingdom was for nearly 200 years one of the most prosperous in the world. From the commencement of the reign of the Seleucidæ, till the year B.C. 114, Antioch remained undisputed capital. At this time the kingdom was rent by the intrigues of Ptolemy Physcon; and Antiochus Cyzicenus, brother of the reigning monarch, established a new sovereignty at Damascus. Just half a century later the Roman army under Pompey overran Syria, abolished the dynasty of the Seleucidæ, and established their head-quarters at Damascus. Syria was immediately annexed to the Roman empire, and placed under the command of Scaurus, Pompey's lieutenant. For many years

after the conquest, the country was the scene of devastating wars, arising partly from the feuds of petty princes, and partly from the rivalries of Roman governors. After the triumph of Augustus, Mesalla Corvinus was appointed prefect, and henceforth the seat of government was fixed at Antioch.

In the year A.D. 105, Cornelius Palma, the governor of Syria under the emperor Trajan, conquered the region east of the Jordan, and the neighbouring kingdom of Aretas. From this time the various provinces of Syria began to recruit under the secure and paternal government of Rome. Temples, theatres, palaces, and public monuments of great extent and splendour, were erected not only in the chief cities, but in every little provincial town; and their remains even yet, after long centuries of desolation, bear ample testimony to the genius, the wealth, and the taste of the old Syrians. Roads also were constructed, bridges were built, and costly harbours formed. The country remained under Roman and Byzantine rule till A.D. 634. The only circumstances that occurred previous to that period, and which are deserving of notice in a brief sketch like the present, are the establishment of Christianity under the first Constantine, and the conquests of the Persians early in the seventh century. Christianity had spread widely over the land before its establishment as the religion of the empire; and the numbers, the wealth, and the taste of the Christians subsequent to that period may still, to some extent, be estimated by the splendid ruins of sacred edifices in the cities, towns, and villages of Syria.

The Arabs, under the generals Khaled and Abu Obeidah, first invaded Syria in A.D. 633; and only five years afterwards the whole country was conquered, and every city in it garrisoned by their troops. In sixteen years more Damascus became the capital of the vast Mohammedan empire. Syria was then densely populated. Her cities scarcely yielded to any in the world in extent, wealth, and architectural magnificence; but under the withering influence of Islamism their grandeur faded, and their wealth was consumed.

In A.D. 750 the dynasty of the Abassides was founded, and the khalifite was removed from Damascus, first to Cufa and then to Baghdad. Henceforth Syria was a province of the Mohammedan empire. From this period till the middle of the tenth century it was subject to the Khalifs of Baghdad, but it then fell into the hands of the Fatimite dynasty of Egypt. Towards the close of the following century the country was invaded by the Seljukian Turks, and formed into a division of their empire. The cruelties perpetrated by these fanatics on the poor Christian pilgrims that thronged yearly to Jerusalem roused the spirit of western Europe, and excited Christian nations to the first Crusade. In a short time the knights of France and England, headed by Godfrey, were winding through the valleys and marching over the plains of Syria. The fierce, undisciplined followers of the false prophet could not withstand their steady valour. The country was subdued, Jerusalem was taken by storm, and the cruelties perpetrated on Christian pilgrims were fearfully avenged.

Godfrey was elected first Christian king of Jerusalem. Bohemund reigned at Antioch; Baldwin, Godfrey's brother, at Edessa; and the Count of Toulouse at Tripolis. Thus was the country divided into Christian principalities, and ruled by the bravest knights of western Europe. Damascus, however, withstood every assault of the Crusaders; and it is still the boast of the proud Muslem, that its sacred precincts have never been polluted by the feet of an infidel since the dav the soldiers of Mohammed first entered it.

About the middle of the twelfth century Nur-ed-Dîn, a Tartar chief, seized Damascus and some neighbouring cities. He ruled his acquired territory with justice and vigour. At the request of the Fatimite Khalif, he attacked and defeated the Crusaders on the borders of Egypt. His successor, Saladin, was by far the most formidable opponent the Crusaders ever encountered. After gaining a decisive victory over their united forces at Hattîn, near Tiberias, he captured Jerusalem (A.D. 1187), and drove the Franks out of almost every town and fortress of Palestine. Soon afterwards Syria was invaded by the shepherd-soldiers of Tartary, under Holagou, the grandson of Gengis Khan. But, after the death of this chief, Bibars, better known in Arabian history as Melek-edh-Dhaher, brought Syria under the rule of Egypt, and pursued the Tartars beyond the Euphrates. His victories were fatal to the declining power of the Crusaders. Their remaining history is one continued tale of misfortunes. At length, in A.D. 1291, Acre was taken, and the Christian knights driven from the shores of Syria.

For more than two centuries after this period the country was the theatre of fierce contests between the hordes of Tartary and the Mamluke rulers of Egypt. Timur, or Tamerlane, invaded Syria in A.D. 1401, and committed the most fearful ravages. Antioch, Emesa, Bâalbek, and Damascus were reduced to ashes, and their unfortunate inhabitants either murdered or sold into slavery.

In the year 1517 Syria was conquered by the Sultan Selim I., and from that time till the present day it has formed part of the Ottoman empire. During this period, though the country has been visited by few striking vicissitudes, it has steadily declined in power, wealth, and population. The greater part of the inhabitants, oppressed by foreign rulers who take no interest in commerce or agriculture, have sunk into helpless and almost hopeless slavery. What little energy and spirit remain are exhausted in private quarrels and party feuds, which are sedulously fostered by their unprincipled rulers. In 1832 Ibrahim Pasha conquered Syria for his father, Mohammed Aly. The iron rule of that wonderful man did much to break down the fanaticism which for ages has been a curse to the people. He promoted industry, he suppressed the robber bands which infested the leading roads, and he drove the Arab tribes from the eastern borders to the interior of their native deserts, and even there he taught them to fear and obey him. Though the whole population groaned under his yoke, yet it may be truly said that he was the only real ruler Syria had for centuries. In the year 1841, through the armed intervention of England, the country was restored to the Porte.

The long history of Syria may thus be divided into six periods; and it is remarkable that, during each period, a distinct section of the human family has had rule over it. During the first period, of about 1450 years, it was independent under its native princes. During the second period, of 417 years, the Babylonian and Persian monarchs held it. During the third period of 268 years, it was subject to the Greek dynasty of the Seleucidæ. During the fourth period, of 699 years, the Romans possessed it. During the fifth period, of 441 years, it was desolated rather than governed by the Saracens or Arabs. It then fell into the hands of the Tartar or Turkish tribes, who still retain it. But their power is rapidly declining. The throne founded by Othman is tottering to its fall; and the sixth period of Syrian history is fast drawing to a close. (J. L. P.)

SYSTYLE. See ARCHITECTURE, *Glossary* to.

SYZRAN, a town of European Russia, government and 78 miles S. of Simbirsk, on a hill at the confluence of the Syzran with the Volga. It is meanly built, and has unpaved streets. There are here ten churches, two of which are of wood; a monastery; an important cattle market; manufactories of soap and leather, and an active trade. Pop. 15,400.

SYZYGY. See ASTRONOMY.

SZALONTA, a market-town of Hungary, in the county of South Bihar, 50 miles S.S.W. of Margitta. It contains a church; and has an active trade in cattle and swine. Pop. 9500.

SZARRAS, a market-town of Hungary, in the county of Bekes, 13 miles N.N.W. of Gyulla, in a plain near the river Körös. It has two churches; a Protestant gymnasium, and a trade in corn and cattle. Pop. 17,000.

SZASZ REGEN, or SAXON REEN, a market-town of the Austrian empire, Transylvania, on the Maros, in the circle and 25 miles S. of Bistritz. Weaving, tanning, and coopering are carried on here; as well as a considerable trade in planks, shingles, and onions. In the vicinity stands the fine ducal palace of Gernyeszeg. Pop. 4140.

SZATHMAR, or SZATHMAR-NEMETI, a free town of Hungary, capital of a county of the same name, on the Samos, 69 miles E.N.E. of Grosswardein, and about 60 E. of Pesth. It consists properly of two towns, Szamos and Nemeti, on opposite sides of the river, but united under the same municipal government. It is for the most part ill built; but contains a number of public buildings. It is the seat of a bishop; has Protestant and Roman Catholics churches; an Episcopal lyceum; theological seminary; Catholic and Protestant gymnasiums, and other schools. Linen cloth, earthenware, and plum brandy are made here; wine and fruit are raised in the vicinity. Pop. 10,552.

SZEGEDIN, a town of the Austrian empire, Hungary, capital of the county of Csongrad, on the right bank of the Theiss, 60 miles W. of Arad, and 89 S.S.E. of Pesth. The river is here crossed by a bridge of boats, leading to the suburb of New Szegedin on the other side. The town is defended by an old fortress, built by the Turks in the beginning of the sixteenth century, containing barracks and a house of correction. There are also six Roman Catholic churches, one of them a fine Gothic building; a handsome Greek church; a Piarist college, with a gymnasium; a school of industry and trade; and a Hungarian national theatre. Cloth, tobacco, soda, and soap are made here; and vessels for the navigation of the Theiss are built. An important trade is carried on; and annual cattle fairs are held. Pop. 50,244.

SZENTA, or ZENTA, a town of Hungary, in the county of Zombor, on the right bank of the Theiss, 10 miles S. of Kis-Kamsa, and 42 E.N.E. of Zombor. It contains two churches; has an important fishery in the river; and an extensive trade in cattle. Szenta is historically memorable for a victory gained over the Turks here by Prince Eugene, September 11, 1696, the anniversary of which is still celebrated here. Pop. 14,985.

SZENTES, a market-town of Hungary, in the county of Csongrad, on the Kurcza, 29 miles N.N.E. of Szegedin. It is well built; and has a town-house, five churches of different sects, a Latin school, and a trade in corn, wine, timber, and cattle. Pop. 22,150.

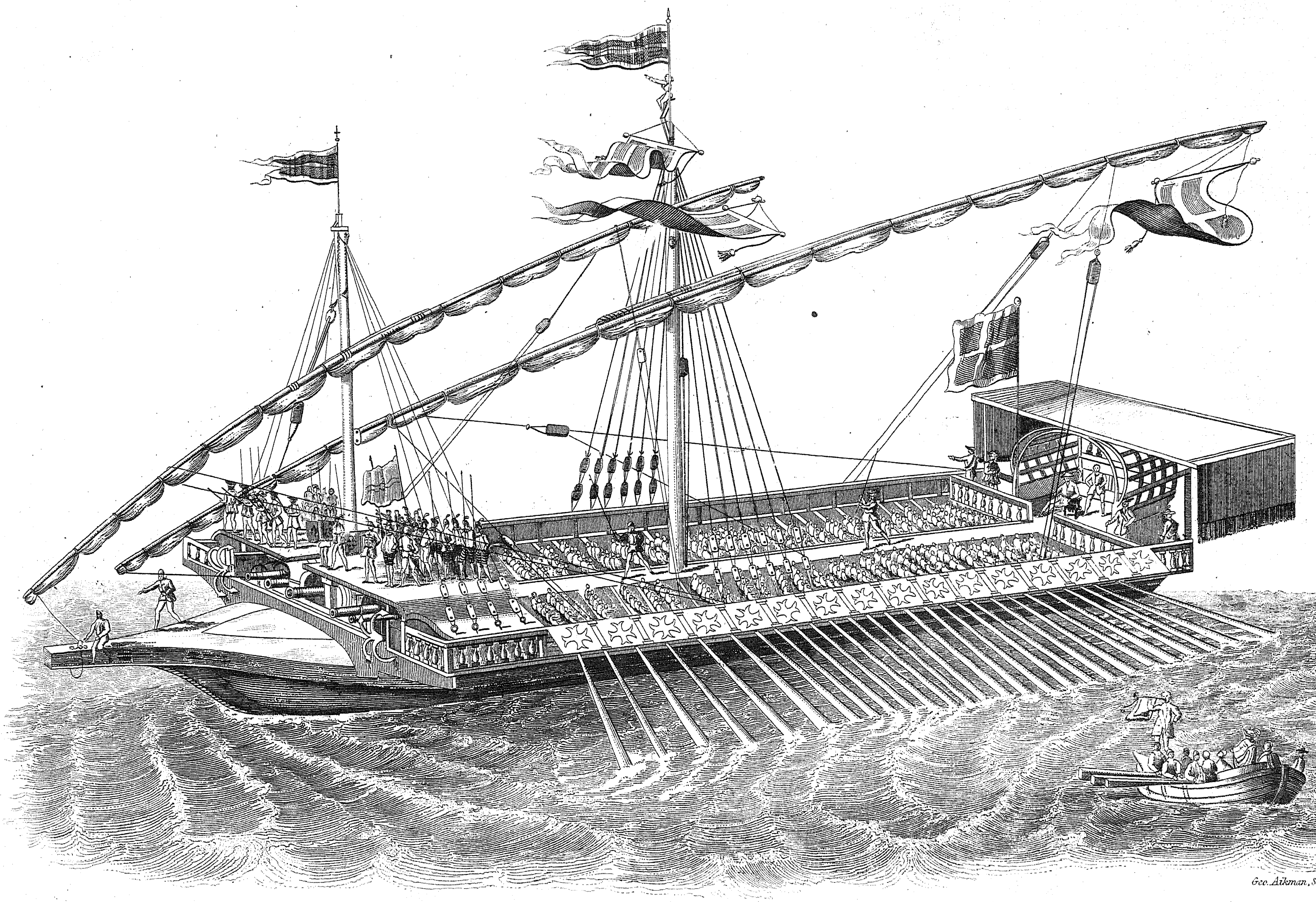
SZEXARD, or SZEGSZARD, a market-town of Hungary, capital of the county of Tolna, on the Sarvitz, not far from the Danube, 81 miles S.W. of Pesth. It is defended by dykes from the inundations of the Danube, and is generally well-built, having Protestant and Roman Catholic churches, a high school, a large silk mill, and a considerable trade, especially in wine. Pop. 10,500.

SZIGETH, a market-town of Hungary, capital of the county of Marmaros, on the Theiss, 221 miles E.N.E. of Pesth. It has Protestant and Roman Catholic churches; two gymnasiums, and a Piarist college, large salt-works, and a trade in salt. Pop. 6300.

SZOLNOK, a market-town of Hungary, capital of a county of the same, on the Theiss, at its confluence with the Zagyra, in the midst of marshes, 29 miles S. by W. of Heves, and 49 S.E. of Pesth. It has the remains of an old cathedral; a church; an old Turkish mosque, now a chapel; a gymnasium; court of law; and extensive salt-works. There is an active trade in salt, timber, fruit, and fish. Pop. 10,617.

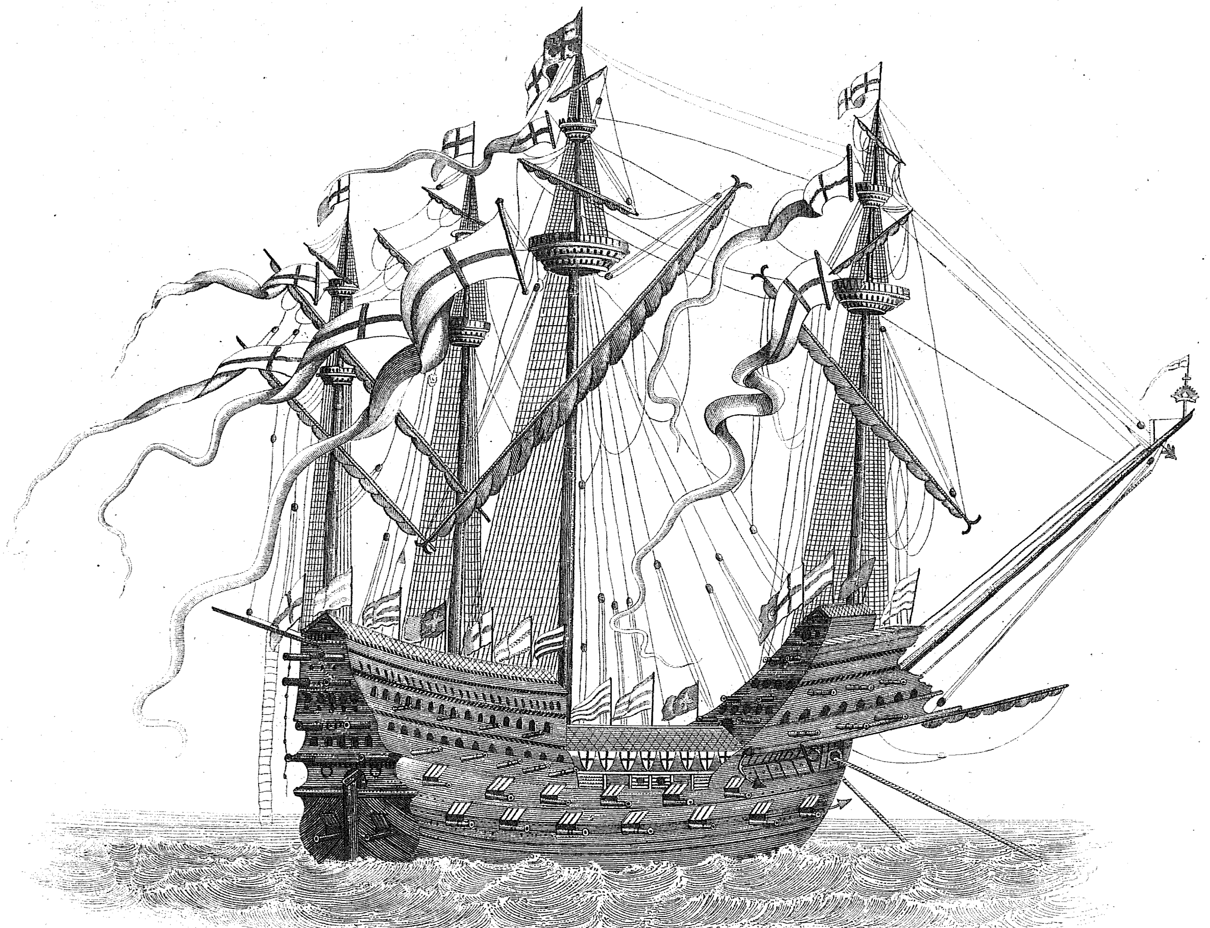
END OF VOLUME TWENTIETH.

PRINTED BY NEILL AND CO., OLD FISHMARKET, EDINBURGH.

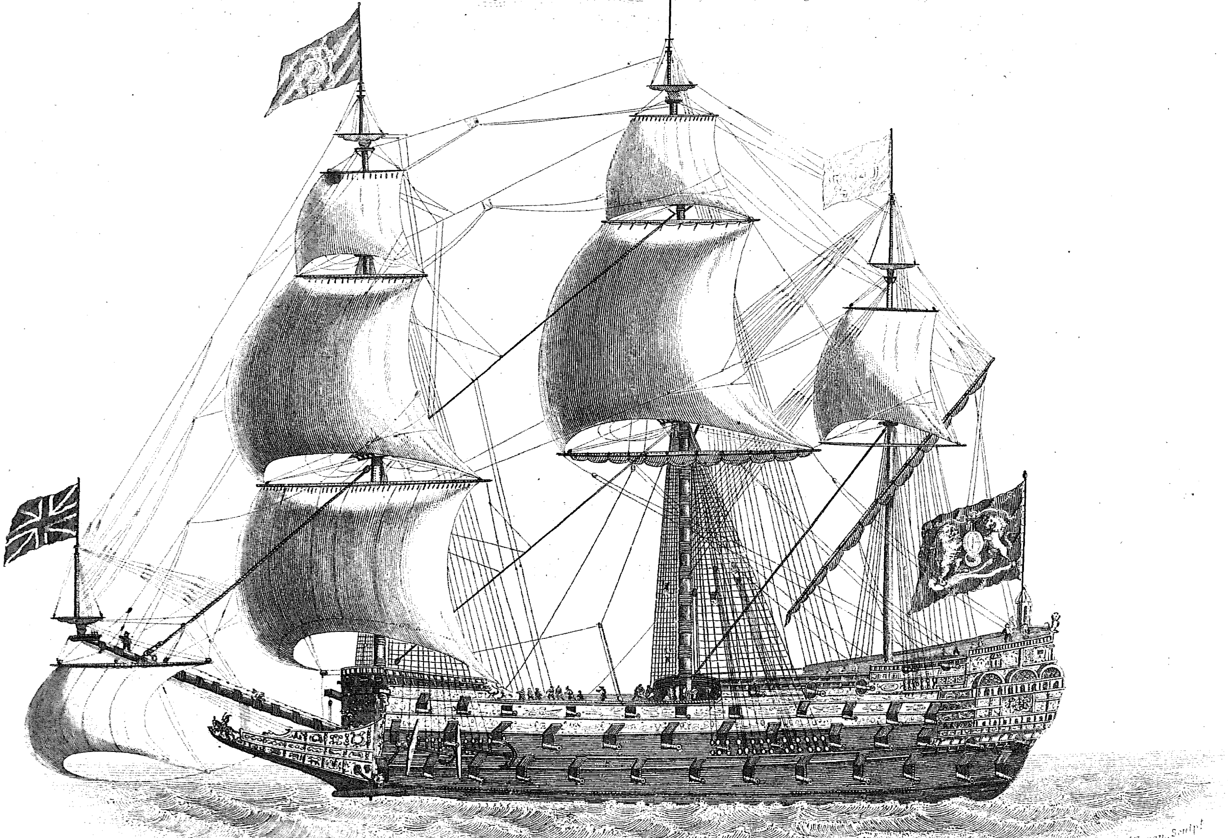


Geo. Aikman, Sculpt.

Galley of the Seventeenth Century, from Van Yk.



The Henri Grace à Dieu, built in the reign of Henry 7th from a drawing in the Pepysian Collection.



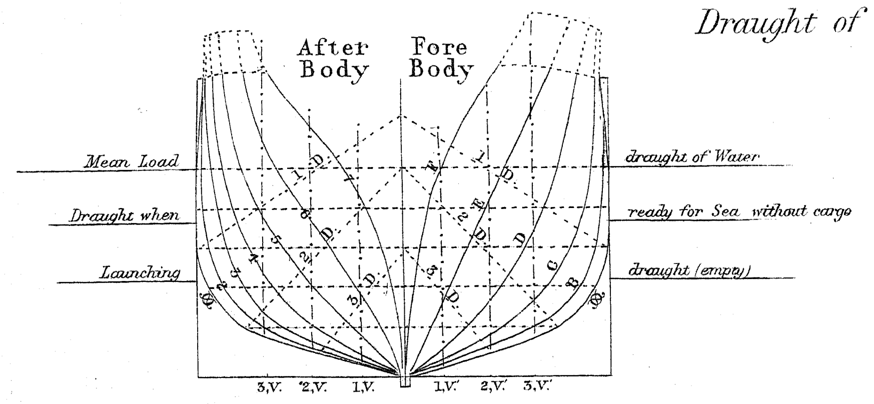
Geo. Aikman, Sculpt.

The Sovereign of the Seas, built 1637. From a Painting by Vandevelde.

Published by A. & C. Black, Edinburgh.

SHIP BUILDING.

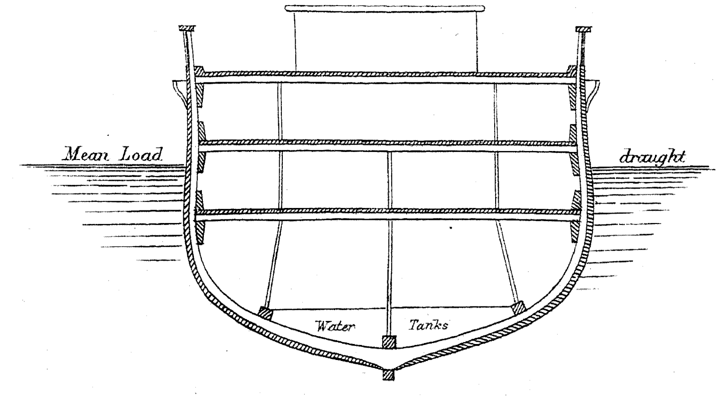
Draught of the Wooden CLIPPER SHIP "SCHOMBERG", Built by Mess.rs A. Hall & Co. of Aberdeen.



BODY PLAN

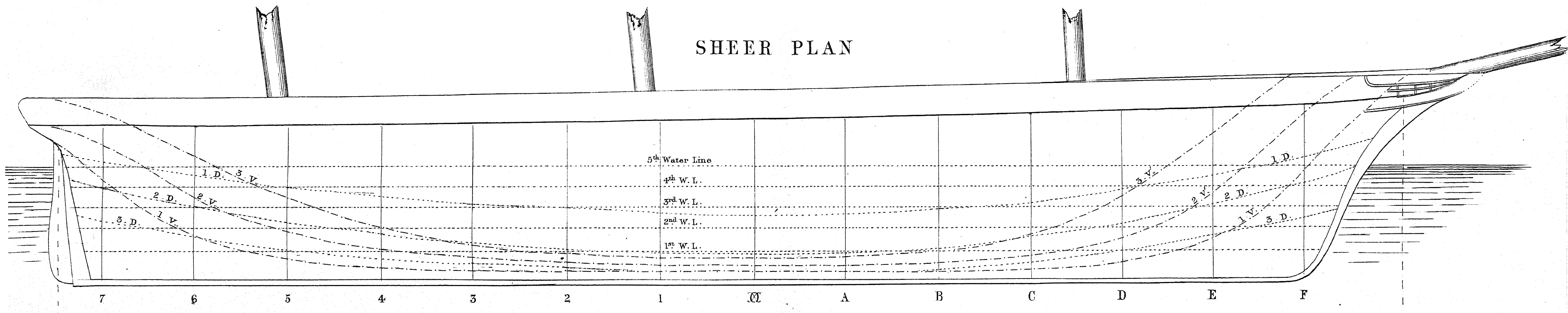
Principal Dimensions.

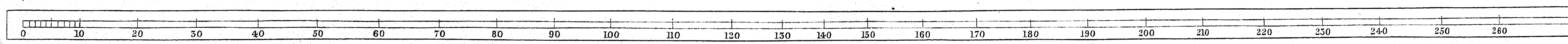
	Feet	In.s
Length between the Perpendiculars	262	6
Length of Keel	245	"
Breadth Extreme	45	"
Breadth of Frame	42	"
Depth of Hold	29	9
Burthen in Tons, Builder's Old Measurement, 2600 Tons		



MIDSHIP SECTION

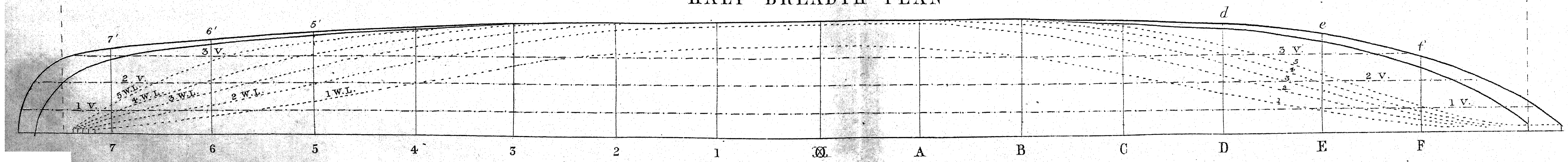
SHEER PLAN





Scale of Feet

HALF BREADTH PLAN



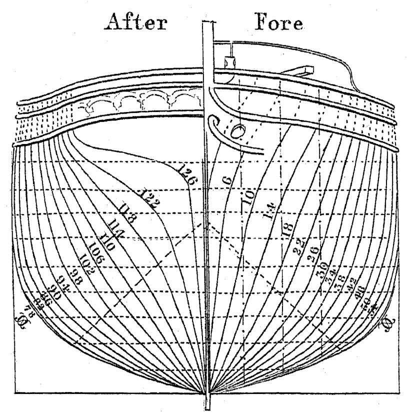
Published by A. & C. Black, Edinburgh.

G. Aikman sc. Edin.

SHIP BUILDING.

DRAUGHT OF THE IRON CLIPPER SAILING-SHIP "LORD OF THE ISLES."

BODY PLAN

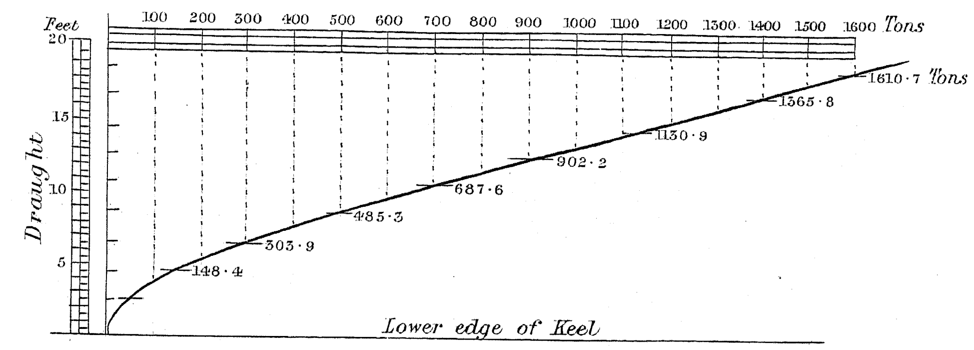


Dimensions

	Ft.	In.
Length between Perpendiculars	185	0
Breadth extreme	29	0
Depth in Hold	18	0

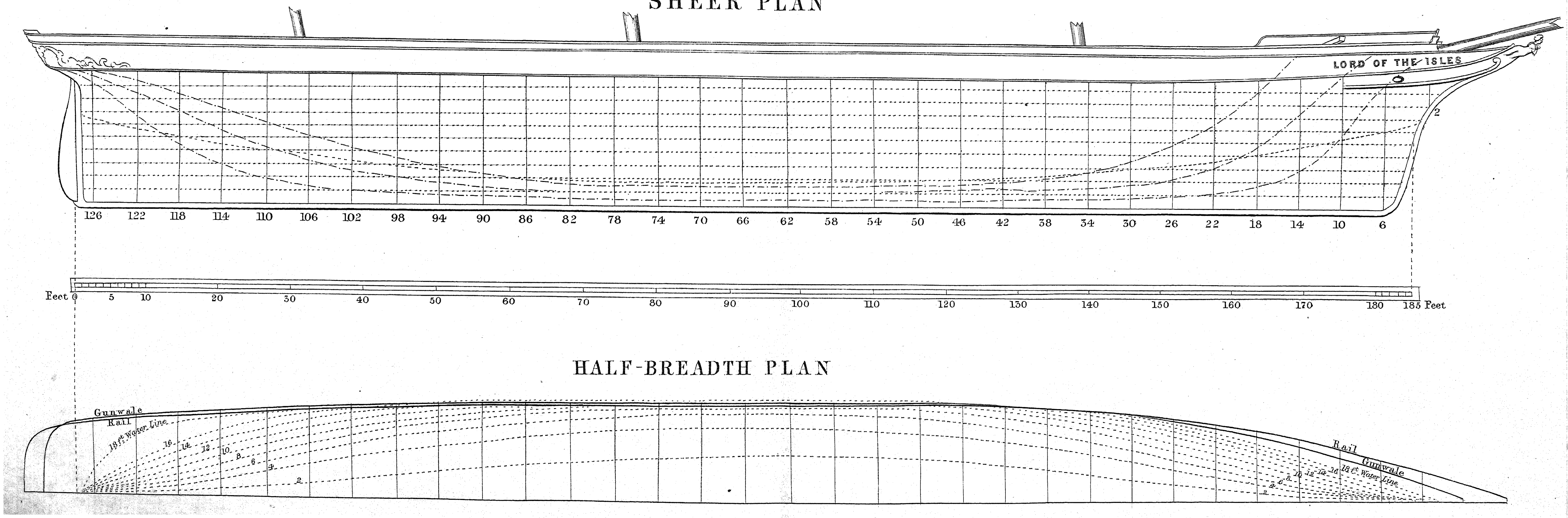
Builders, Scott & Co., Greenock.

Displacement



SHEER PLAN

HALF-BREADTH PLAN



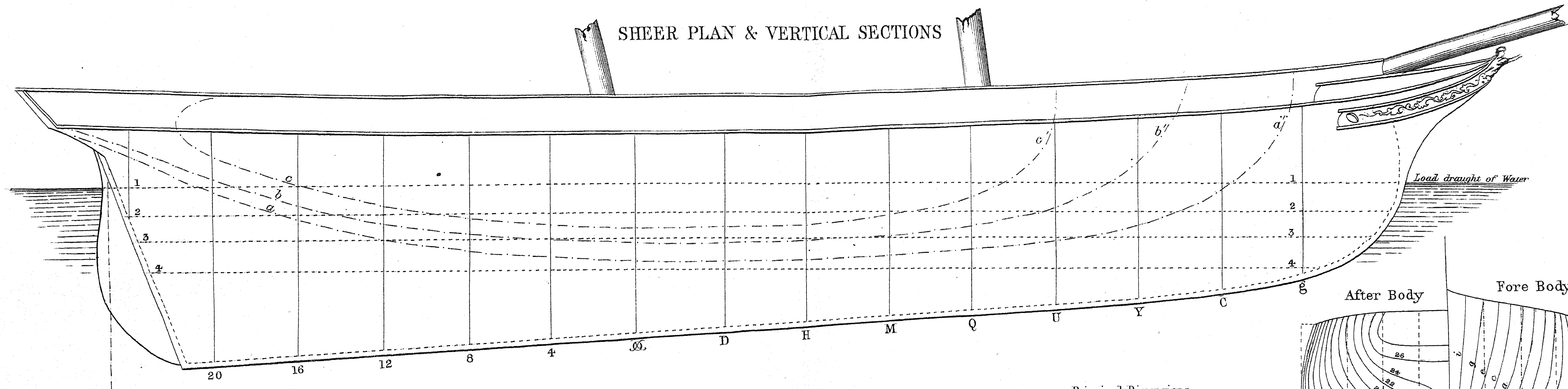
Published by A. & C. Black, Edinburgh.

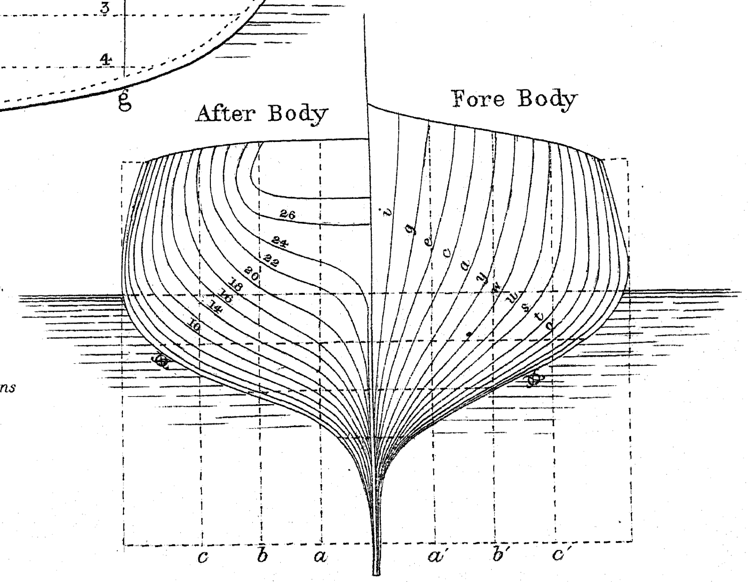
SHIP BUILDING.

THE ENGLISH SAILING-YACHT "TITANIA"

By J. Scott Russell F.R.S.

SHEER PLAN & VERTICAL SECTIONS

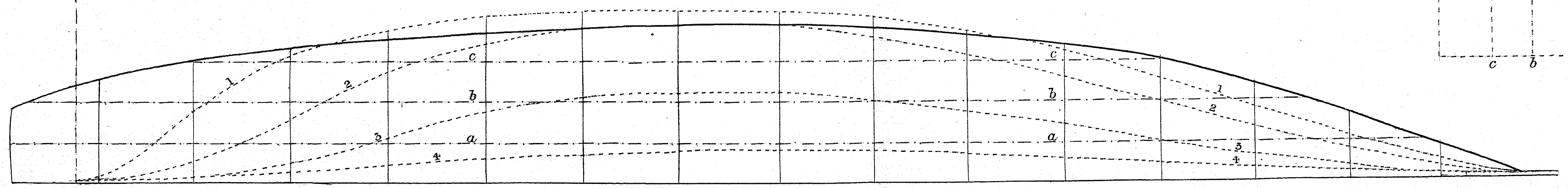




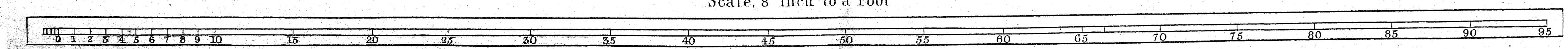
Principal Dimensions

	Ft.	In.
Length on the Load water line	93	0
Breadth extreme	21	6
Depth at the side	13	0
Tonnage, Builder's Old Measurement 184 Tons		

PLAN OF HORIZONTAL WATER LINES



Scale, $\frac{1}{8}$ Inch to a Foot

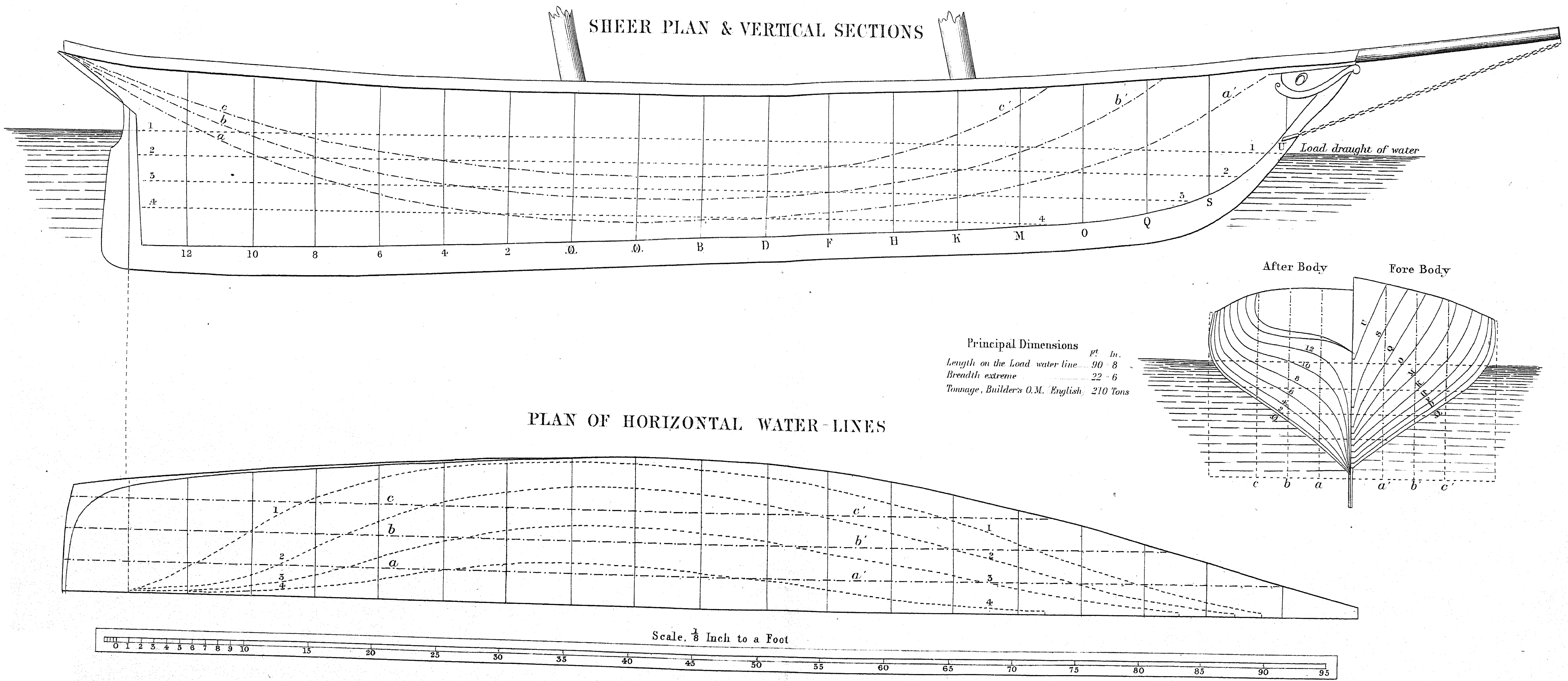


G. Aikman sc. Ed.

Published by A. & C. Black, Edinburgh.

SHIP BUILDING.

THE AMERICAN SAILING-YACHT "AMERICA"



Published by A. & C. Black, Edinburgh.

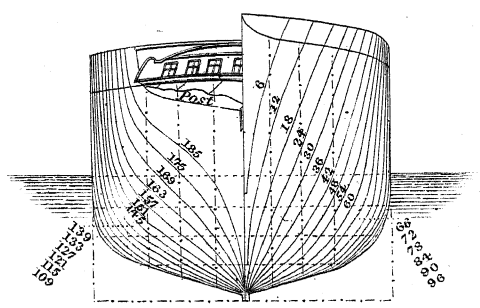
G. Aikman sc. Edin.

SHIP BUILDING

DRAUGHT OF THE PADDLE WHEEL STEAM SHIP "DELTA"

Belonging to the Pen. & Oriental Steam Nav. C°.

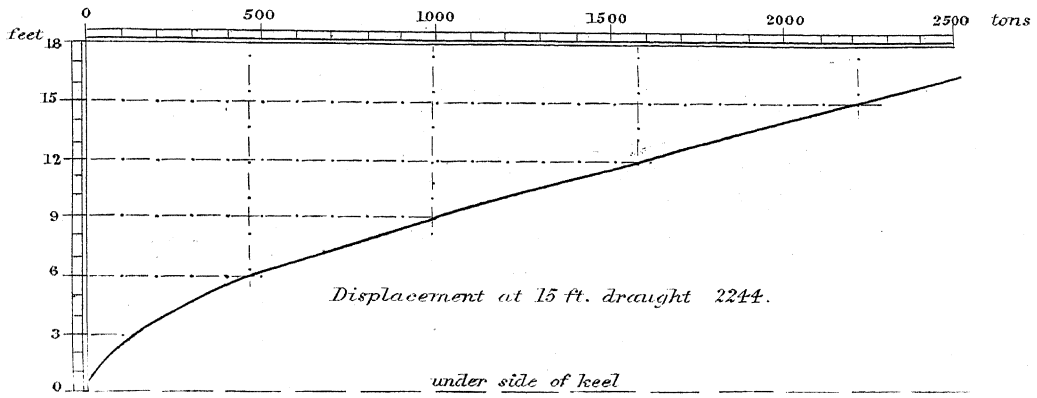
BODY PLAN.



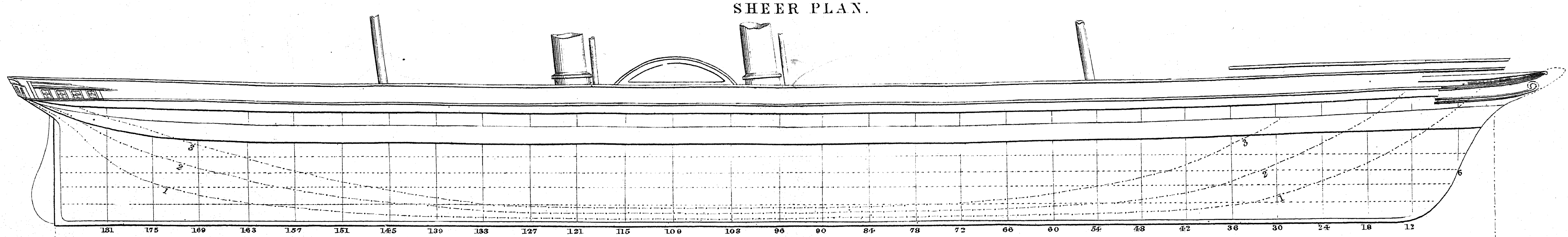
Principal Dimensions

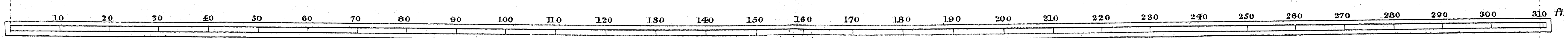
	Ft. In.
Length between Perpendiculars	310. 0.
Do of keel for Tonnage	288. 10½
Breadth for Tonnage	35. 3.
Depth in Midships (from top of keel)	24. 6.
Burthen in tons N°. 1909 $\frac{11}{94}$	
Horses power (nominal) 400.	
Builders of the Ship Thames Iron Ship Building C°.	
Makers of the Machinery J. Penn & Son.	

Scale of Displacement

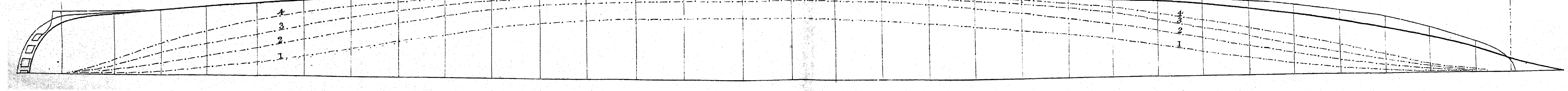


SHEER PLAN.





HALF BREADTH PLAN.



Published by A. & C. Black, Edinburgh.

G. Aikman Sc. Edin.

SHIP BUILDING.

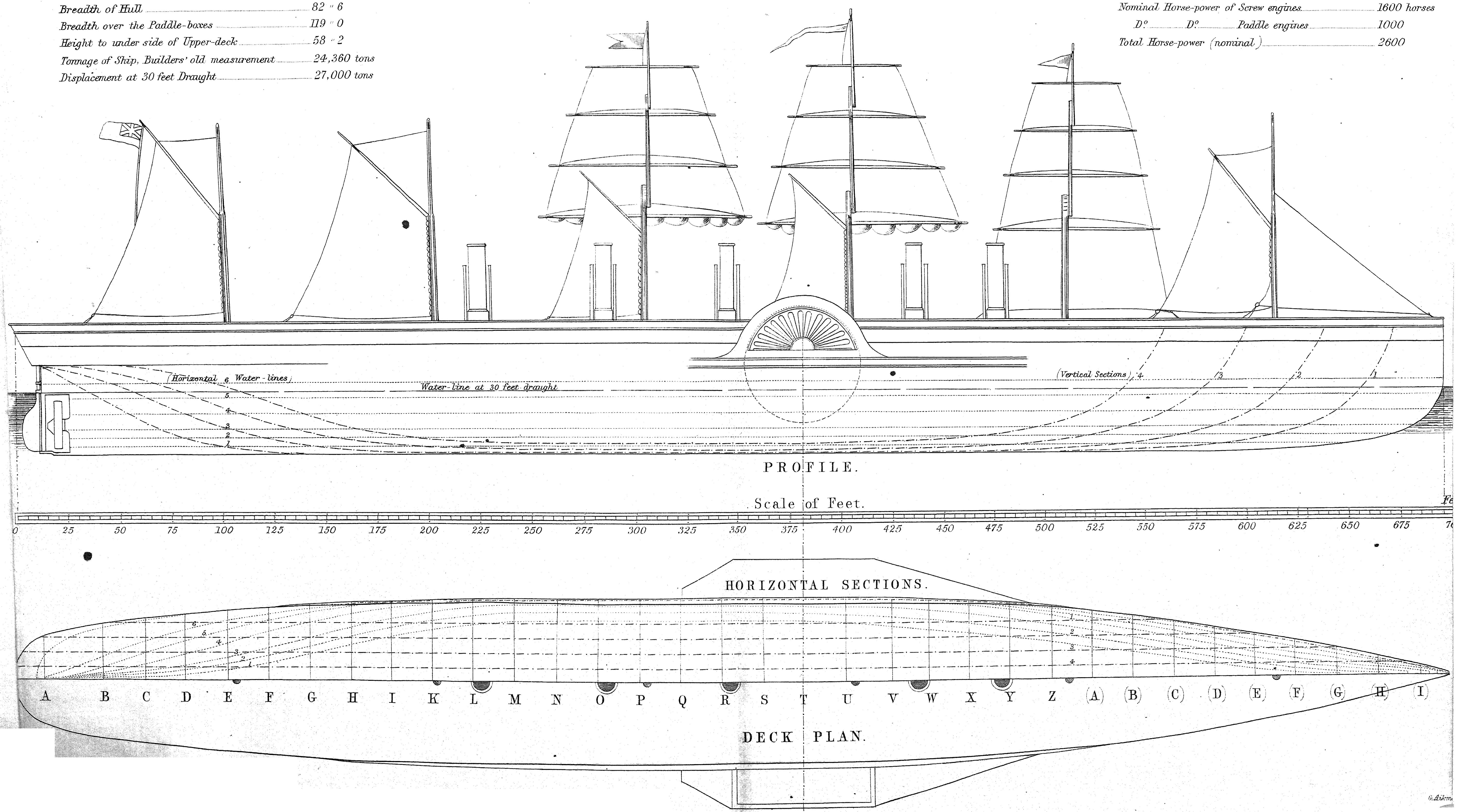
"GREAT EASTERN" STEAM SHIP.

Dimensions of the Hull.

	ft. in.
Length from centre of rudder-post to stem	680 " 0
Length on the Upper-deck	692 " 0
Breadth of Hull	82 " 6
Breadth over the Paddle-boxes	119 " 0
Height to under side of Upper-deck	58 " 2
Tonnage of Ship, Builders' old measurement	24,360 tons
Displacement at 30 feet Draught	27,000 tons

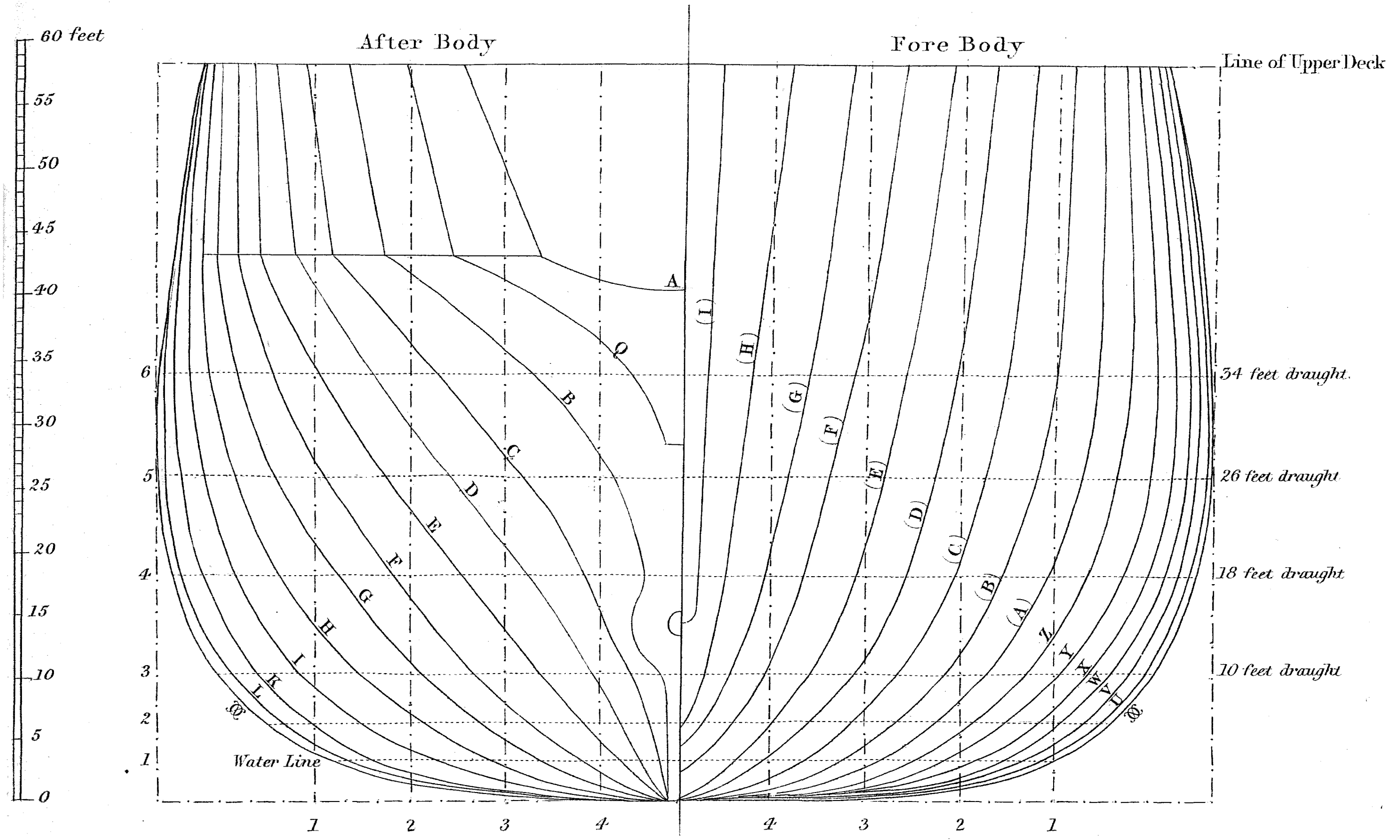
Dimensions of the Machinery.

	ft. in.
Diameter of the Screw-propeller	24 " 0
Diameter of Paddle-wheels to outside of iron	56 " 10
Nominal Horse-power of Screw engines	1600 horses
D° D° Paddle engines	1000
Total Horse-power (nominal)	2600



Published by A. & C. Black, Edinburgh.

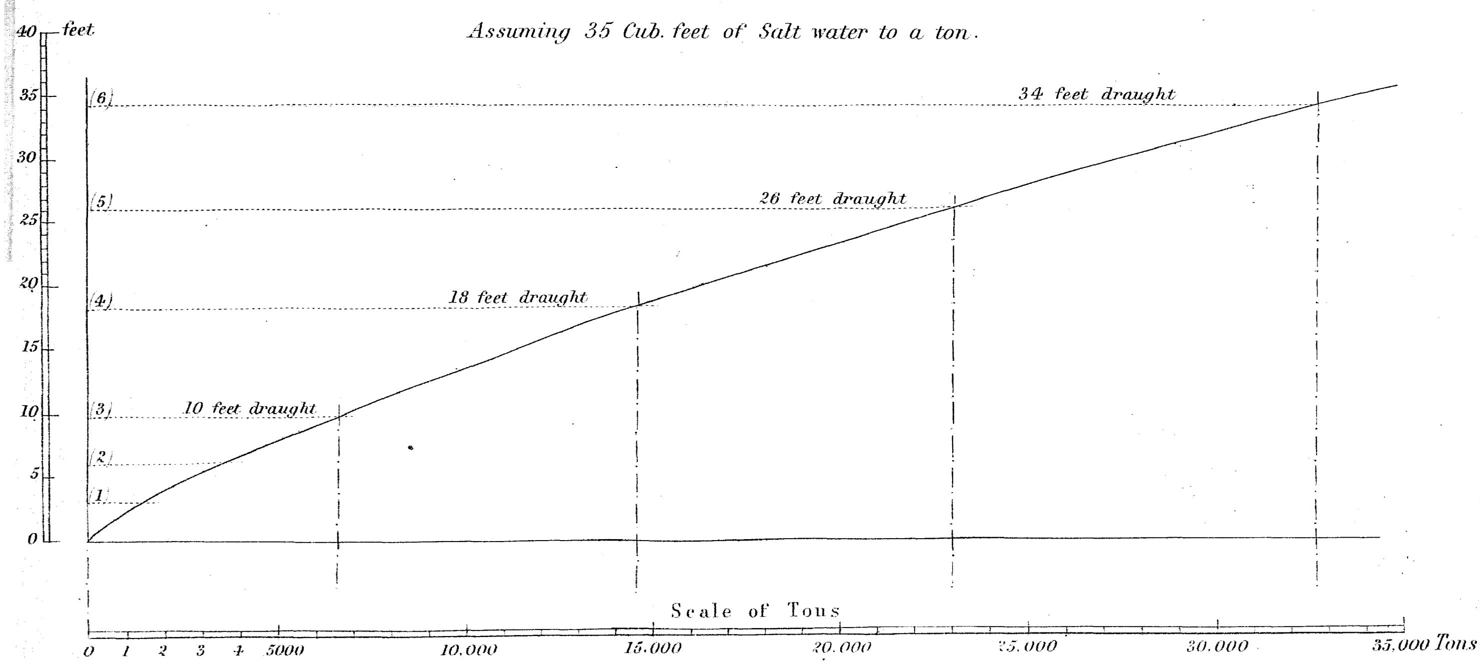
"GREAT EASTERN" STEAM SHIP.



VERTICAL SECTIONS.

SCALE OF DISPLACEMENT,

Assuming 35 Cub. feet of Salt water to a ton.



Published by A. & C. Black, Edinburgh.

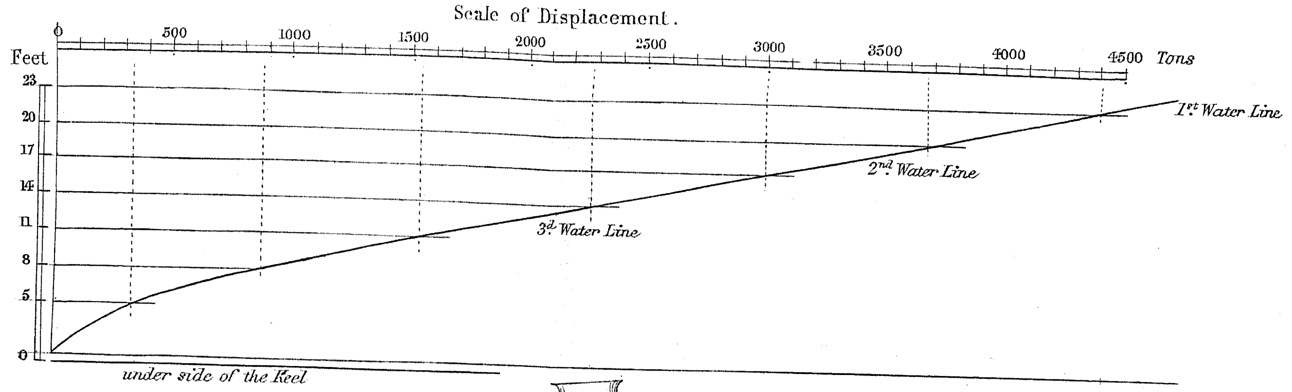
SHIP BUILDING.

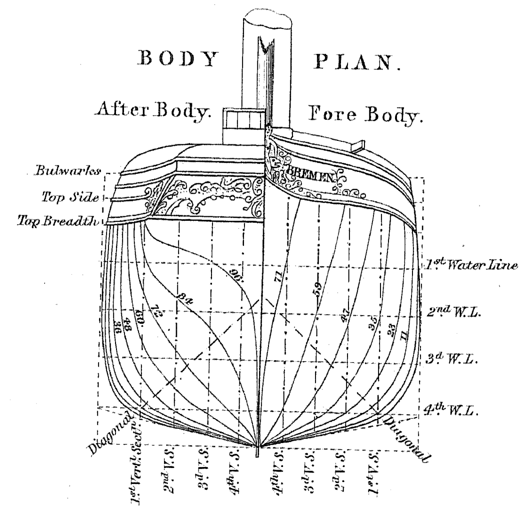
DRAUGHT OF THE SCREW STEAM SHIPS "BREMEN" AND "NEW YORK."

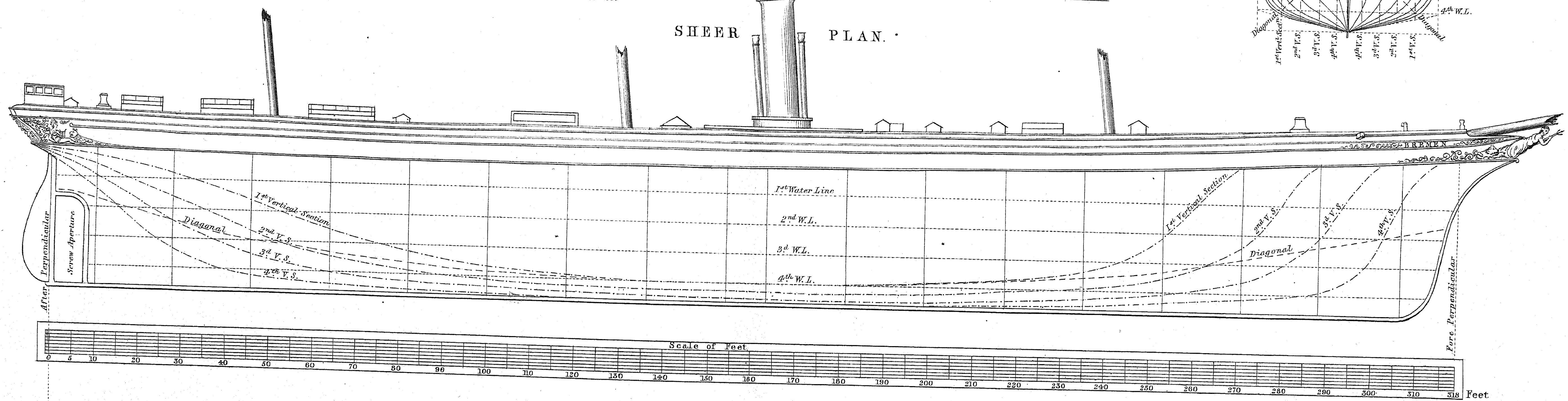
Dimensions.

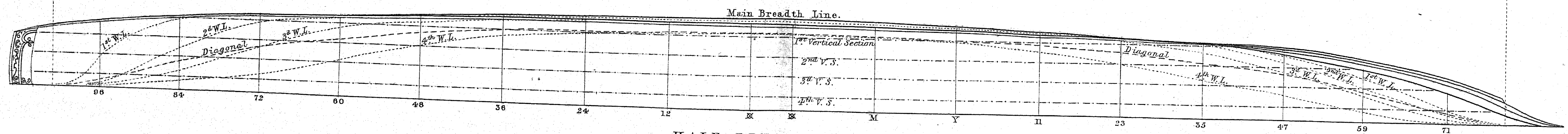
	Ft. in.
Length of Keel and Fore-rake	318 · 0
Breadth of Beam (Extreme)	40 · 0
Depth of Hold to Spar-deck	26 · 0
Tonnage, Builders' old measurement	2500 Tons
Horses' Power, nominal	700 Horses

Builders of Ship and Machinery, Messrs. Caird & Co. of Greenock.









HALF BREADTH PLAN.

Published by A. & C. Black, Edinburgh.

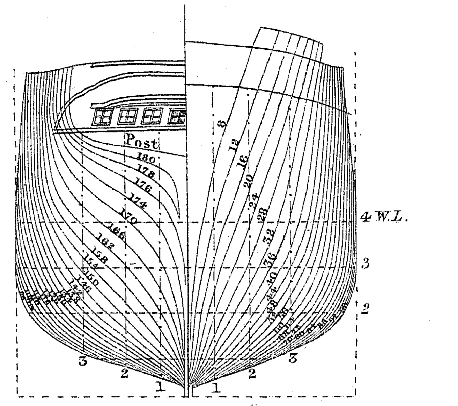
G. Aikman Sc.

SHIP BUILDING.

DRAUGHT OF THE SCREW STEAM SHIP "PERA."

Belonging to the Pen. & Oriental Steam Nav. C^o

BODY PLAN



Principal Dimensions.

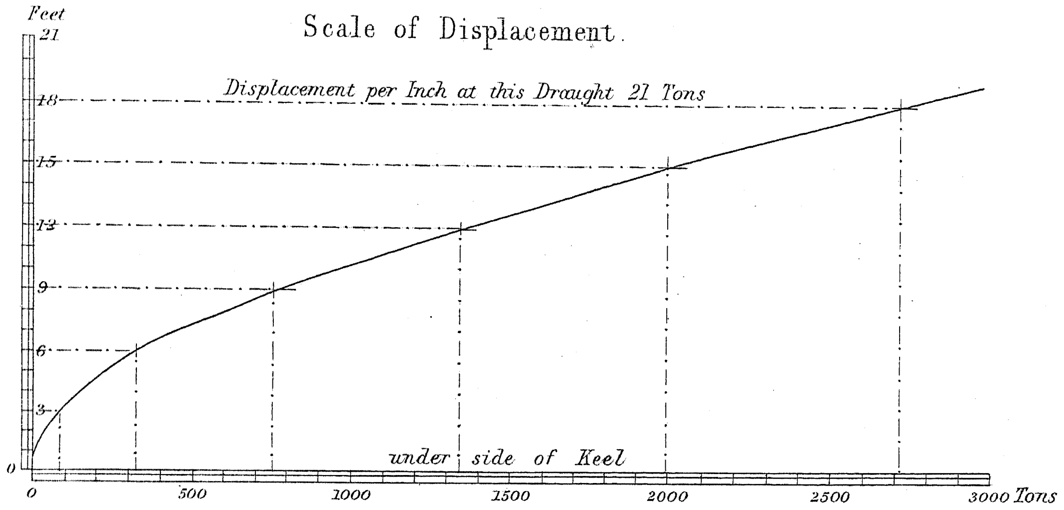
	Feet	In.s
Length between Perpendiculars	303	8
D^o of Keel for Tonnage	278	$4\frac{3}{4}$
Breadth for Tonnage	42	1
Depth in Midships (from top of Keel)	29	$2\frac{1}{2}$

Burthen in Tons N^os $2622\frac{66}{94}$ *O.M.*

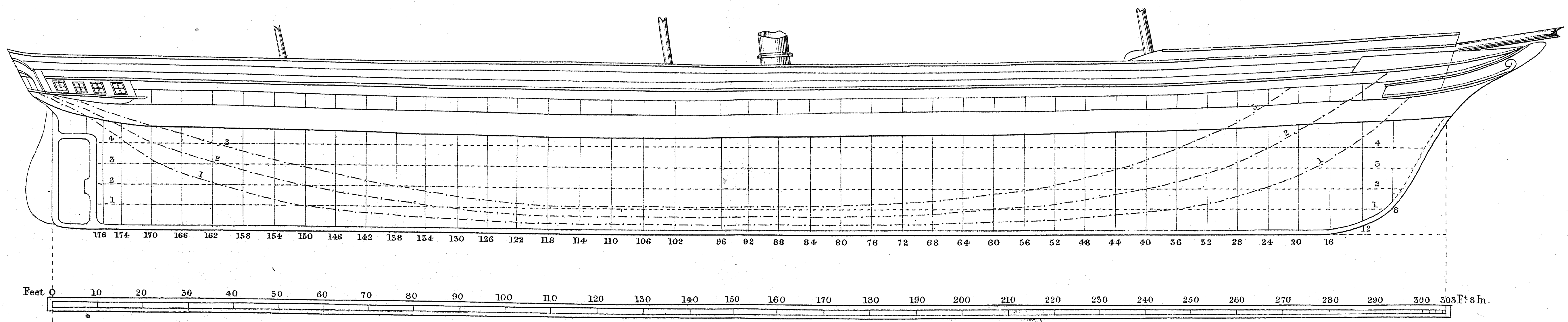
Builders of the Ship, Mare & C^o

Makers of the Machinery, G. & J. Rennie.

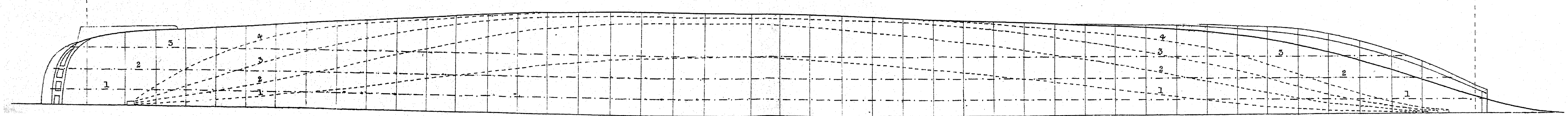
Scale of Displacement.



SHEER PLAN



HALF BREADTH PLAN



Published by A. & C. Black, Edinburgh.

G. Aikman sc. Edi.

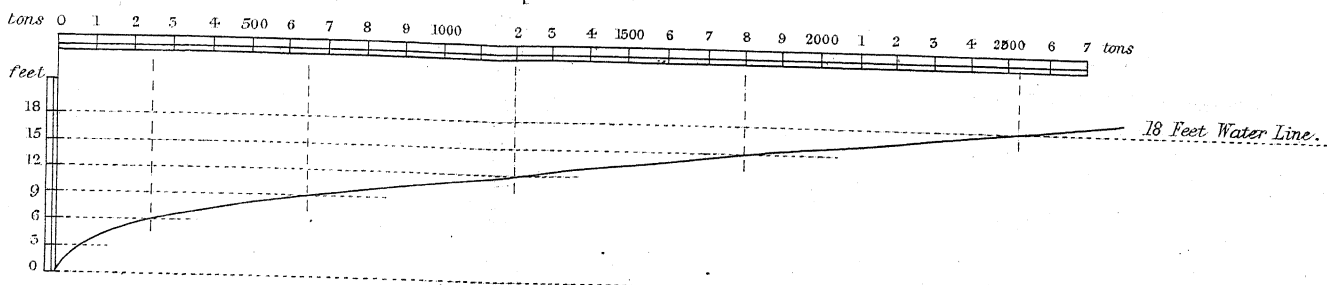
SHIP BUILDING.

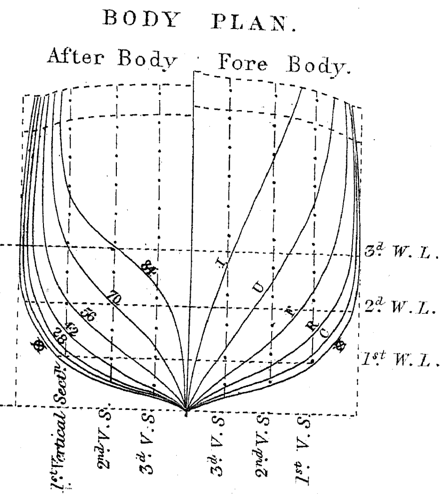
DRAUGHT OF THE SCREW STEAM SHIP "NUBIA"

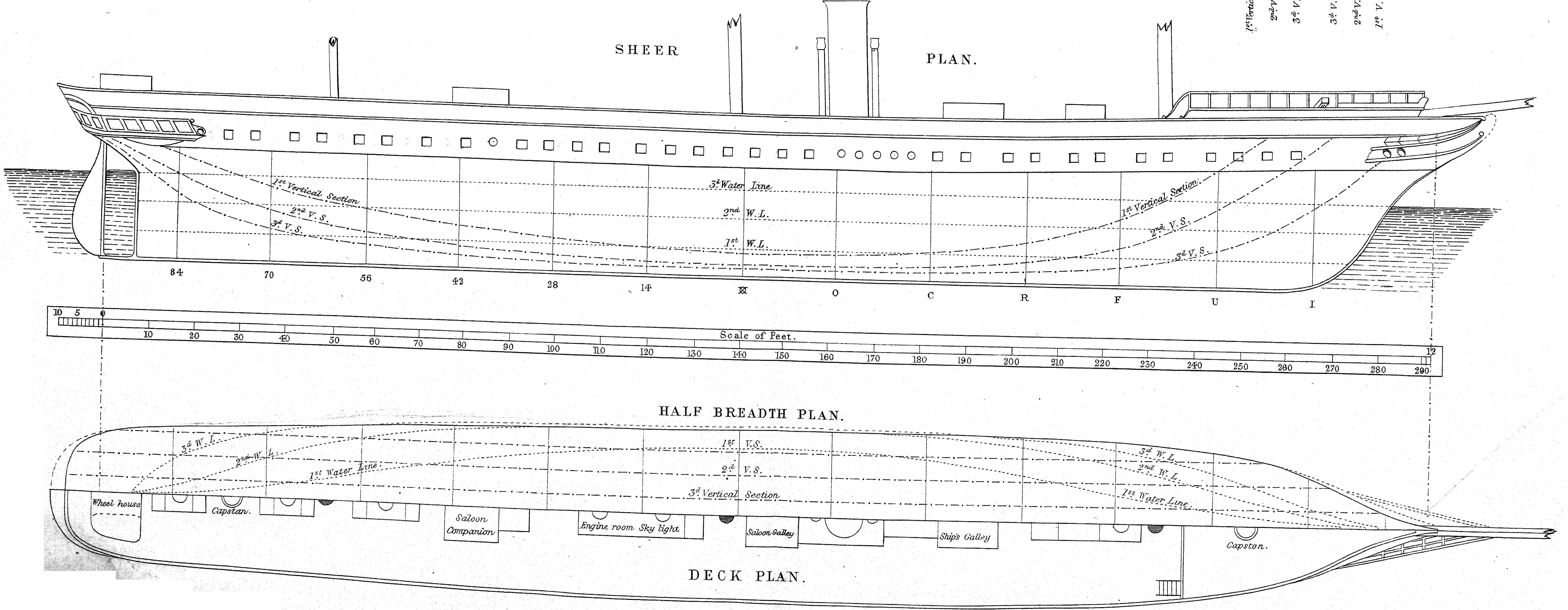
BELONGING TO THE PENINSULAR AND ORIENTAL STEAM NAVIGATION Co.

Dimensions.

		ft.	in.
Length over all		320	0
" for tonnage		292	2
Breadth for tonnage		39	5½
Depth of Hold from ceiling to spar deck		27	9
Tonnage, Builders old measurement	(tons)	2221	$\frac{72}{94}$
Load Draught of water		18	10
Displacement at load-draught	(tons)	2808	0
Area of midship section at 18ft 10in	(sq. ft.)	530	0
Horses-power (nominal)	(horses)	450	0
Builder of the Ship	John Laird, Birkenhead.		
Makers of the Machinery	Fawcett Preston & Co.		







Published by A. & C. Black, Edinburgh.

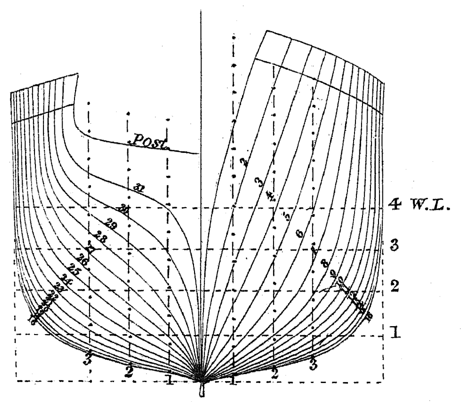
G. Aikman Sc.

SHIP BUILDING.

DRAUGHT OF THE IRON SCREW STEAM SHIP "CEYLON"

Belonging to the Pen. & Oriental Steam Nav. C^o.

BODY PLAN.

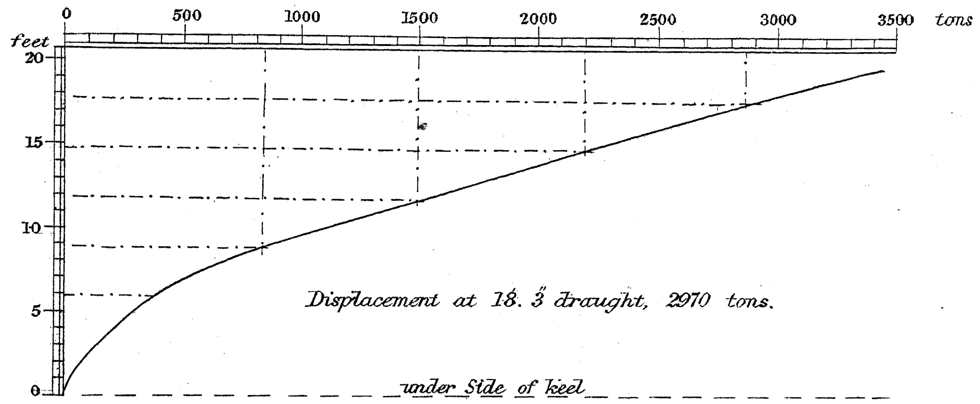


Dimensions

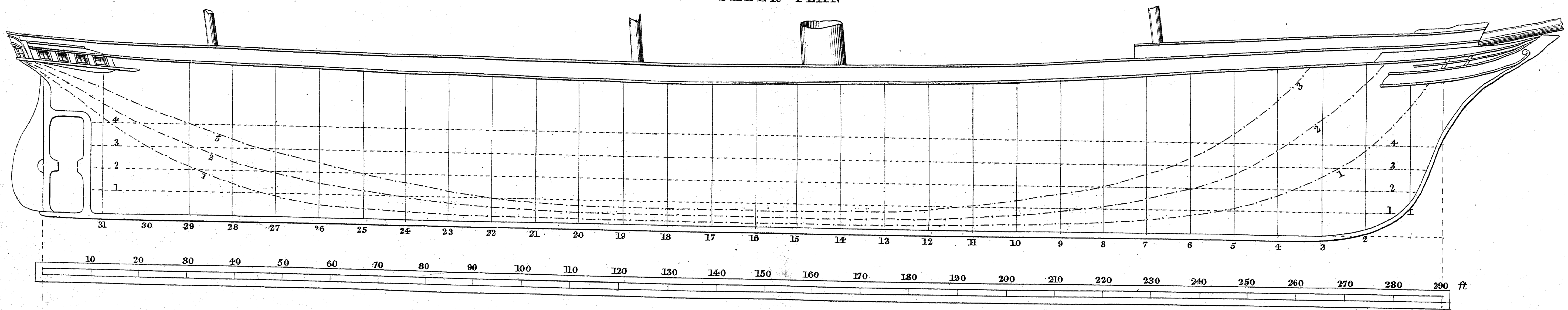
	feet
Length between perpendicutars	290.
Breadth extreme	41.
Depth amidships (from top of keel)	29.

Burthen in tons N^os 2373 $\frac{6}{94}$. B.M.
Horses power (nominal) 450.
Builders of the Ship, Samuda & C^o.
Makers of the Machinery, Humphrys & Tennant.

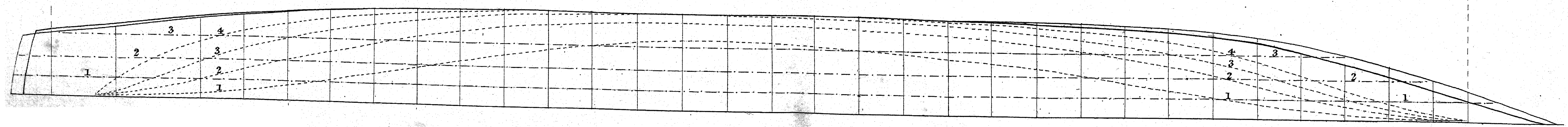
Scale of Displacement



SHEER PLAN



HALF BREADTH PLAN



Published by A. & C. Black, Edinburgh.

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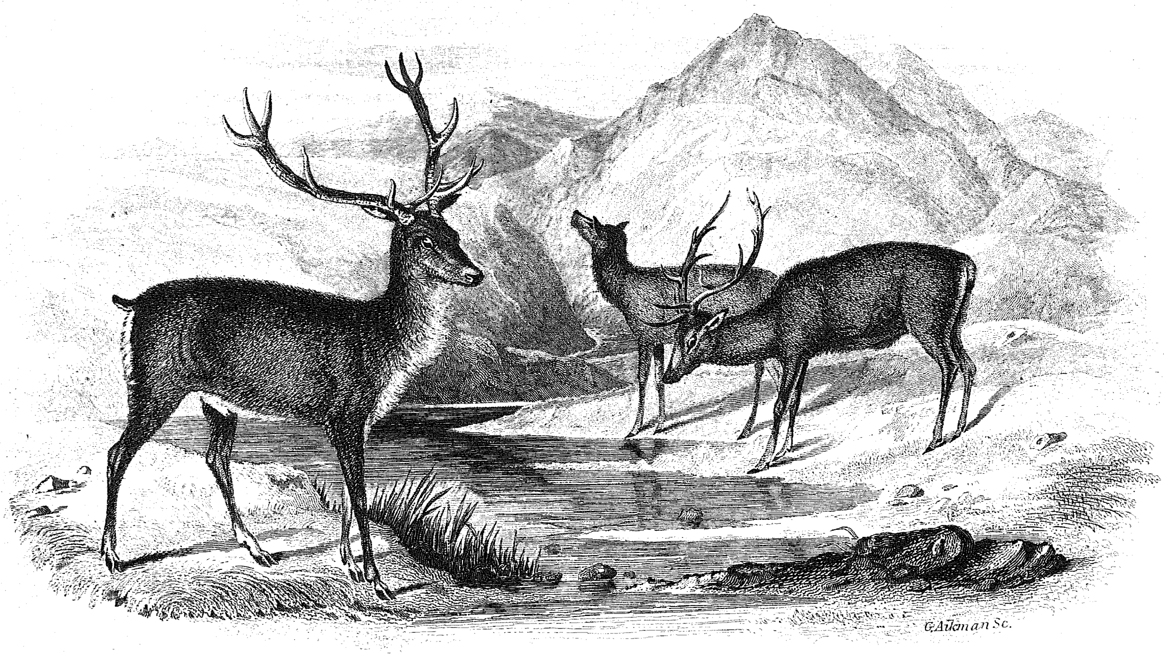
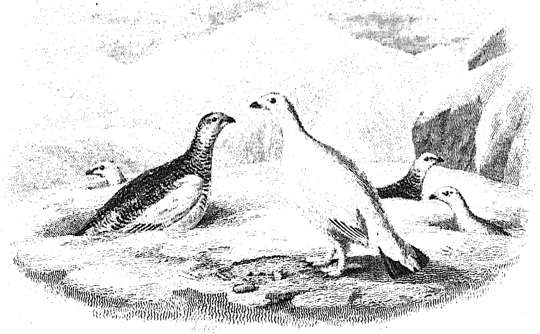
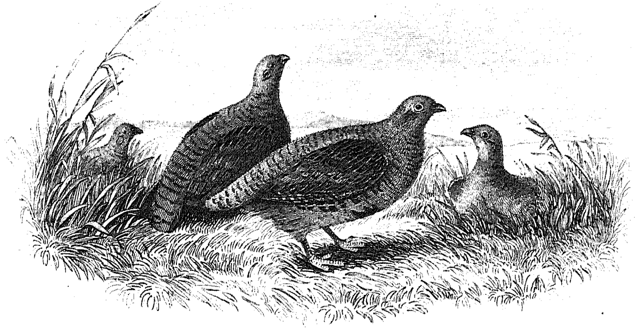
GROUSE SHOOTING.

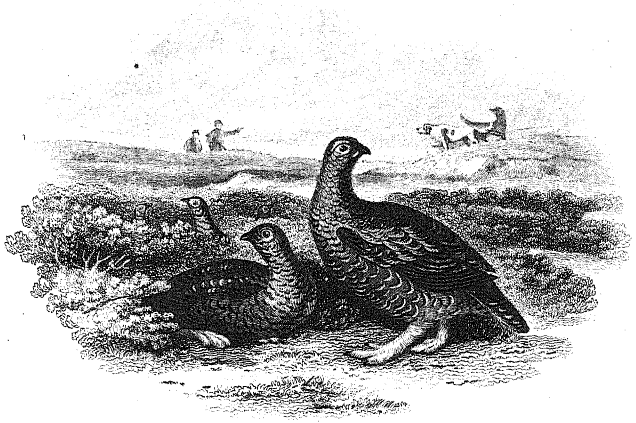


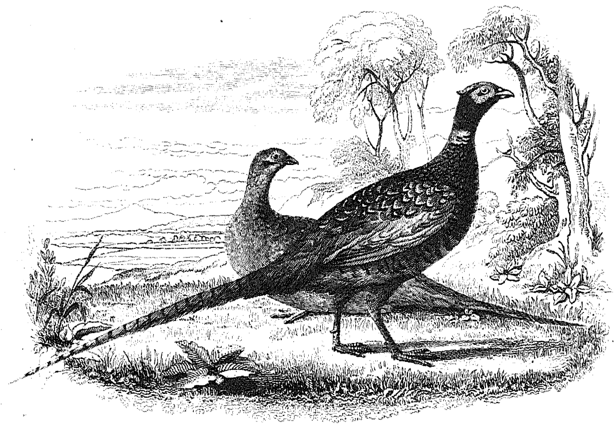
RED DEER.

Published by A. & C. Black, Edinburgh.


PTARMIGAN.


PARTRIDGES.


RED GROUSE.


PHEASANTS.

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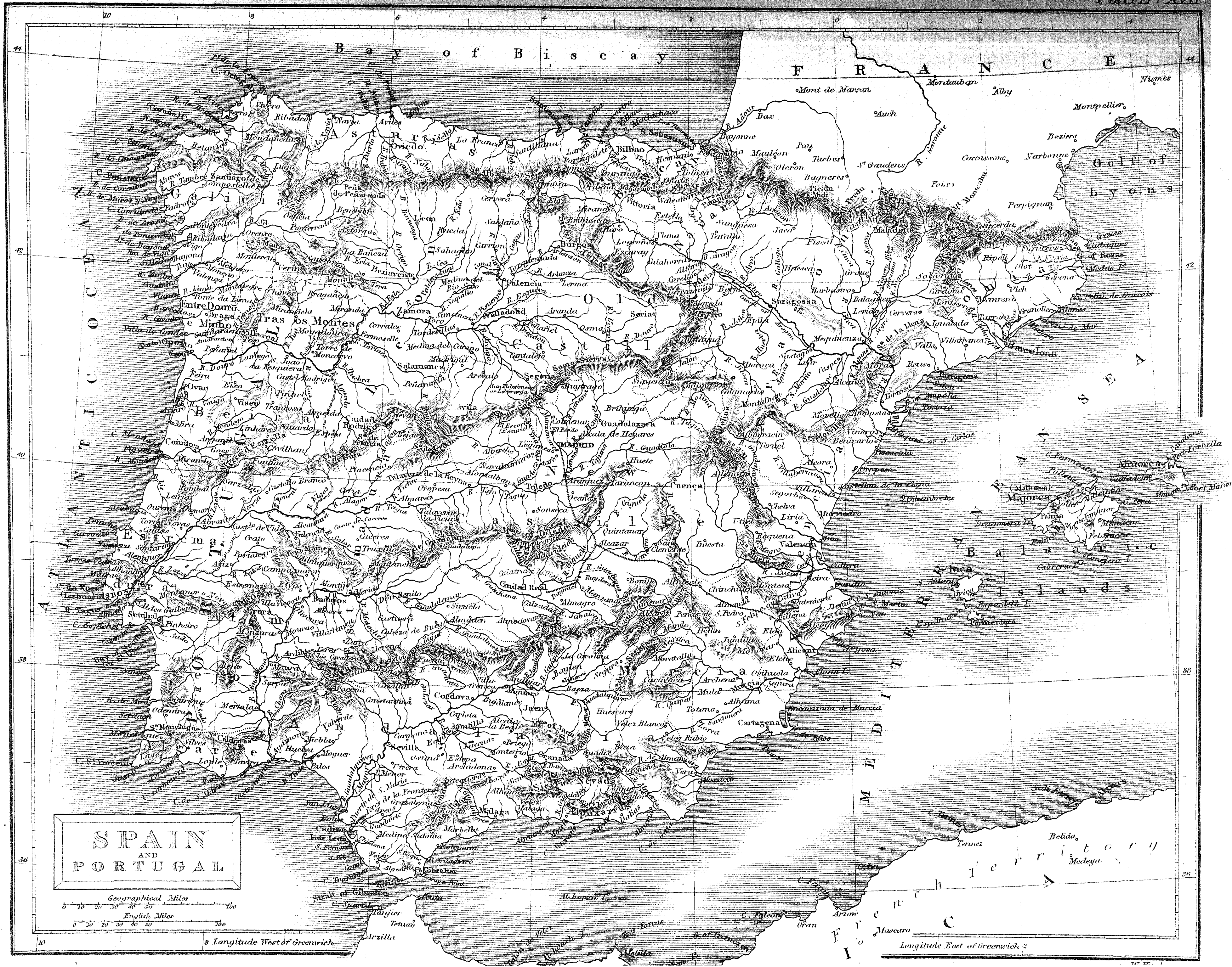
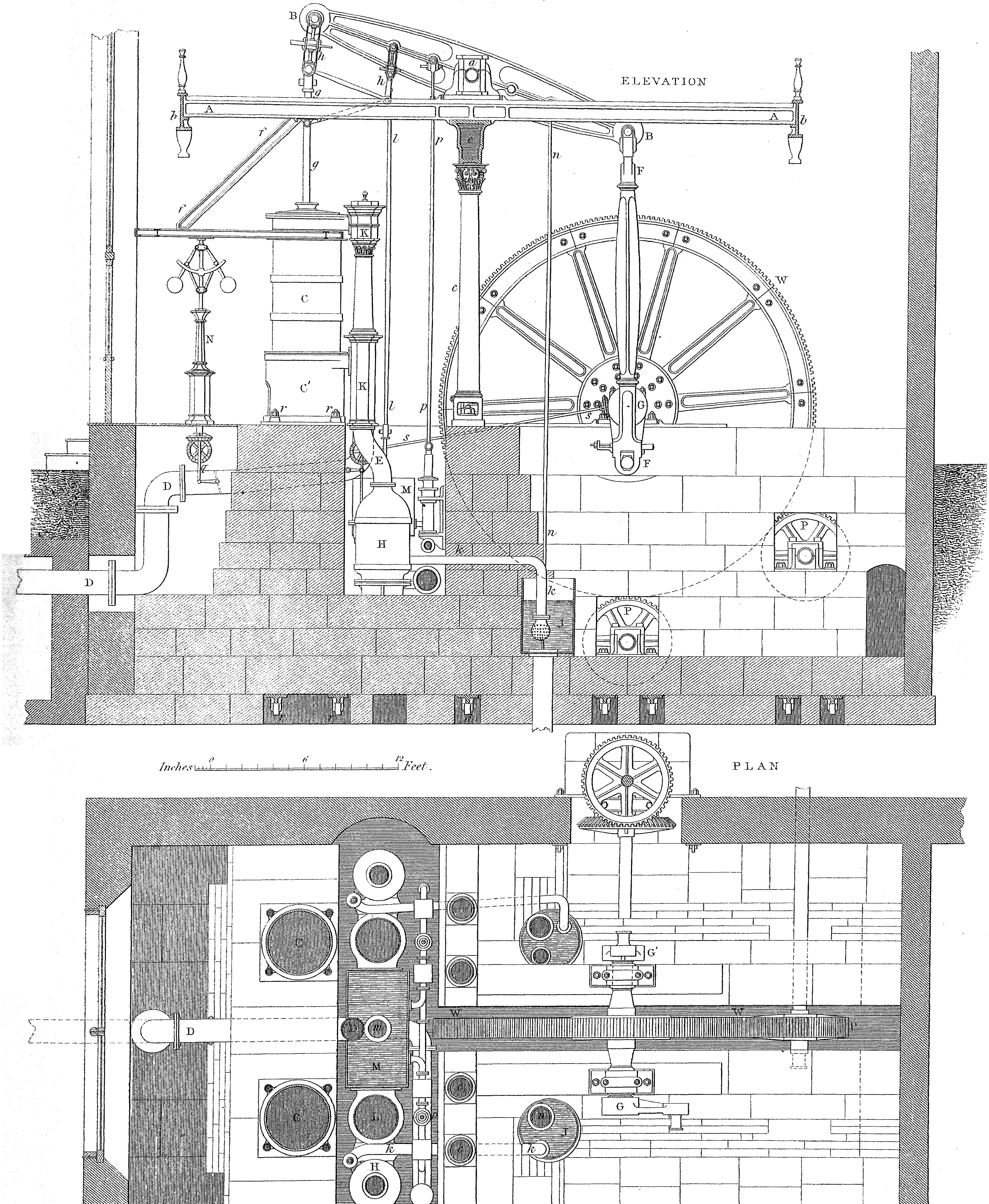

SPAIN
AND
PORTUGAL
Geographical Miles
English Miles
Longitude West of Greenwich
Longitude East of Greenwich
Bay of Biscay
FRANCE
Gulf of Lyons
ATLANTIC OCEAN
MEDITERRANEAN SEA
Balearic Islands
French Territory
MADRID
Lisboa
Strait of Gibraltar

STEAM ENGINE

CONDENSING BEAM-ENGINES, 200 H. P.—SALTAIRE.



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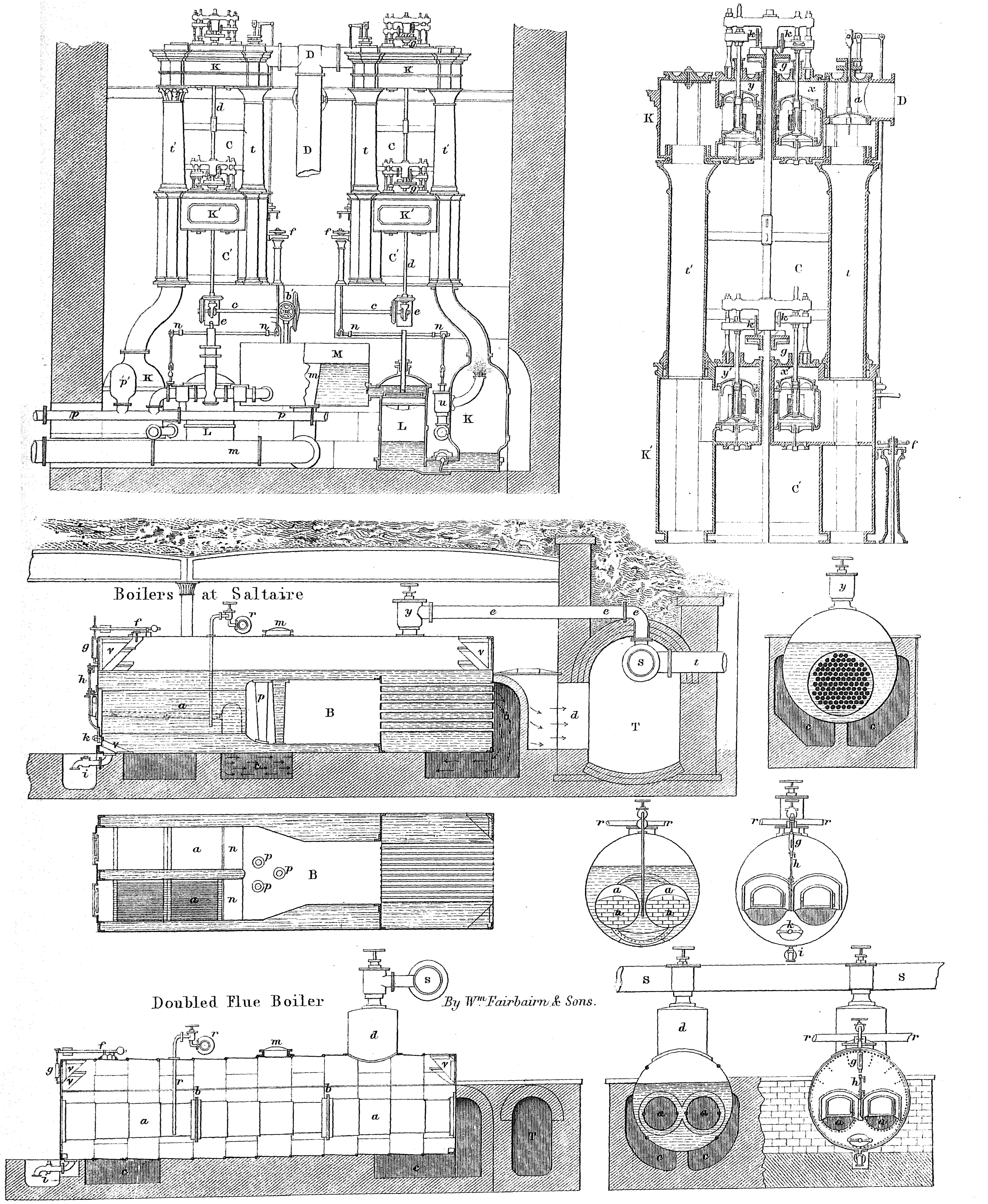
STEAM ENGINE.

CONDENSING BEAM ENGINES.

Saltaire Cross Section.



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High Pressure Engine used at the Liverpool Railway Station.

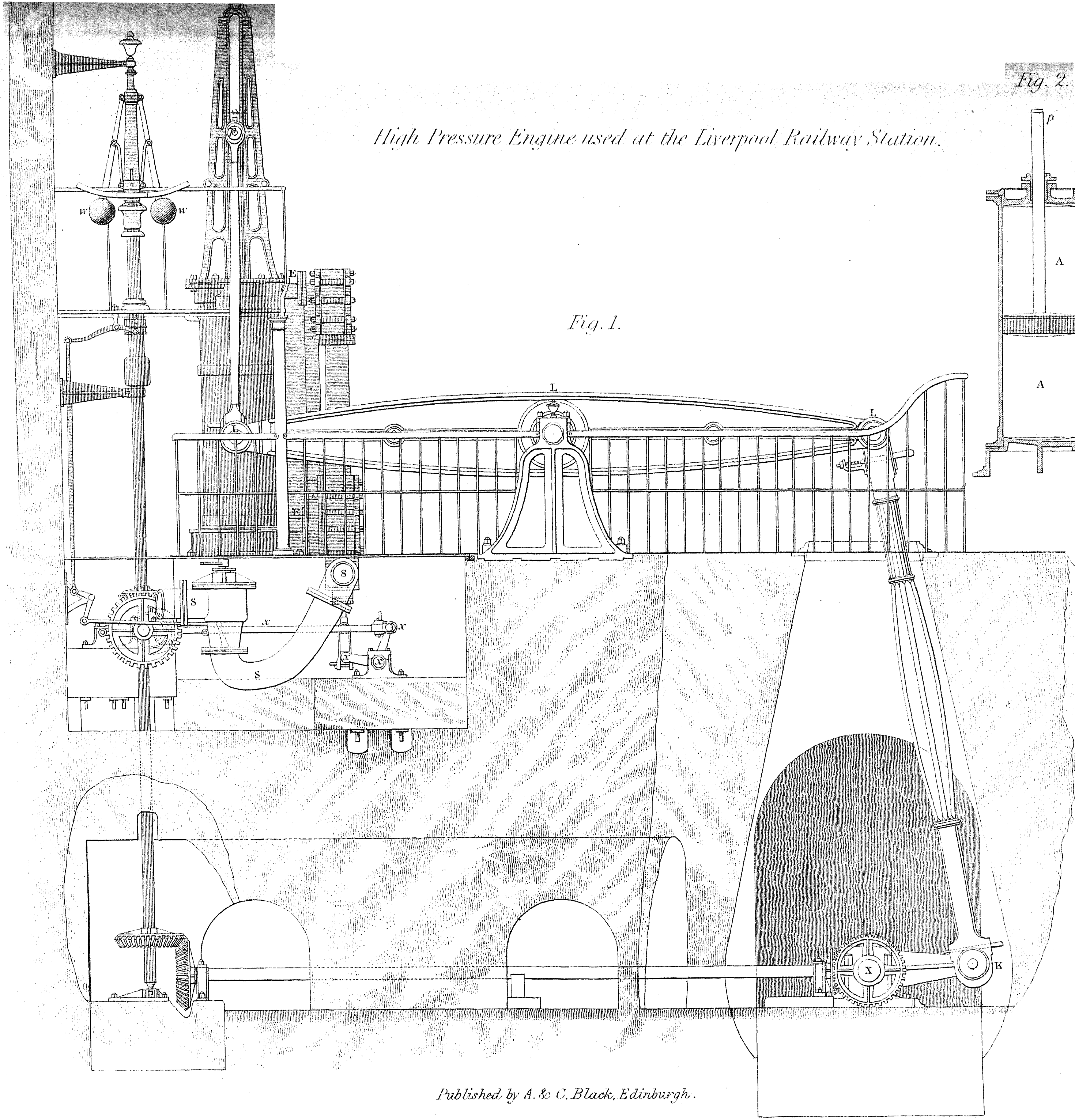
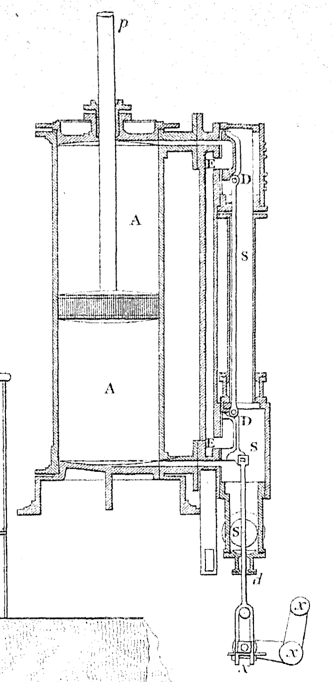


Fig. 1.

Fig. 2.



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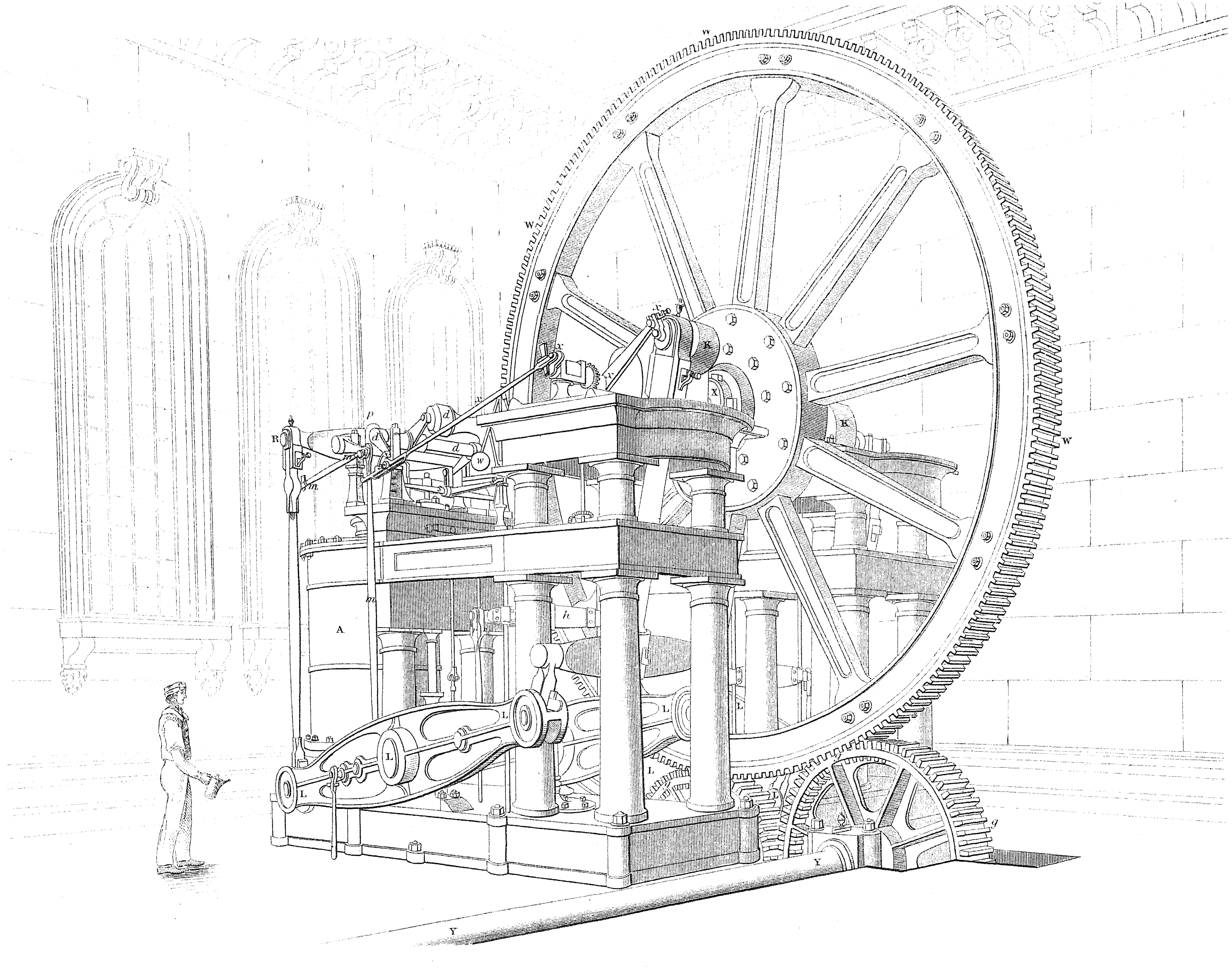
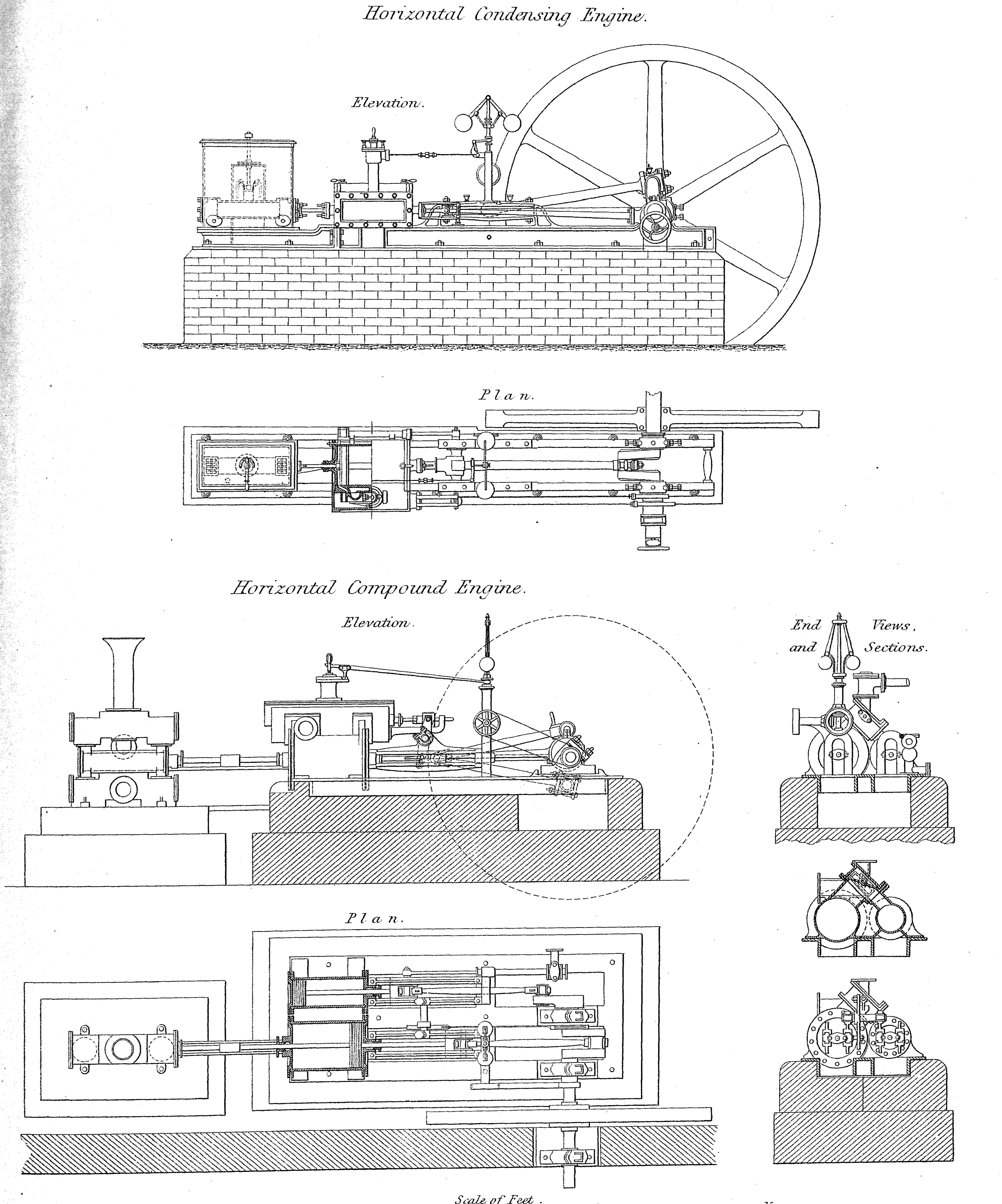
Geo. Aikman, Sculpt.

STEAM ENGINE.



Published by A. & C. Black, Edinburgh.

Geo. Aikman, Sculpt.



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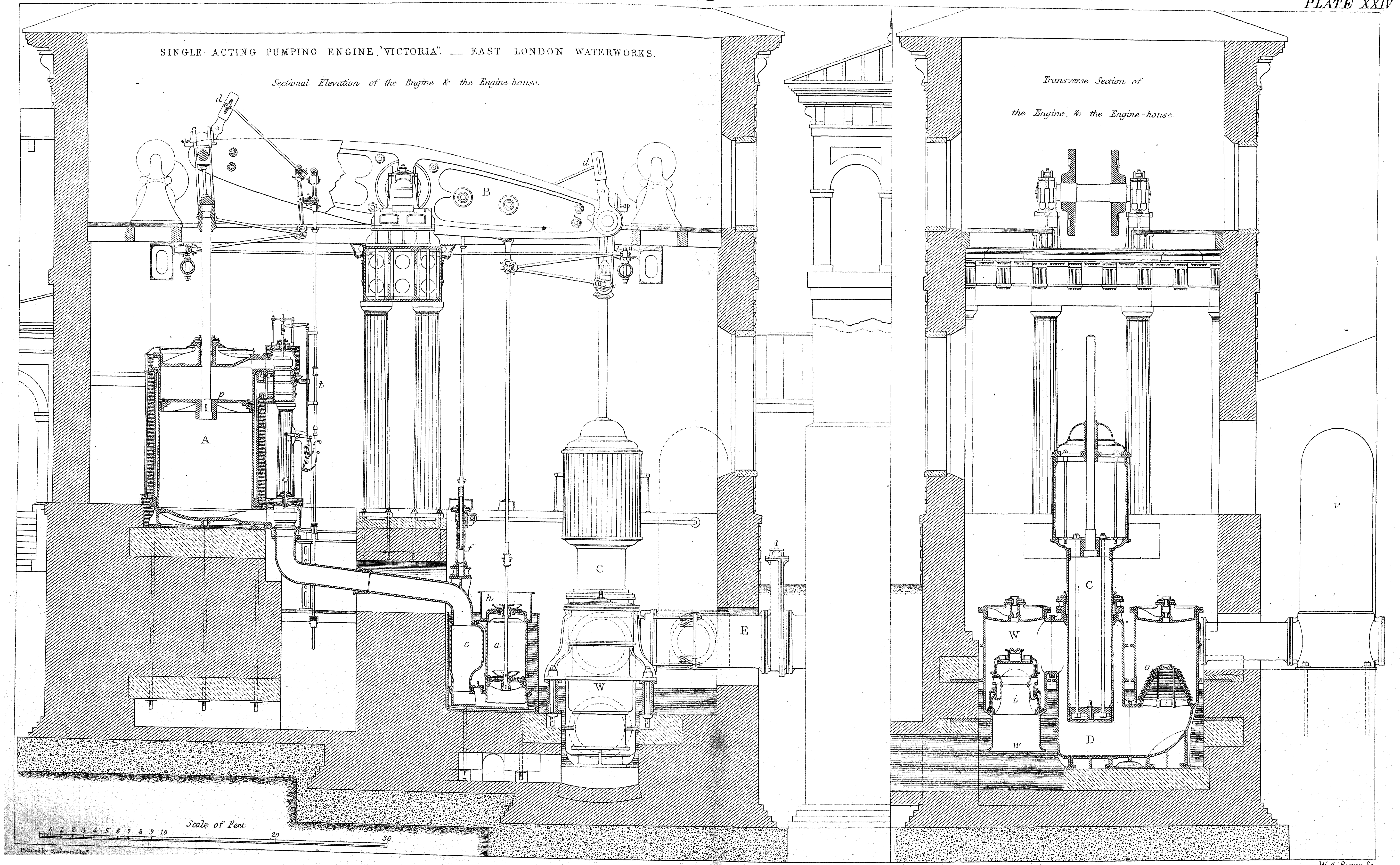
Published by A. & C. Black, Edinburgh.

STEAM ENGINE.



Printed by G. Aikman Edin.

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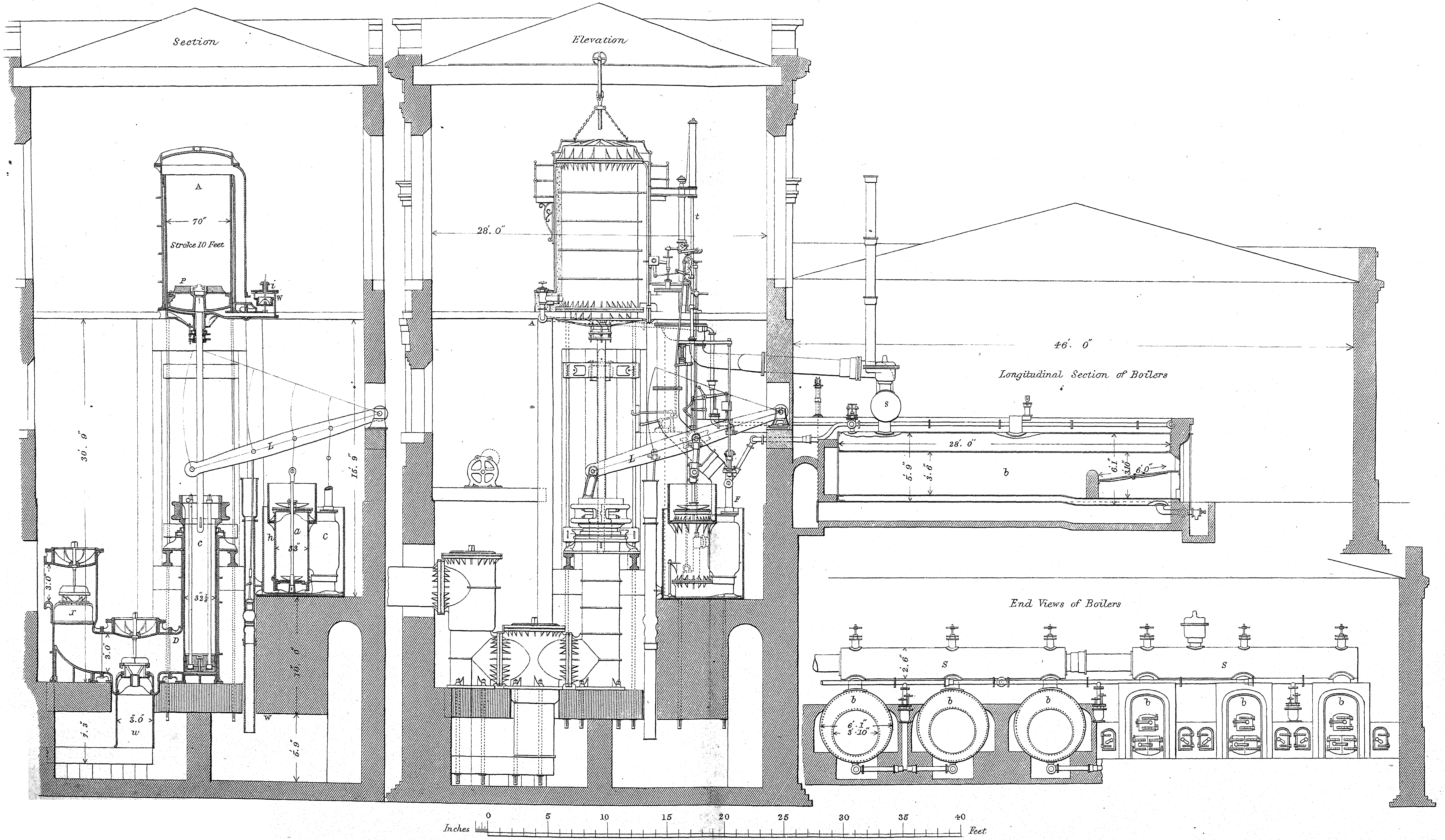
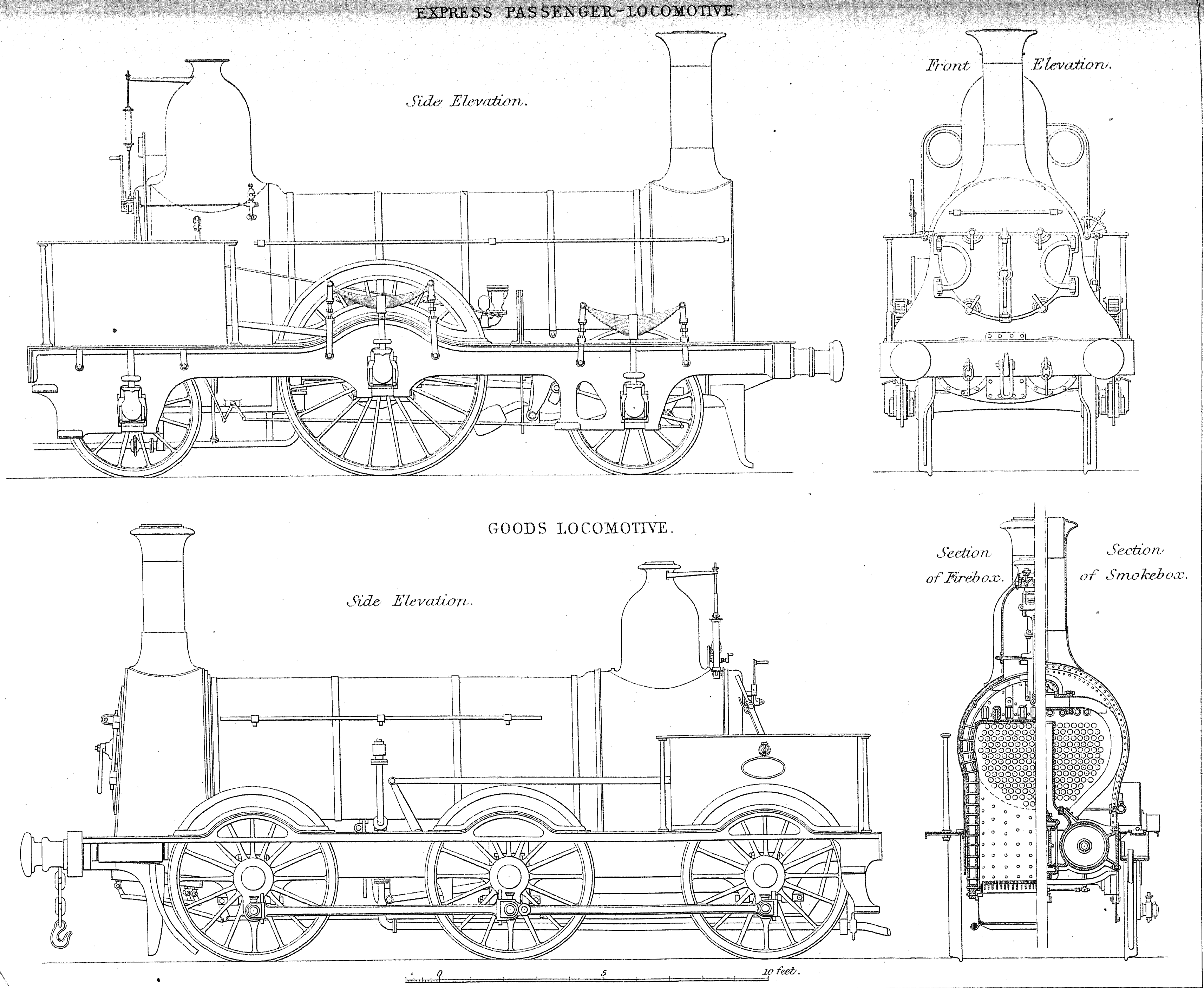
Published by A. & C. Black, Edinburgh.

STEAM ENGINE

70-INCH DIRECT ACTION PUMPING ENGINE—CAMPDEN HILL.



Published by A. & C. Black, Edinburgh.



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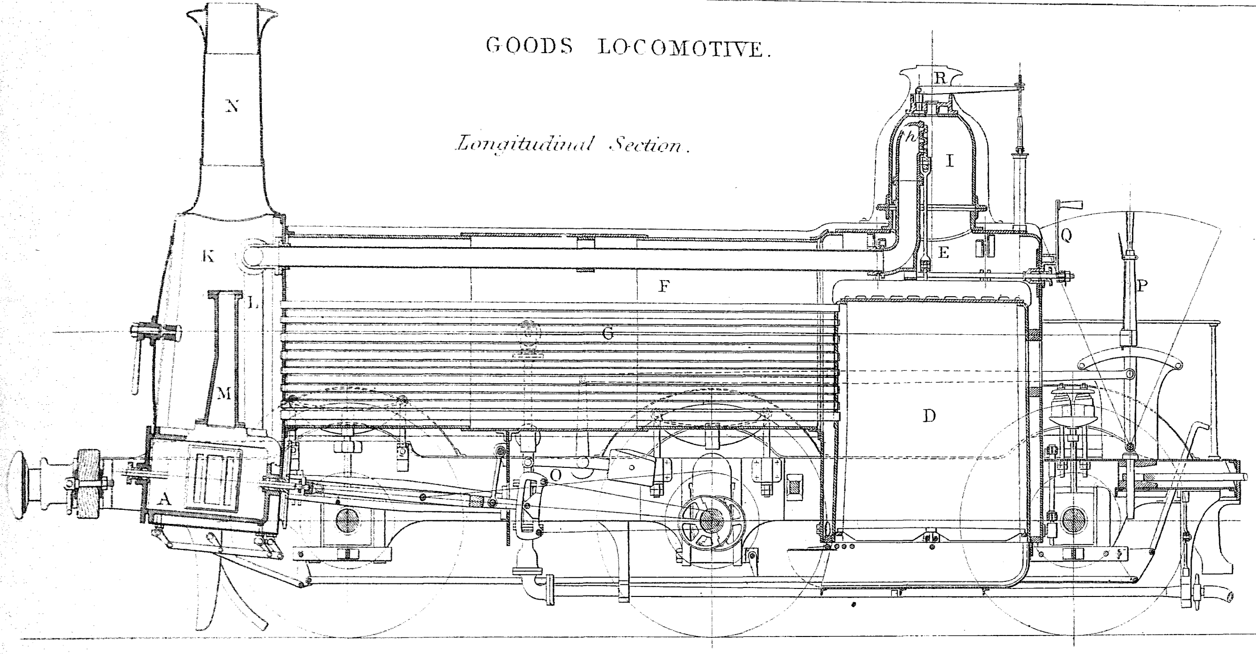
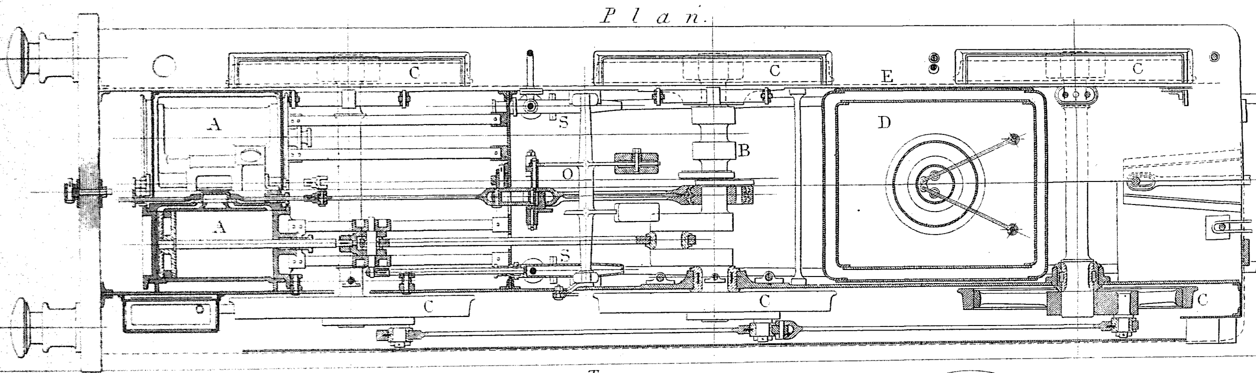
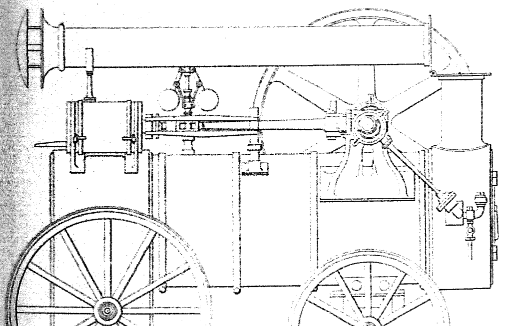
GOODS LOCOMOTIVE.

Longitudinal Section.



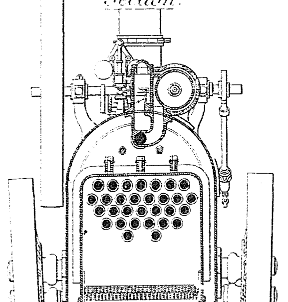
Plan.



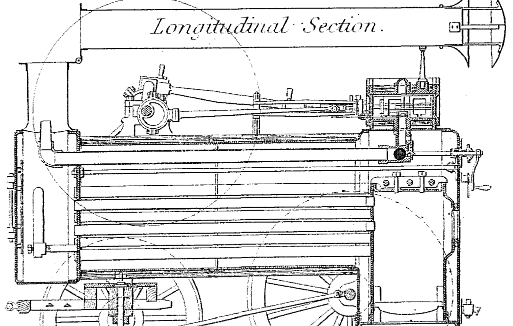


Engine with axle through boiler.

Transverse Section.

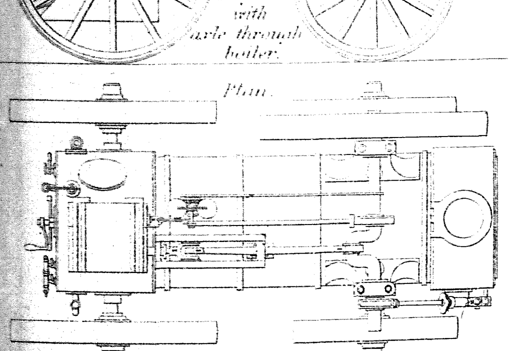


Longitudinal Section.



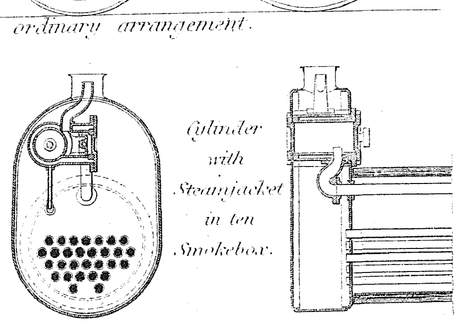
Engine of the ordinary arrangement.

Plan.



AGRICULTURAL

LOCOMOTIVE ENGINES.



Cylinder with Steamjacket in the Smokebox.

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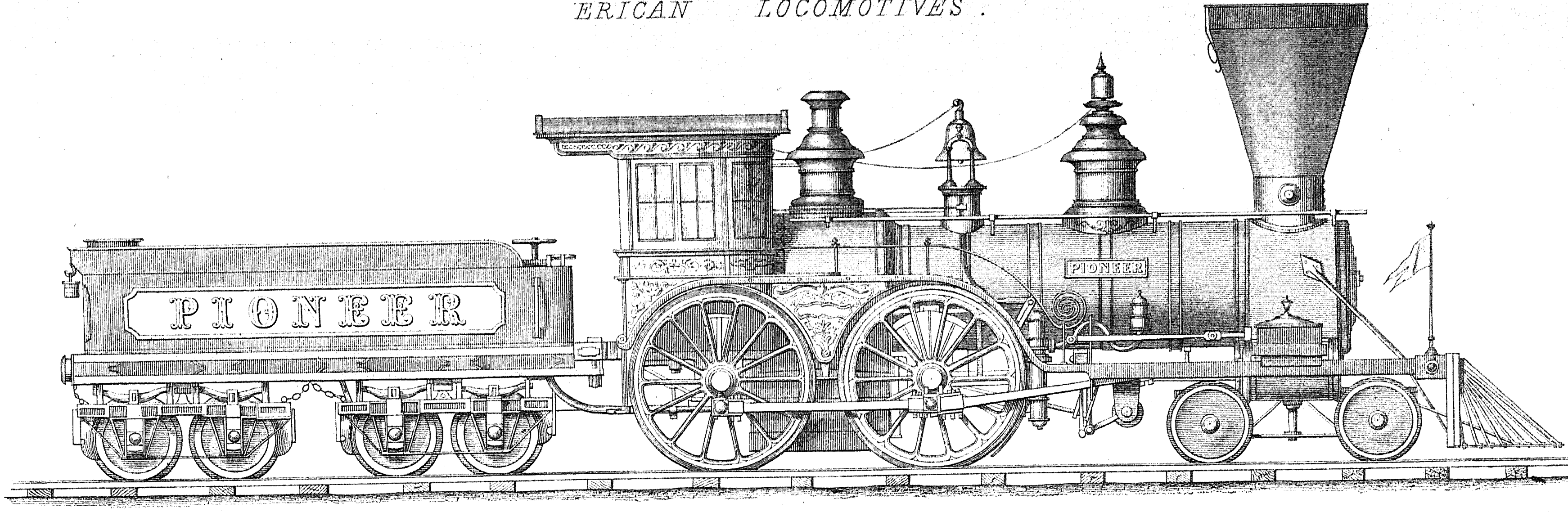
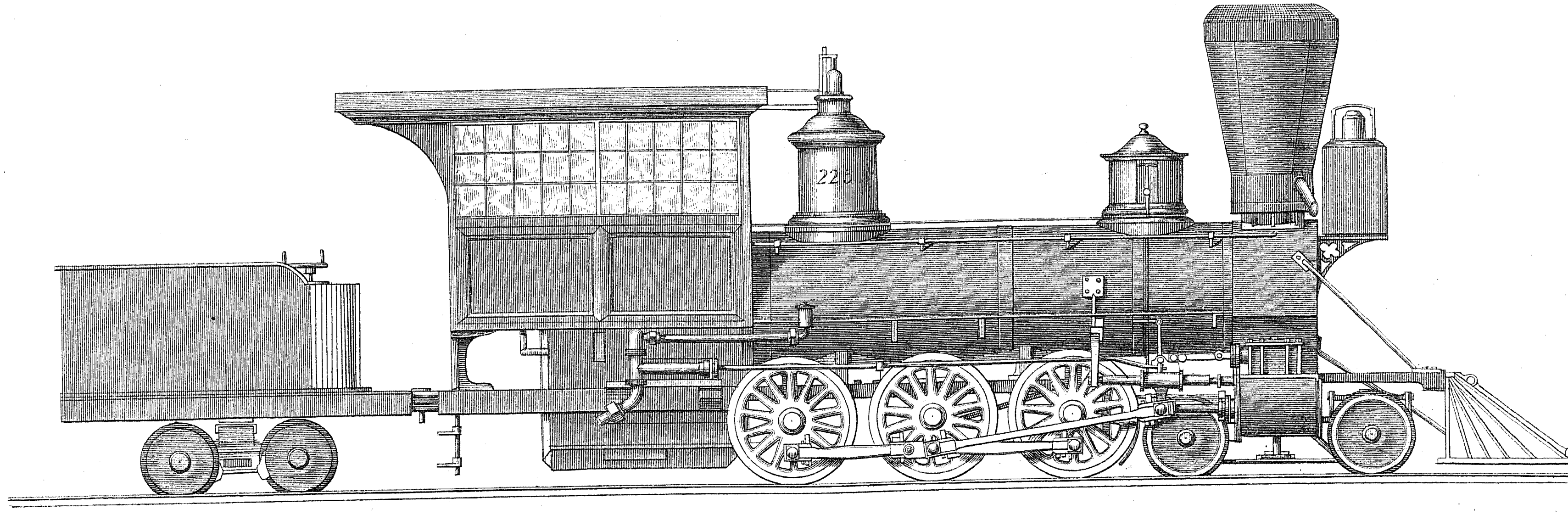
Published by A. & C. Black, Edinburgh.

ERICAN LOCOMOTIVES.



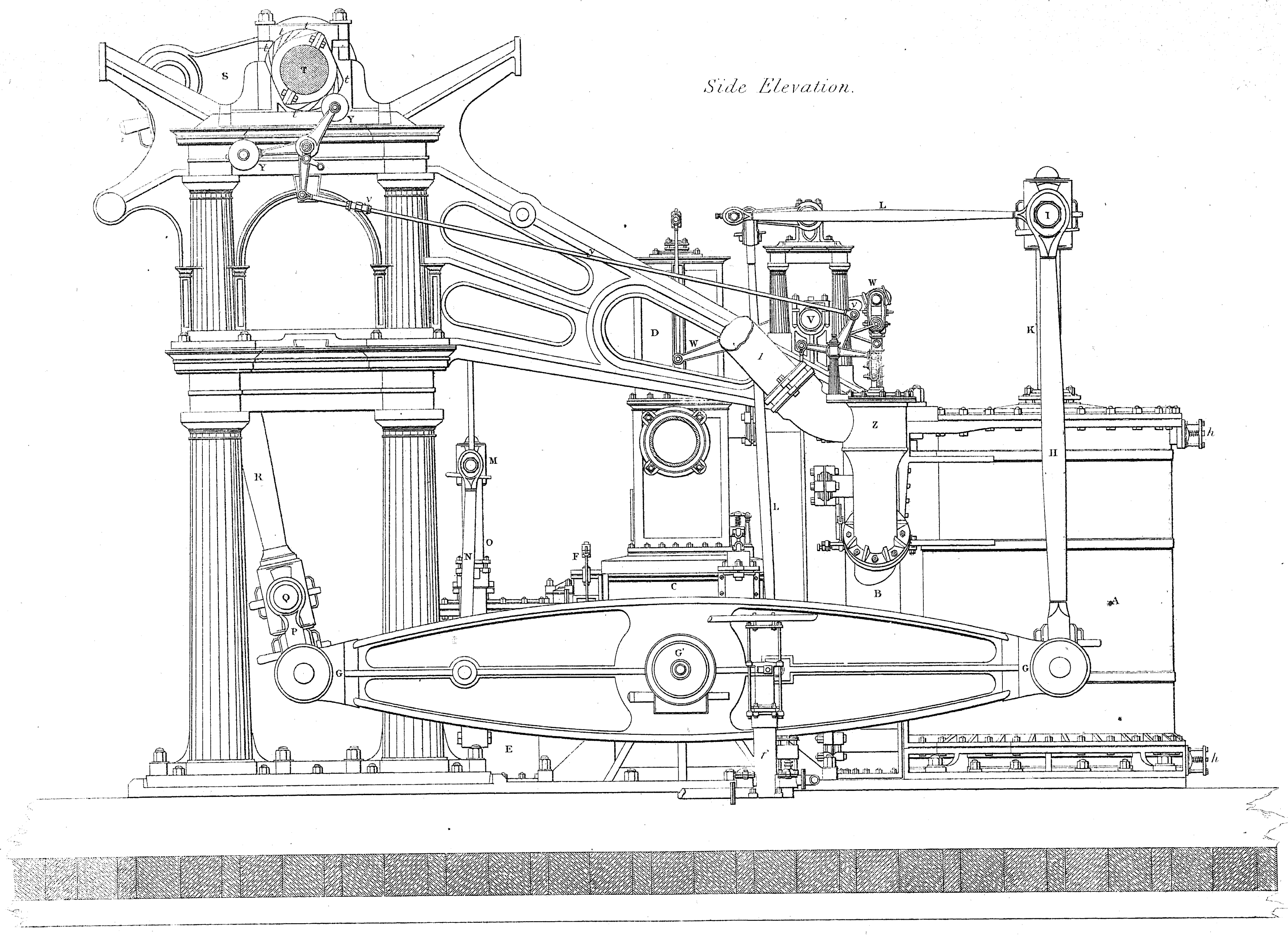


G. Aikman sc. Edin.[r]

Published by A. & C. Black, Edinburgh.

SIDE LEVER MARINE ENGINE.

Side Elevation.



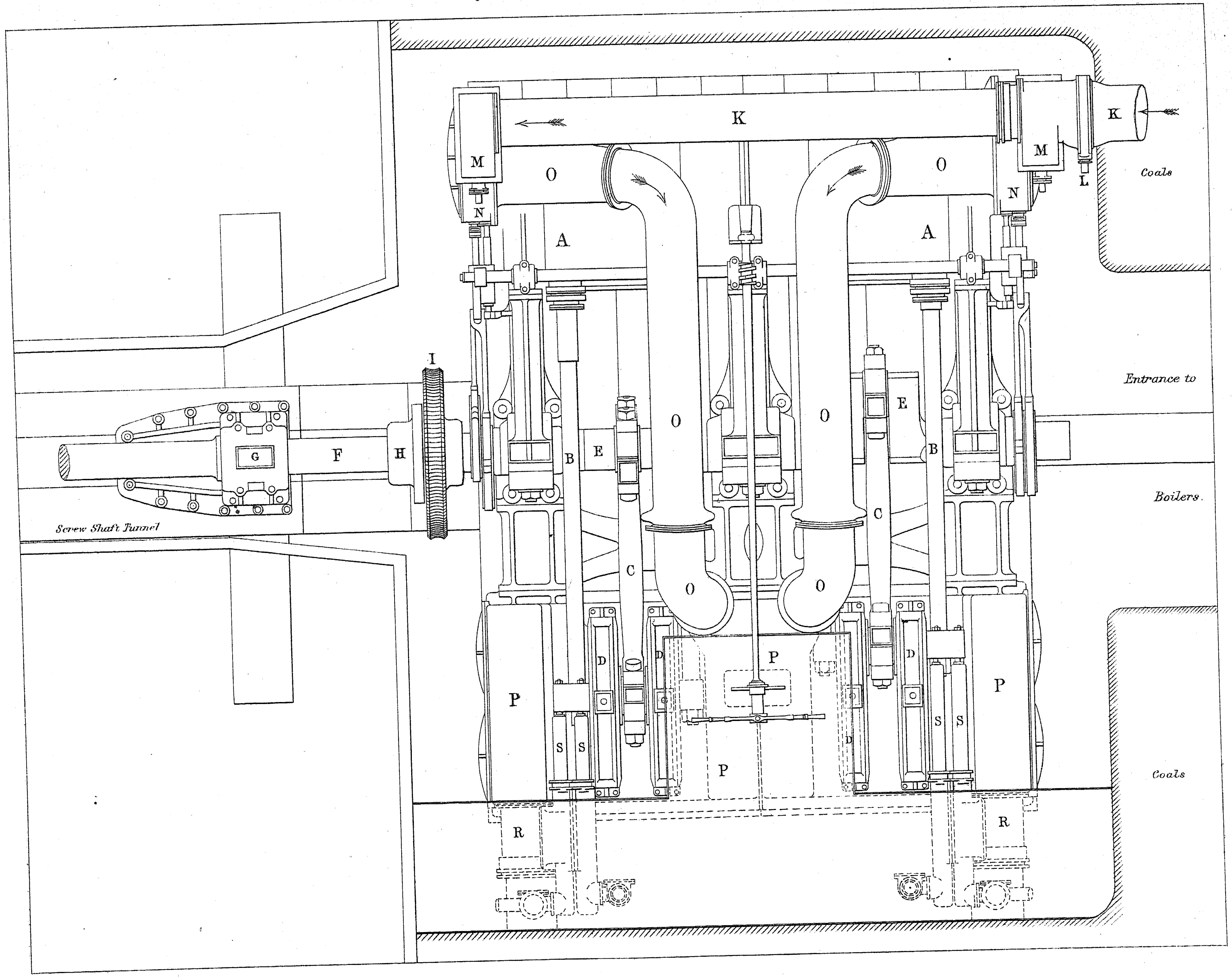
Published by A. & C. Black, Edinburgh.

Geo. Aikman, Sculp.t

STEAM NAVIGATION.

PLAN OF A PAIR OF DIRECT ACTION SCREW ENGINES OF 500 HORSE POWER.

By Ravenhill, Salkeld & C^o. 1859.



Scale ¼ Inch – 1 Foot

G. Aikman sc.

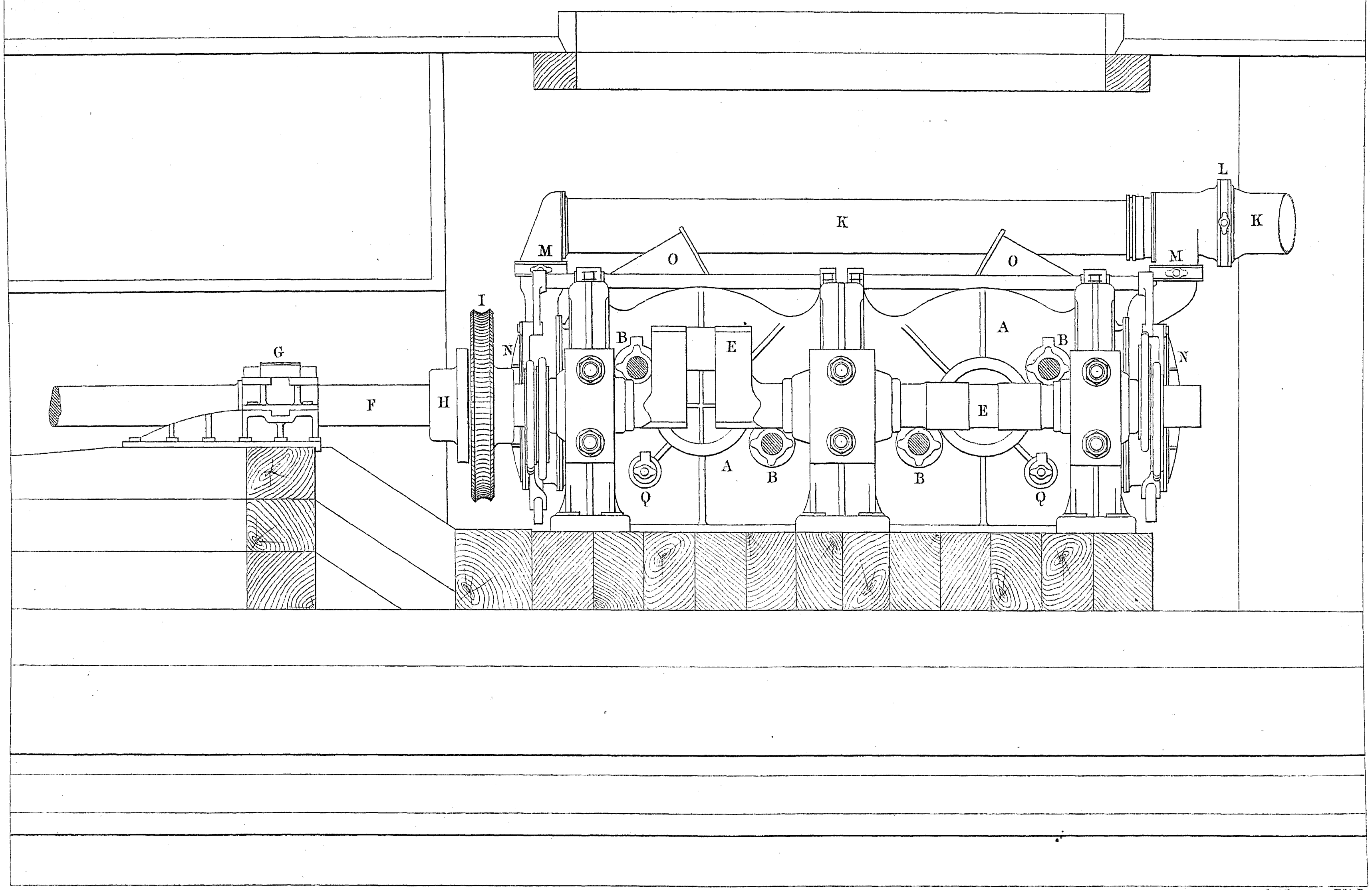
Published by A. & C. Black, Edinburgh.

FORE AND AFT ELEVATION OF A PAIR OF DIRECT ACTION SCREW ENGINES OF 500 HORSE POWER

By Ravenhill, Salkeld & C°. 1859.

As fitted on board H. M. S.s. "Waterloo", "Nelson" &c.

Scale, ¼ inch = 1 Foot.

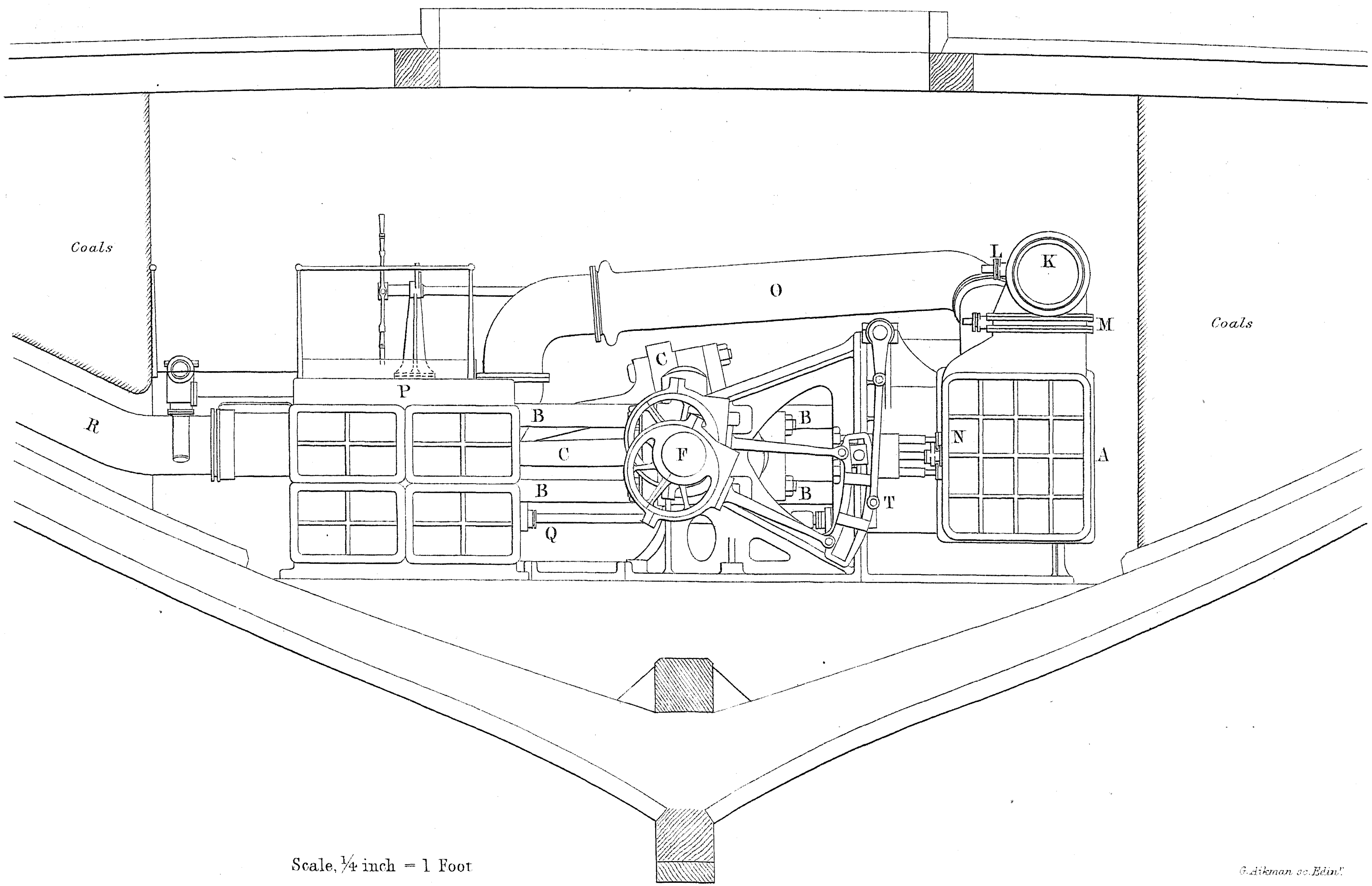


G. Aikman sc. Edin^r.

Published by A. & C. Black, Edinburgh.

ATHWARTSHIP ELEVATION OF A PAIR OF DIRECT ACTION SCREW ENGINES OF 500 HORSE POWER

By Ravenhill, Salkeld & Co. 1859.

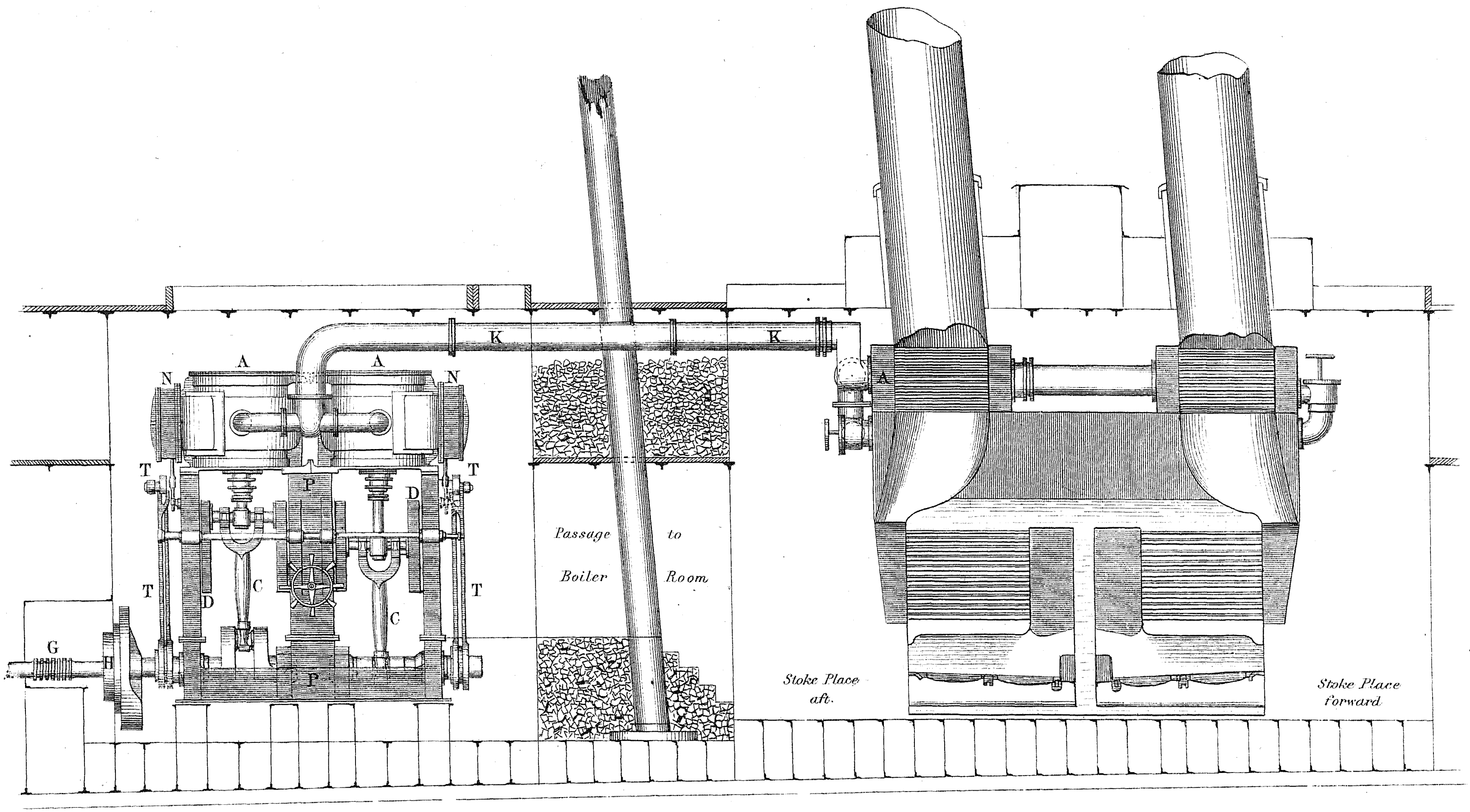


Scale, 1/4 inch = 1 Foot

Published by A. & C. Black, Edinburgh.

ENGINES AND BOILERS OF THE SCREW STEAM. SHIP "THUNDER".

J. & W. Dudgeon, Millwall, London.



Scale 1/8 Inch = 1 Foot

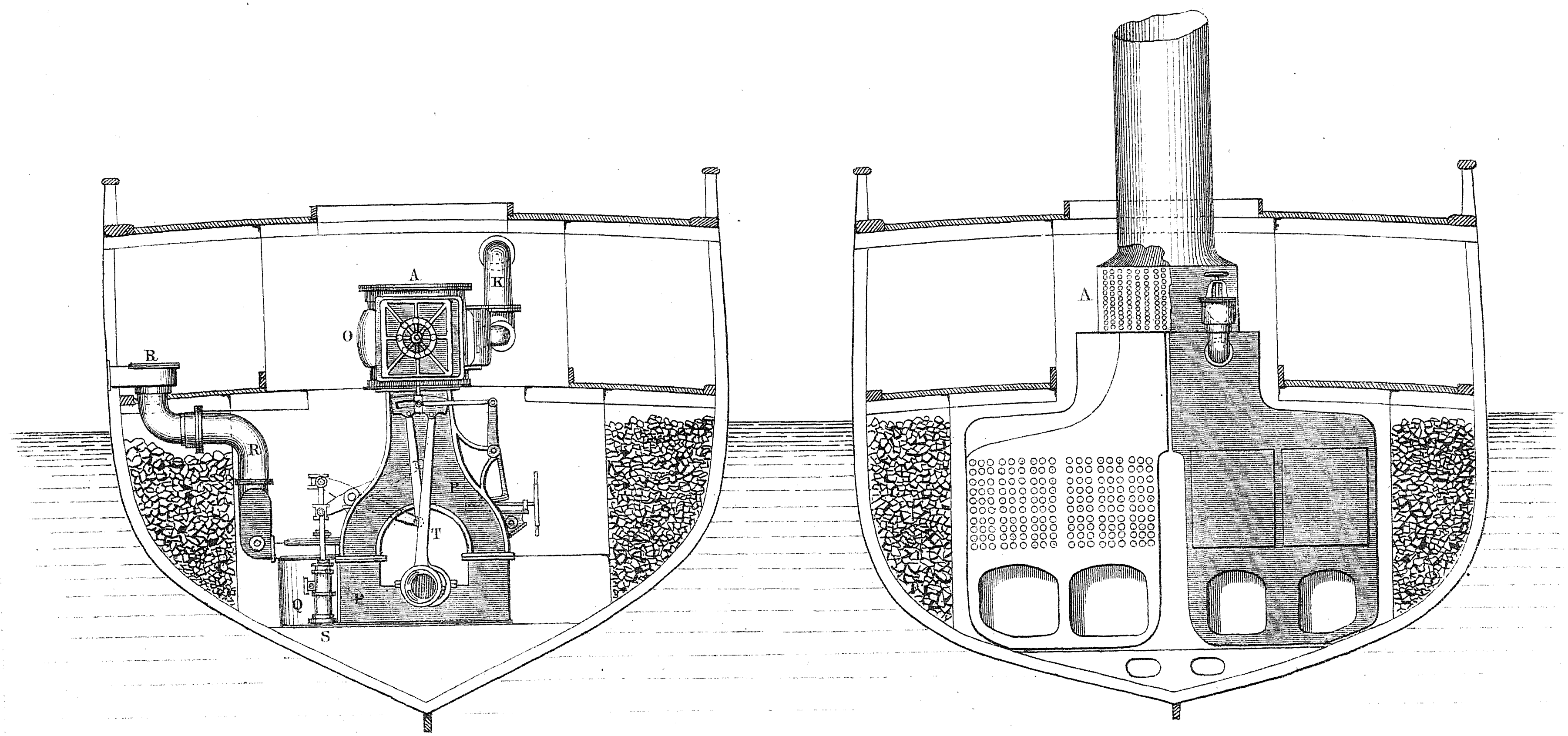
G. Aikman sc.

Published by A. & C. Black, Edinburgh.

STEAM NAVIGATION.

ENGINES AND BOILERS OF THE SCREW STEAM SHIP "THUNDER".

J. & W. Dudgeon, Millwall, London.



G. Aikman sc. Edin.

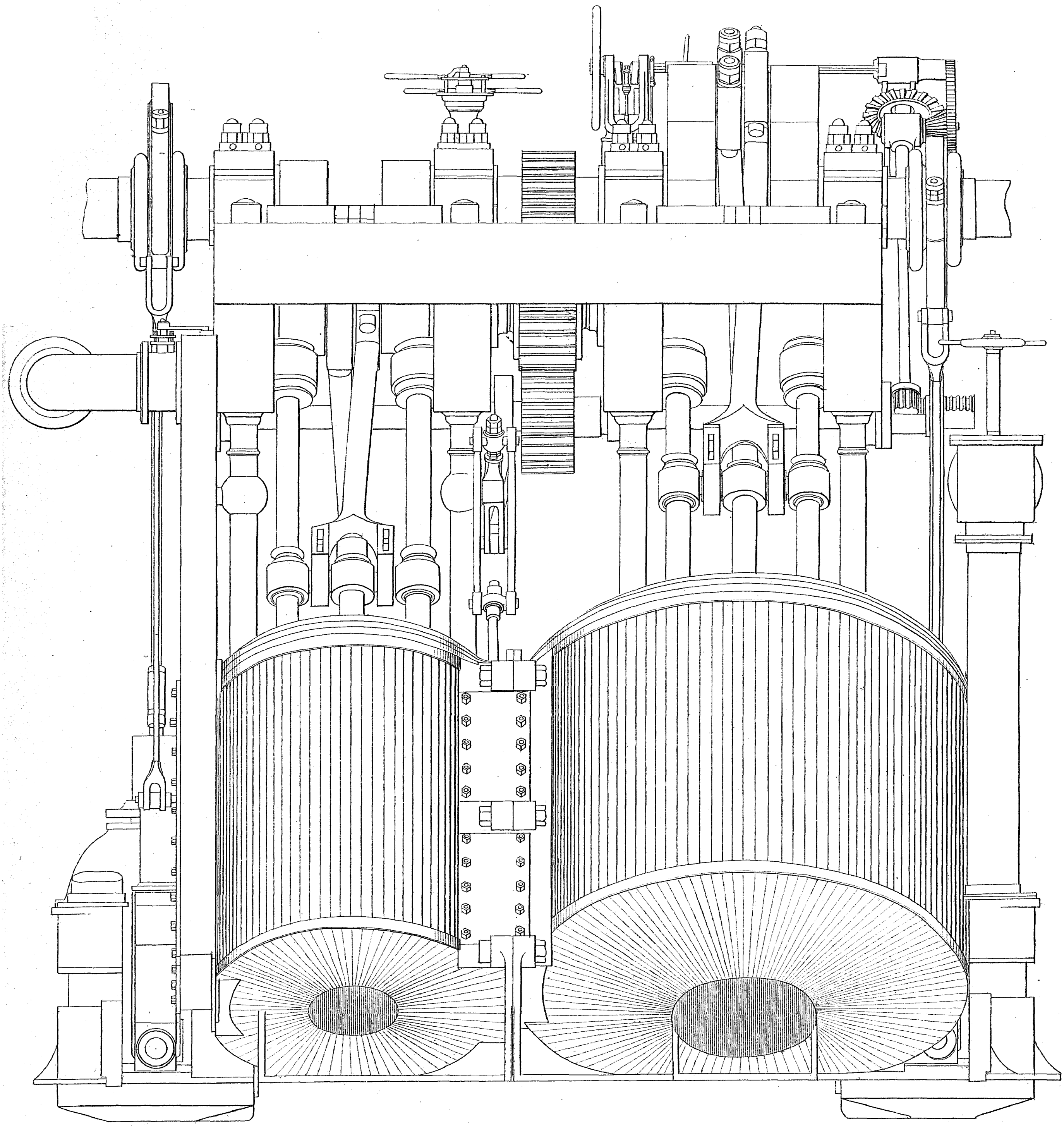
Scale, 1/8 inch = 1 Foot.

Published by A. & C. Black, Edinburgh.

STEAM NAVIGATION.

ENGINES OF STEAMERS CALLAO, LIMA & BOGOTA.

320 Horse Power.



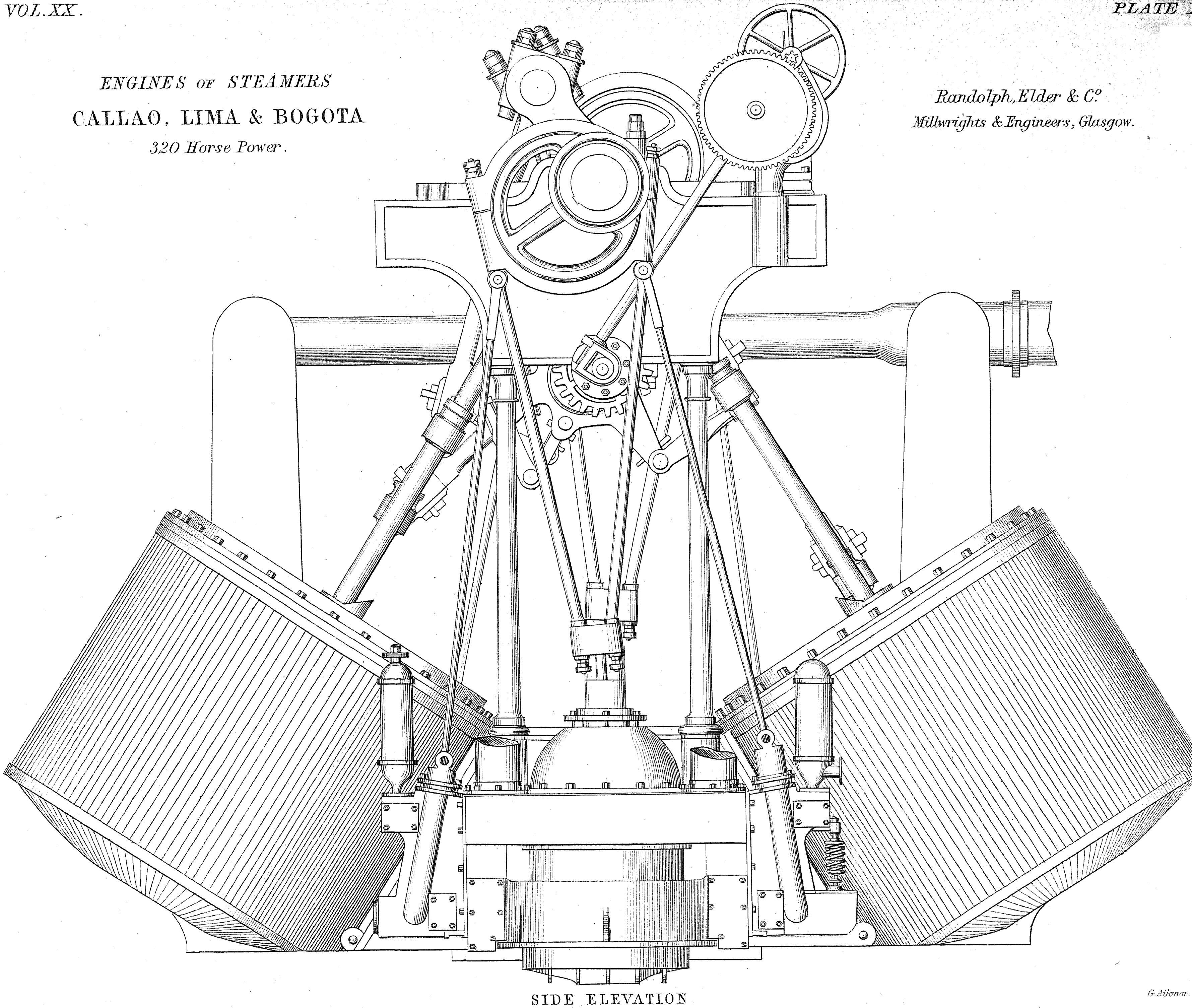
FRONT ELEVATION.

G. Aikman sc.

Published by A. & C. Black, Edinburgh.

ENGINES OF STEAMERS
CALLAO, LIMA & BOGOTA
320 Horse Power.

Randolph, Elder & Co.
Millwrights & Engineers, Glasgow.



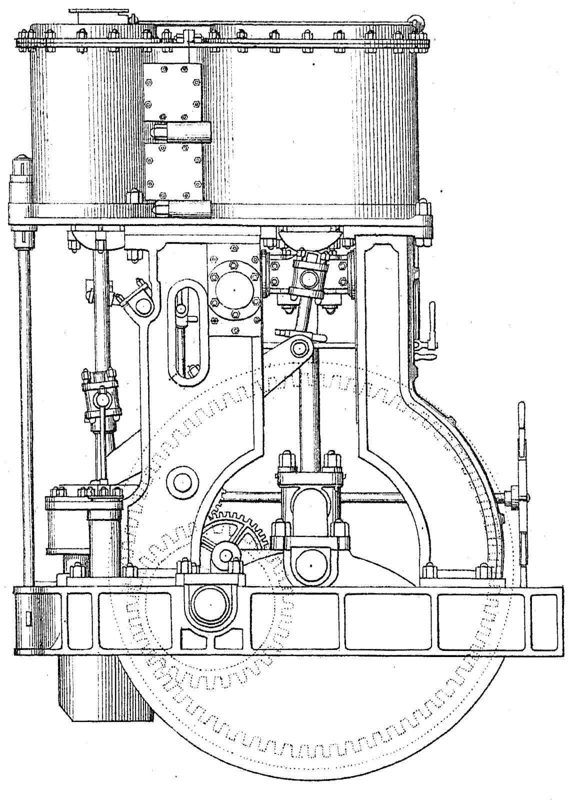
SIDE ELEVATION

G. Aikman sc. Edin.

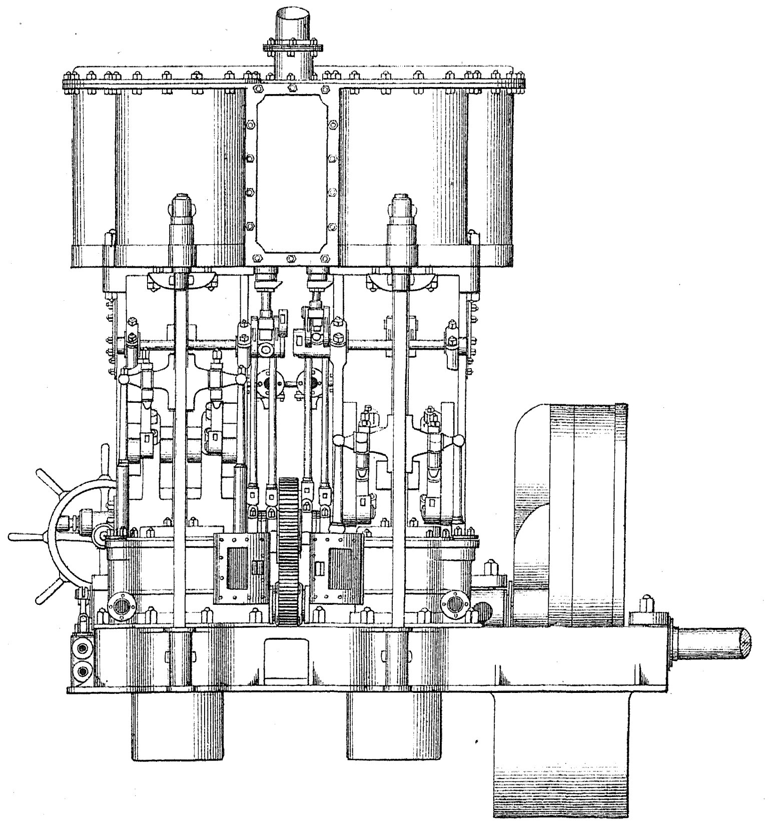
STEAM NAVIGATION.

INVERTED DOUBLE CYLINDER ENGINES.

End Elevation



Side Elevation



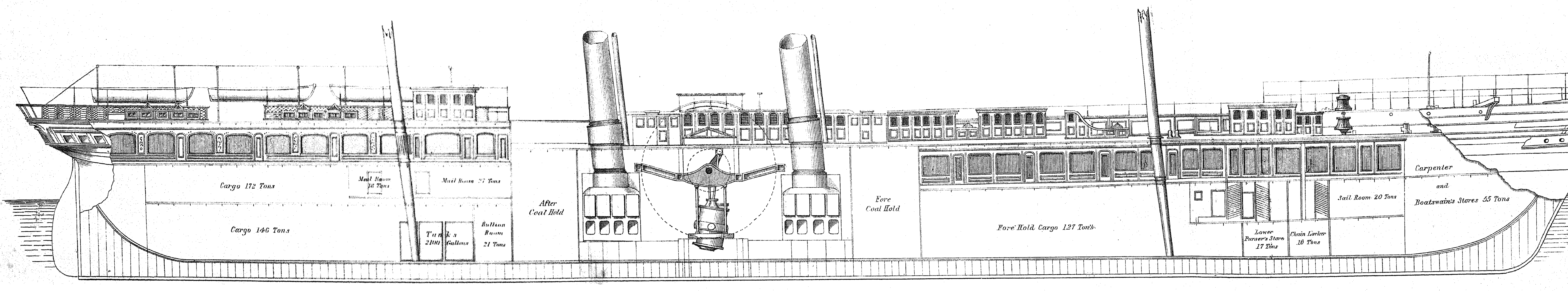
Published by A. & C. Black, Edinburgh.

G. Aikman sc.

STEAM NAVIGATION.

STEAM SHIP "DELTA"

of 1618 Tons and 400 Horse Power. Propelled by Paddle wheels.

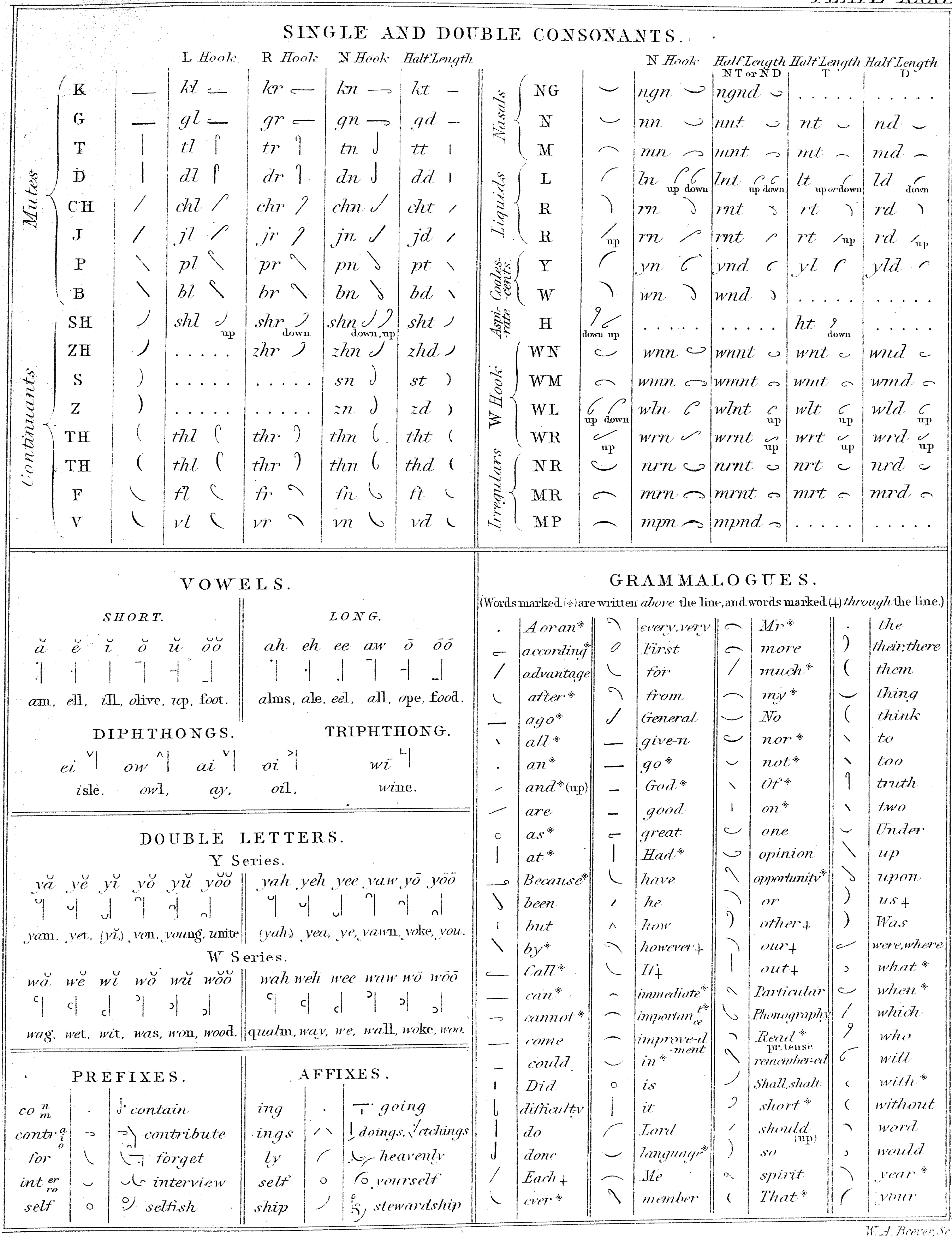


Length ... 324 " 3
Breadth ... 35 " 3
Depth ... 22 " 1

Scale 1/16 inch = 1 Foot

G. Aikman sc. Edin.

Edinburgh, Published by A. & C. Black.

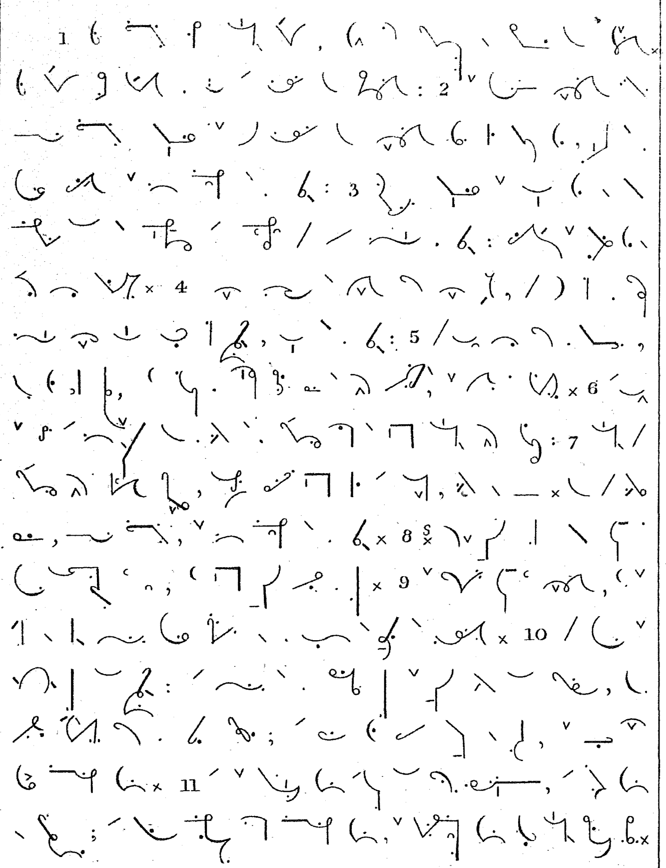


W. A. Beever, Sc.

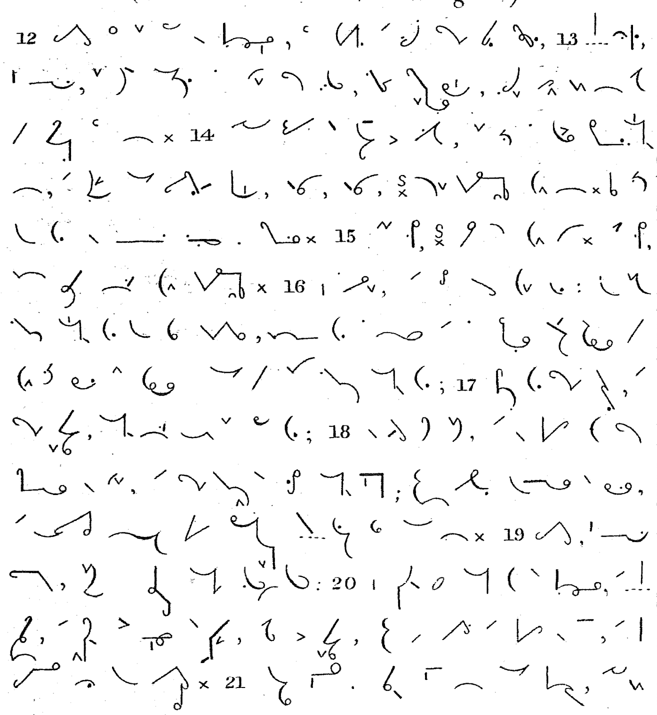
Published by A. & C. Black, Edinburgh.

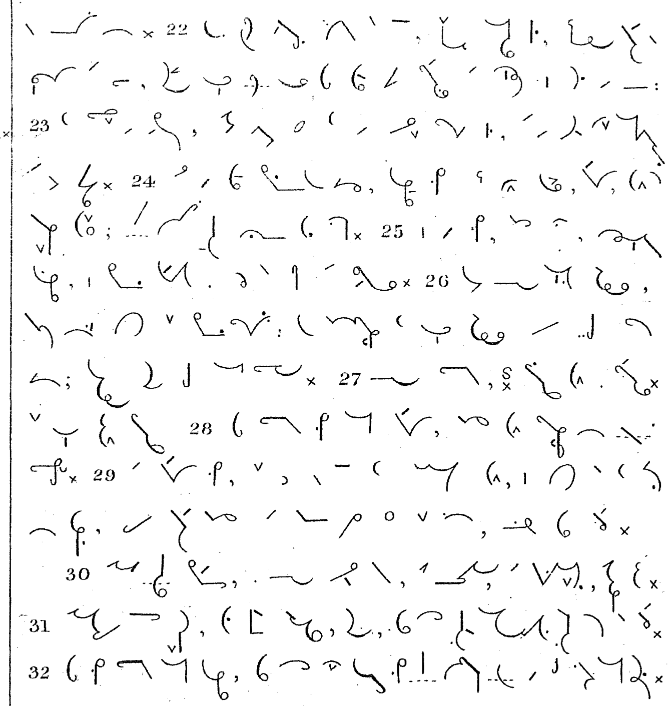
ACTS Chap XXVI.

(Written in an Easy Style, with Few Grammalogues.)



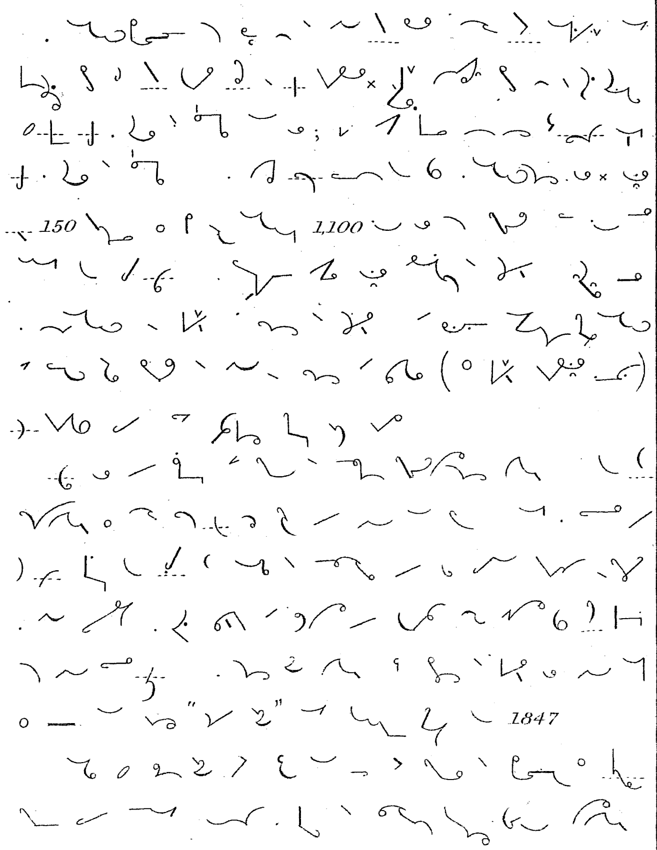
(Written with all the Grammalogues.)





THE ROMAN SYSTEM OF SHORTHAND.

(Written in the Reporting Style. For *Key* see Article "Stenography.")



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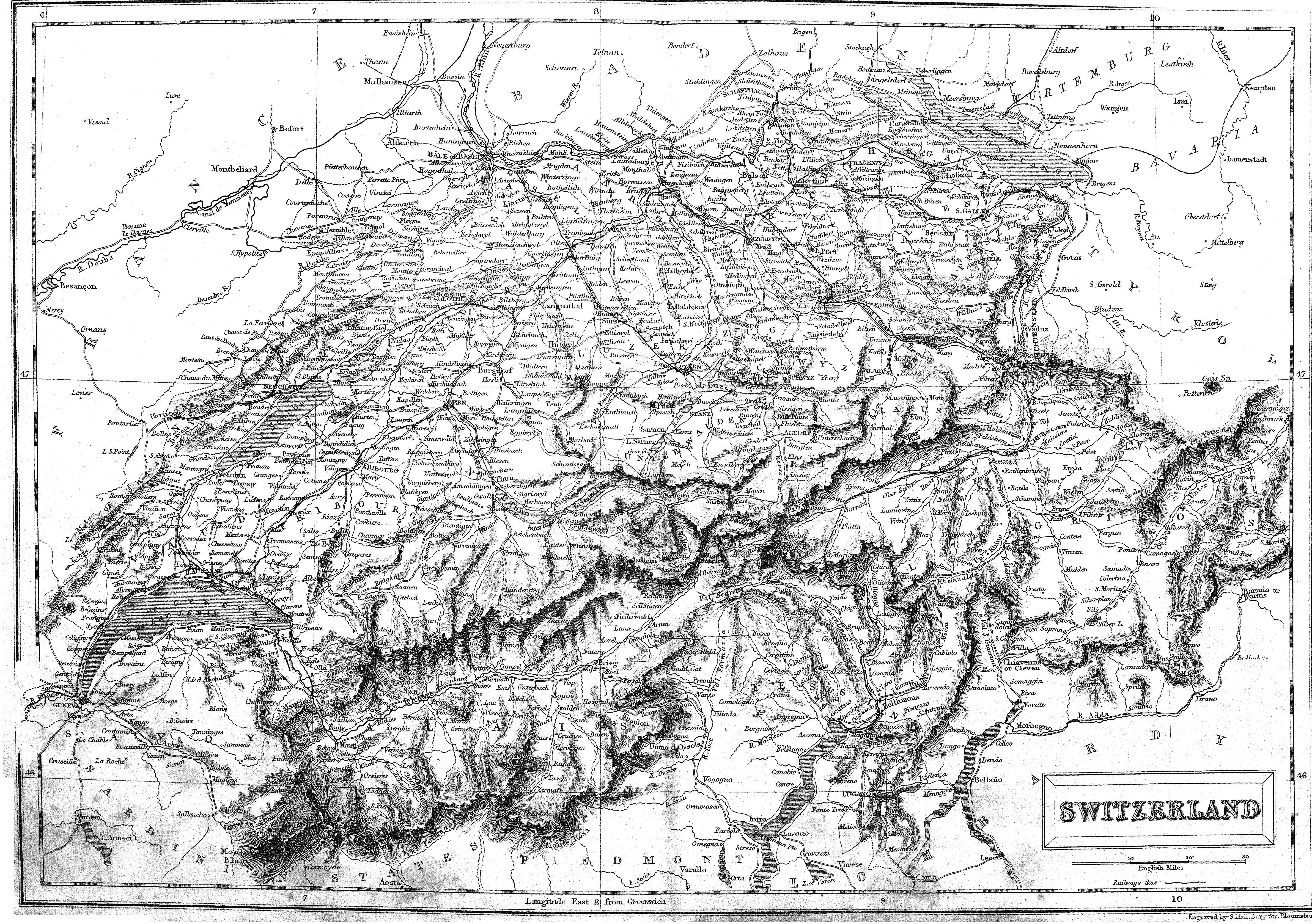
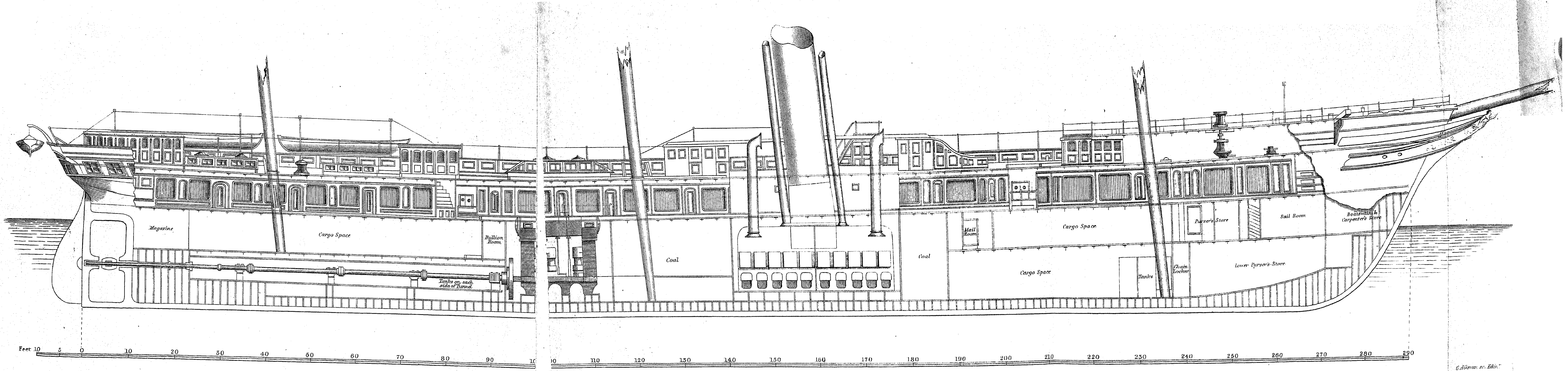

SWITZERLAND
English Miles
10
20
30
Railways thus
Longitude East 8 from Greenwich
FRANCE
BADEN
WURTEMBURG
BAVARIA
TYROL
LOMBARDY
PIEDMONT
SARDINIAN STATES
SAVOY
LAKE OF GENEVA OR LAC LEMAN
LAKE OF CONSTANCE
Lake of Neuchatel
GENEVA
LAUSANNE
BERN
FRIBOURG
NEUCHATEL
SOLOTHURN
BÂLE or BASEL
ZURICH
SCHAFFHAUSEN
LUZERN
ZUG
SCHWYZ
ALTORF
GLARUS
S. GALLEN
APPENZELL
CHUR
LIECHTENSTEIN
Besançon
Mulhausen
Montbeliard
Befort
Aosta
Como
Monte Rosa
Mont Blanc

SHIP BUILDING.

"CEYLON."

Draught of Inboard Works.



C. Aikman sc. Edin.

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